Attachment 2b

Division 21-33

Technical Specifications

SECTION 210500 - COMMON WORK RESULTS FOR FIRE SUPPRESSION

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. Mechanical sleeve seals.
3. Sleeves.
4. Escutcheons.
5. Grout.
6. Fire-suppression equipment and piping demolition.
7. Equipment installation requirements common to equipment sections.
8. Painting and finishing.
9. Concrete bases.
10. Supports and anchorages.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe 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. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

D. The following are industry abbreviations for plastic materials:
1. CPVC: Chlorinated polyvinyl chloride plastic.

E. 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. Mechanical sleeve seals.
2. Escutcheons.

B. Welding certificates.

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 Fire-Suppression 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 fire-suppression 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 fire-suppression items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section 033100"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. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to Division 211000 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. 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.

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, 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.

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

G. Solvent Cements for Joining CPVC Plastic Piping: ASTM F 493.

2.4 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.

2.5 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.

E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.

F. PVC Pipe: ASTM D 1785, Schedule 40.

G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

2.6 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 and rough brass.

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, and chrome-plated finish.

G. One-Piece, Floor-Plate Type: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.7 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 FIRE-SUPPRESSION DEMOLITION

A. Refer to Division 01 Section "Cut, Patch, Sleeves, and Inserts" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove fire-suppression 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. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping 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 211000 Sections specifying piping systems.

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 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. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
c. Insulated Piping: One-piece, stamped-steel type with spring clips.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, Split-casting, One-piece or split-casting, cast-brass type with polished chrome-plated finish.
g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge and set screw.
h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.
i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and set screw.
j. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
k. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw.
l. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

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

M. Permanent sleeves are not required for holes formed by removable PE sleeves.

N. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

O. 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 Sealants" for materials and installation.

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 Division 07 Section "Penetration Firestopping" for materials.

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 21 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 PAINTING

A. Painting of fire-suppression systems, equipment, and components is specified in Division 09 Section "Painting and Coating."

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

3.5 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

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

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

3.6 GROUTING

A. Mix and install grout for fire-suppression 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

SECTION 210513 - COMMON MOTOR REQUIREMENTS FOR FIRE SUPPRESSION EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 COORDINATION

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

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

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with requirements in this Section except when stricter requirements are specified in fire suppression equipment schedules or Sections.

B. Comply with NEMA MG 1 unless otherwise indicated.

C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

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

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

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Service Factor: 1.15.

D. Multispeed Motors: Variable torque.

1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

E. Multispeed Motors: Separate winding for each speed.

F. Rotor: Random-wound, squirrel cage.

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

H. Temperature Rise: Match insulation rating.

I. Insulation: Class F

J. Code Letter Designation:

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

K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: 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

SECTION 211000 - WATER-BASED FIRE-SUPPRESSION SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following fire-suppression piping inside the building:
   1. Wet-pipe sprinkler systems.
   2. Preaction sprinkler systems.

B. Related Sections include the following:

   1. Division 10 Sections "Fire Protection Cabinets" and "Fire Extinguishers" for cabinets and fire extinguishers.
   2. Division 22 Section "Facility Water Distribution Piping" for piping outside the building.
   3. Division 28 Section "Fire Detection and Alarm" for alarm devices not specified in this Section.

1.3 DEFINITIONS

A. CPVC: Chlorinated polyvinyl chloride plastic.

B. CR: Chlorosulfonated polyethylene synthetic rubber.

C. High-Pressure Piping System: Fire-suppression piping system designed to operate at working pressure higher than standard 175 psig.

D. PE: Polyethylene plastic.

E. Underground Service-Entrance Piping: Underground service piping below the building.

1.4 SYSTEM DESCRIPTIONS

A. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device. Hose connections are included if indicated.

1.5 PERFORMANCE REQUIREMENTS

A. Delegated Design: ``The fire suppression system shall be considered a delegated design by the Contractor whom is responsible for verifying the quantities, locations, and the final sprinkler layout required to meet the requirements of this specification.

B. Standard Piping System Component Working Pressure: Listed for at least 175 psig.

C. Fire-suppression sprinkler system design shall be approved by authorities having jurisdiction.

1. Margin of Safety for Available Water Flow and Pressure: 20 percent, including losses through water-service piping, valves, and backflow preventers.
2. Sprinkler Occupancy Hazard Classifications:

a. Building Service Areas: Ordinary Hazard, Group 1
b. Electrical Equipment Rooms: Ordinary Hazard, Group 1
c. General Storage Areas: Ordinary Hazard, Group 1
d. Mechanical Equipment Rooms: Ordinary Hazard, Group 1
e. Office and Public Areas: Light Hazard

3. Minimum Density for Automatic-Sprinkler Piping Design:

a. Light-Hazard Occupancy: 0.10 gpm over 1500-sq. ft. area.
b. Ordinary-Hazard, Group 1 Occupancy: 0.15 gpm over 1500-sq. ft. area.

4. Maximum Protection Area per Sprinkler: Per UL listing.
5. Maximum Protection Area per Sprinkler:

a. Office Spaces: 225 sq. ft..
b. Storage Areas: 130 sq. ft..
c. Mechanical Equipment Rooms: 130 sq. ft..
d. Electrical Equipment Rooms: 130 sq. ft..
e. Other Areas: According to NFPA 13 recommendations, unless otherwise indicated.

D. Seismic Performance: Fire-suppression piping shall be capable of withstanding the effects of earthquake motions determined according to NFPA 13 and ASCE 7, "Minimum Design Loads for Buildings and Other Structures": Section 9, "Earthquake Loads."

1.6 SUBMITTALS

A. Product Data: For the following:

1. Piping materials, including dielectric fittings and flexible connections and sprinkler specialty fittings.
2. Pipe hangers and supports, including seismic restraints if required.
3. Valves, including listed fire-protection valves, unlisted general-duty valves, and specialty valves and trim.
4. Air compressors, including electrical data.
5. Excess-pressure pumps, including electrical data.
6. Sprinklers, escutcheons, and guards. Include sprinkler flow characteristics, mounting, finish, and other pertinent data.
7. Fire hydrants.
8. Fire department connections, including type; number, size, and arrangement of inlets; caps and chains; size and direction of outlet; escutcheon and marking; and finish.
9. Alarm devices, including electrical data.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Fire-hydrant flow test report.

D. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations, if applicable.

E. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping."

F. Welding certificates.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For sprinkler specialties to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installer's responsibilities include designing, fabricating, and installing fire-suppression systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire-hydrant flow test.

a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer.

B. NFPA Standards: Fire-suppression-system equipment, specialties, accessories, installation, and testing shall comply with the following:

1. NFPA 13, "Installation of Sprinkler Systems."

1.8 COORDINATION

A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies. Provide coordinated shop drawings as a submittal to EOR.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to 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, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 STEEL PIPE AND FITTINGS

A. Threaded-End, Standard-Weight Steel Pipe: ASTM A 53/A 53M, ASTM A 135, or ASTM A 795, hot-dip galvanized where indicated and with factory- or field-formed threaded ends.

1. Cast-Iron Threaded Flanges: ASME B16.1.
2. Malleable-Iron Threaded Fittings: ASME B16.3.
3. Gray-Iron Threaded Fittings: ASME B16.4.
4. Steel Threaded Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, seamless steel pipe hot-dip galvanized where indicated. Include ends matching joining method.
5. Steel Threaded Couplings: ASTM A 865 hot-dip galvanized-steel pipe where indicated.

B. Plain-End, Standard-Weight Steel Pipe: ASTM A 53/A 53M, ASTM A 135, or ASTM A 795.

1. Steel Welding Fittings: ASTM A 234/A 234M, and ASME B16.9 or ASME B16.11.
2. Steel Flanges and Flanged Fittings: ASME B16.5.

C. Grooved-End, Standard-Weight Steel Pipe: ASTM A 53/A 53M, ASTM A 135, or ASTM A 795, hot-dip galvanized where indicated and with factory- or field-formed, square-cut- or roll-grooved ends.

1. Grooved-Joint Piping Systems:

a. Manufacturers:

1) Anvil International, Inc.
2) Central Sprinkler Corp.
3) Victaulic Co. of America.

b. Grooved-End Fittings: UL-listed, ASTM A 536, ductile-iron casting with OD matching steel-pipe OD.
c. Grooved-End-Pipe Couplings: UL 213 and AWWA C606, rigid pattern, unless otherwise indicated; gasketed fitting matching steel-pipe OD. Include ductile-iron housing with keys matching steel-pipe and fitting grooves, rubber gasket listed for use with housing, and steel bolts and nuts.

D. Grooved-End, Schedule 10 Steel Pipe: ASTM A 135 or ASTM A 795, Schedule 10 in NPS 5 and smaller; and NFPA 13-specified wall thickness in NPS 6 to NPS 10; with factory- or field-formed, roll-grooved ends.

1. Grooved-Joint Piping Systems:

    a. Manufacturers:

        1) Anvil International, Inc.
        2) Central Sprinkler Corp.
        3) Victaulic Co. of America.

    b. Grooved-End Fittings: UL-listed, ASTM A 536, ductile-iron casting with OD matching steel-pipe OD.

    c. Grooved-End-Pipe Couplings: UL 213 and AWWA C606, rigid pattern, unless otherwise indicated; gasketed fitting matching steel-pipe OD. Include ductile-iron housing with keys matching steel-pipe and fitting grooves,[prelubricated] rubber gasket listed for use with housing, and steel bolts and nuts.

2.3 DIELECTRIC FITTINGS

A. Assembly shall be copper alloy, ferrous, and insulating materials with ends matching piping system.

B. Dielectric Unions: Factory-fabricated assembly, designed for 250-psig minimum working pressure at 180 deg F. Include insulating material that isolates dissimilar materials and ends with inside threads according to ASME B1.20.1.

C. Dielectric Flange Insulation Kits: Components for field assembly shall include CR or phenolic

D. Dielectric Couplings: Galvanized steel with inert and noncorrosive thermoplastic lining and threaded ends and 300-psig working-pressure rating at 225 deg F.

E. Dielectric Nipples: Electroplated steel with inert and noncorrosive thermoplastic lining, with combination of plain, threaded, or grooved ends and 300-psig working-pressure rating at 225 deg F.

2.4 FLEXIBLE CONNECTORS

A. Flexible connectors shall have materials suitable for system fluid. Include 175-psig minimum working-pressure rating and ends according to the following:

1. NPS 2 and Smaller: Threaded.
2. NPS 2-1/2 and Larger: Flanged.
3. Option for NPS 2-1/2 and Larger: Grooved for use with grooved-end-pipe couplings.

B. Manufacturers:

1. Anvil International, Inc.
2. Victaulic Co. of America.

C. Bronze-Hose, Flexible Connectors: Corrugated, bronze, inner tubing covered with bronze wire braid. Include copper-tube ends or bronze flanged ends, braze welded to hose.

D. Stainless-Steel-Hose/Steel Pipe, Flexible Connectors: Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include steel nipples or flanges, welded to hose.

E. Stainless-Steel-Hose/Stainless-Steel Pipe, Flexible Connectors: Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to hose.

2.5 CORROSION-PROTECTIVE ENCASEMENT FOR PIPING

A. Encasement for Underground Metal Piping: ASTM A 674 or AWWA C105, PE film, 0.008-inch minimum thickness, tube or sheet.

2.6 SPRINKLER SPECIALTY FITTINGS

A. Sprinkler specialty fittings shall be UL listed or FMG approved, with 175-psig minimum working-pressure rating, and made of materials compatible with piping. Sprinkler specialty fittings shall have 250-psig minimum working-pressure rating if fittings are components of high-pressure piping system.

B. Outlet Specialty Fittings:

1. Manufacturers:

    a. Anvil International, Inc.
    b. Central Sprinkler Corp.
    c. Victaulic Co. of America.

2. Mechanical-T and -Cross Fittings: UL 213, ductile-iron housing with gaskets, bolts and nuts, and threaded, locking-lug, or grooved outlets.
3. Snap-On and Strapless Outlet Fittings: UL 213, ductile-iron housing or casting with gasket and threaded outlet.

C. Sprinkler Drain and Alarm Test Fittings: Cast- or ductile-iron body; with threaded or locking-lug inlet and outlet, test valve, and orifice and sight glass.

1. Manufacturers:

    a. Central Sprinkler Corp.
    b. Fire-End and Croker Corp.
    c. Viking Corp.
    d. Victaulic Co. of America.

D. Sprinkler Branch-Line Test Fittings: Brass body with threaded inlet, capped drain outlet, and threaded outlet for sprinkler.

1. Manufacturers:

    a. Elkhart Brass Mfg. Co., Inc.
    b. Fire-End and Croker Corp.
    c. Potter-Roemer; Fire-Protection Div.

E. Sprinkler Inspector's Test Fitting: Cast- or ductile-iron housing with threaded inlet and drain outlet and sight glass.

1. Manufacturers:

    a. AGF Manufacturing Co.
    b. Central Sprinkler Corp.
    c. G/J Innovations, Inc.
    d. Triple R Specialty of Ajax, Inc.

F. Drop-Nipple Fittings: UL 1474, adjustable with threaded inlet and outlet, and seals.

1. Manufacturers:

    a. CECA, LLC.
    b. Merit.

2.7 LISTED FIRE-PROTECTION VALVES

A. Valves shall be UL listed or FMG approved, with 175-psig minimum pressure rating. Valves shall have 250-psig minimum pressure rating if valves are components of high-pressure piping system.

B. Gate Valves with Wall Indicator Posts:

1. Gate Valves: UL 262, cast-iron body, bronze mounted, with solid disc, nonrising stem, operating nut, and flanged ends.
2. Indicator Posts: UL 789, horizontal-wall type, cast-iron body, with hand wheel, extension rod, locking device, and cast-iron barrel.
3. Manufacturers:

    a. Grinnell Fire Protection.
    b. McWane, Inc.; Kennedy Valve Div.
    c. NIBCO.
    d. Stockham.

C. Ball Valves: Comply with UL 1091, except with ball instead of disc.

1. NPS 1-1/2 and Smaller: Bronze body with threaded ends.
2. NPS 2 and NPS 2-1/2: Bronze body with threaded ends or ductile-iron body with grooved ends.
3. NPS 3: Ductile-iron body with grooved ends.
4. Manufacturers:

    a. NIBCO.
    b. Victaulic Co. of America.

D. Butterfly Valves: UL 1091.

1. NPS 2 and Smaller: Bronze body with threaded ends.

    a. Manufacturers:

        1) Global Safety Products, Inc.
        2) Milwaukee Valve Company.

2. NPS 2-1/2 and Larger: Bronze, cast-iron, or ductile-iron body; wafer type or with flanged or grooved ends.

a. Manufacturers:

1) Central Sprinkler Corp.
2) Global Safety Products, Inc.
3) McWane, Inc.; Kennedy Valve Div.
4) Mueller Company.
5) NIBCO.
6) Pratt, Henry Company.
7) Victaulic Co. of America.

E. Check Valves NPS 2 and Larger: UL 312, swing type, cast-iron body with flanged or grooved ends.

1. Manufacturers:

a. AFAC Inc.
b. American Cast Iron Pipe Co.; Waterous Co.
c. Central Sprinkler Corp.
d. Clow Valve Co.
e. Crane Co.; Crane Valve Group; Crane Valves.
f. Crane Co.; Crane Valve Group; Jenkins Valves.
g. Firematic Sprinkler Devices, Inc.
h. Globe Fire Sprinkler Corporation.
i. Grinnell Fire Protection.
j. Hammond Valve.
k. Matco-Norca, Inc.
l. McWane, Inc.; Kennedy Valve Div.
m. Mueller Company.
n. NIBCO.
o. Potter-Roemer; Fire Protection Div.
p. Reliable Automatic Sprinkler Co., Inc.
q. Star Sprinkler Inc.
r. Stockham.
s. United Brass Works, Inc.
t. Venus Fire Protection, Ltd.
u. Victaulic Co. of America.
v. Watts Industries, Inc.; Water Products Div.

F. Gate Valves: UL 262, OS&Y type.

1. NPS 2 and Smaller: Bronze body with threaded ends.

a. Manufacturers:

1) Crane Co.; Crane Valve Group; Crane Valves.
2) Hammond Valve.
3) NIBCO.
4) United Brass Works, Inc.

2. NPS 2-1/2 and Larger: Cast-iron body with flanged ends.

a. Manufacturers:

1) Clow Valve Co.
2) Crane Co.; Crane Valve Group; Crane Valves.

3) Crane Co.; Crane Valve Group; Jenkins Valves.
4) Hammond Valve.
5) Milwaukee Valve Company.
6) Mueller Company.
7) NIBCO.
8) Red-White Valve Corp.
9) United Brass Works, Inc.

G. Indicating Valves: UL 1091, with integral indicating device and ends matching connecting piping.

1. Indicator: Electrical, 115-V ac, prewired, single-circuit, supervisory switch.
2. NPS 2 and Smaller: Ball or butterfly valve with bronze body and threaded ends.

a. Manufacturers:

1) Milwaukee Valve Company.
2) NIBCO.
3) Victaulic Co. of America.

3. NPS 2-1/2 and Larger: Butterfly valve with cast- or ductile-iron body; wafer type or with flanged or grooved ends.

a. Manufacturers:

1) Central Sprinkler Corp.
2) Grinnell Fire Protection.
3) McWane, Inc.; Kennedy Valve Div.
4) Milwaukee Valve Company.
5) NIBCO.
6) Victaulic Co. of America.

2.8 UNLISTED GENERAL-DUTY VALVES

A. Ball Valves NPS 2 and Smaller: MSS SP-110, 2-piece copper-alloy body with chrome-plated brass ball, 600-psig minimum CWP rating, blowout-proof stem, and threaded ends.

B. Check Valves NPS 2 and Smaller: MSS SP-80, Type 4, Class 125 minimum, swing type with bronze body, nonmetallic disc, and threaded ends.

C. Gate Valves NPS 2 and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, solid wedge, and threaded ends.

D. Globe Valves NPS 2 and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, nonmetallic disc, and threaded ends.

2.9 SPECIALTY VALVES

A. Sprinkler System Control Valves: UL listed or FMG approved, cast- or ductile-iron body with flanged or grooved ends, and 175-psig minimum pressure rating. Control valves shall have 250-psig minimum pressure rating if valves are components of high-pressure piping system.

1. Manufacturers:

a. AFAC Inc.
b. Central Sprinkler Corp.
c. Globe Fire Sprinkler Corporation.
d. Grinnell Fire Protection.
e. Victaulic Co. of America.
f. Viking Corp.

2. Alarm Check Valves: UL 193, designed for horizontal or vertical installation, with bronze grooved seat with O-ring seals, single-hinge pin, and latch design. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gages, retarding chamber, and fill-line attachment with strainer.

a. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
b. Drip Cup Assembly: Pipe drain with check valve to main drain piping.

2.10 MANUAL CONTROL STATIONS

A. Manual Control Stations: UL listed or FMG approved, hydraulic operation, with union, NPS 1/2 pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut to prevent accidental opening.

2.11 CONTROL PANELS

A. Description: Single-area, two-area, or single-area cross-zoned type control panel as indicated, including NEMA ICS 6, Type 1 enclosure, detector, alarm, and solenoid-valve circuitry for operation of deluge valves. Panels contain power supply; battery charger; standby batteries; field-wiring terminal strip; electrically supervised solenoid valves and polarized fire alarm bell; lamp test facility; single-pole, double-throw auxiliary alarm contacts; and rectifier.

1. Panels: UL listed and FMG approved when used with thermal detectors and Class A detector circuit wiring. Electrical characteristics are 120-V ac, 60 Hz, with 24-V dc rechargeable batteries.
2. Manual Control Stations: Electric operation, metal enclosure, labeled "MANUAL CONTROL STATION" with operating instructions and a cover held closed by breakable strut.
3. Manual Control Stations: Hydraulic operation, with union, NPS 1/2 pipe nipple, and bronze ball valve. Include metal enclosure labeled "MANUAL CONTROL STATION" with operating instructions and cover held closed by breakable strut.

2.12 SPRINKLERS

A. Sprinklers shall be UL listed or FMG approved, with 175-psig minimum pressure rating. Sprinklers shall have [250-psig minimum] [300-psig] pressure rating if sprinklers are components of high-pressure piping system.

B. Manufacturers:
1. Globe Fire Sprinkler Corporation.
2. Reliable Automatic Sprinkler Co., Inc.
3. Victaulic Co. of America.
4. Viking Corp.

C. Automatic Sprinklers: With heat-responsive element complying with the following:

1. UL 199, for nonresidential applications.
2. UL 1626, for residential applications.
3. UL 1767, for early-suppression, fast-response applications.

D. Sprinkler Types and Categories: Nominal 1/2-inch orifice for "Ordinary" temperature classification rating, unless otherwise indicated or required by application.

1. Open Sprinklers: UL 199, without heat-responsive element.

a. Orifice: 1/2 inch, with discharge coefficient K between 5.3 and 5.8.
b. Orifice: 17/32 inch, with discharge coefficient K between 7.4 and 8.2.

E. Sprinkler types, features, and options as follows:

1. Concealed ceiling sprinklers, including cover plate.
2. Flush ceiling sprinklers, including escutcheon.
3. High-pressure sprinklers.
4. Pendent sprinklers.
5. Quick-response sprinklers.
6. Recessed sprinklers, including escutcheon.
7. Sidewall sprinklers.
8. Upright sprinklers.

F. Sprinkler Finishes: Chrome plated, bronze, and painted.

G. Special Coatings: Wax, lead, and corrosion-resistant paint.

H. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.

I. Sprinkler Guards: Wire-cage type, including fastening device for attaching to sprinkler.

2.13 HOSE CONNECTIONS

A. Manufacturers:

1. AFAC Inc.
2. Central Sprinkler Corp.
3. Elkhart Brass Mfg. Co., Inc.
4. Fire-End and Croker Corp.
5. Fire Protection Products, Inc.
6. GMR International Equipment Corporation.
7. Grinnell Fire Protection.
8. Guardian Fire Equipment Incorporated.
9. Potter-Roemer; Fire-Protection Div.

B. Description: UL 668, brass or bronze, 300-psig minimum pressure rating, hose valve for connecting fire hose. Include angle or gate pattern design; female NPS inlet and male hose outlet; and lugged cap, gasket, and chain. Include NPS 1-1/2 or NPS 2-1/2 as indicated, and hose valve threads according to NFPA 1963 and matching local fire department threads.

2.14 FIRE DEPARTMENT CONNECTIONS

A. Manufacturers:

1. AFAC Inc.
2. Central Sprinkler Corp.
3. Elkhart Brass Mfg. Co., Inc.
4. Potter-Roemer; Fire-Protection Div.
5. Reliable Automatic Sprinkler Co., Inc.

B. Exposed, Freestanding-Type, Fire Department Connection: UL 405, 175-psig minimum pressure rating; with corrosion-resistant-metal body, brass inlets with threads according to NFPA 1963 and matching local fire department sizes and threads, and bottom outlet with pipe threads. Include brass lugged caps, gaskets, and brass chains; brass lugged swivel connection and drop clapper for each hose-connection inlet; 18-inch- high, brass sleeve; and round, floor, brass escutcheon plate with marking "AUTO SPKR & STANDPIPE."

1. Finish Including Sleeve: Polished chrome-plated.

2.15 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Water-Motor-Operated Alarm: UL 753, mechanical-operation type with pelton-wheel operator with shaft length, bearings, and sleeve to suit wall construction and 10-inch- diameter, cast-aluminum alarm gong with red-enamel factory finish. Include NPS 3/4 inlet and NPS 1 drain connections.

1. Manufacturers:
   a. Central Sprinkler Corp.
   b. Globe Fire Sprinkler Corporation.
   c. Reliable Automatic Sprinkler Co., Inc.
   d. Viking Corp.

C. Electrically Operated Alarm: UL 464, with vibrating-type, metal alarm bell with red-enamel factory finish and suitable for outdoor use.

1. Manufacturers:

   a. Potter Electric Signal Company.
   b. System Sensor.

D. Water-Flow Indicator: UL 346, electrical-supervision, paddle-operated-type, water-flow detector with 250-psig pressure rating and designed for horizontal or vertical installation. Include two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.

1. Manufacturers:
   a. Grinnell Fire Protection.
   b. Potter Electric Signal Company.
   c. Viking Corp.
   d. Watts Industries, Inc.; Water Products Div.

E. Pressure Switch: UL 753, electrical-supervision-type, water-flow switch with retard feature. Include single-pole, double-throw, normally closed contacts and design that operates on rising pressure and signals water flow.

1. Manufacturers:

a. Grinnell Fire Protection.
b. Potter Electric Signal Company.
c. System Sensor.
d. Viking Corp.

F. Valve Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled valve is in other than fully open position.

1. Manufacturers:

a. McWane, Inc.; Kennedy Valve Div.
b. Potter Electric Signal Company.
c. System Sensor.
d.

G. Indicator-Post Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled indicator-post valve is in other than fully open position.

1. Manufacturers:

a. Potter Electric Signal Company.
b. System Sensor.

2.16 PRESSURE GAGES

A. Manufacturers:

1. AGF Manufacturing Co.
2. AMETEK, Inc.; U.S. Gauge.
3. Brecco Corporation.
4. Dresser Equipment Group; Instrument Div.
5. Marsh Bellofram.
6. WIKA Instrument Corporation.

B. Description: UL 393, 3-1/2- to 4-1/2-inch- diameter, dial pressure gage with range of 0 to 250 psig minimum.

1. Water System Piping: Include caption "WATER" or "AIR/WATER" on dial face.

PART 3 - EXECUTION

3.1 PREPARATION

A. Perform fire-hydrant flow test according to NFPA 13 and NFPA 291. Use results for system design calculations required in Part 1 "Quality Assurance" Article.

B. Report test results promptly and in writing.

3.2 EARTHWORK

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.3 EXAMINATION

A. Examine roughing-in for hose connections and stations to verify actual locations of piping connections before installation.

B. Examine walls and partitions for suitable thicknesses, fire- and smoke-rated construction, framing for hose-station cabinets, and other conditions where hose connections and stations are to be installed.

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

3.4 PIPING APPLICATIONS, GENERAL

A. Shop weld pipe joints where welded piping is indicated.

B. Do not use welded joints for galvanized-steel pipe.

C. Flanges, flanged fittings, unions, nipples, and transition and special fittings with finish and pressure ratings same as or higher than system's pressure rating may be used in aboveground applications, unless otherwise indicated.

D. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with grooved ends; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

E. Underground Service-Entrance Piping: Ductile-iron, mechanical-joint pipe and fittings and restrained joints.

3.5 SPRINKLER SYSTEM PIPING APPLICATIONS

A. Standard-Pressure, Wet-Pipe Sprinkler System, 175-psig Maximum Working Pressure:
   1. NPS 1-1/2 and Smaller: Threaded-end, black or galvanized, schedule 40 steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.
   2. NPS 2 to NPS 4: Grooved-end, black or galvanized, schedule 10 steel pipe; grooved-end fittings; grooved-end-pipe couplings; and grooved joints.

3.6 VALVE APPLICATIONS

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

1. Listed Fire-Protection Valves: UL listed and FMG approved for applications where required by NFPA 13.

a. Shutoff Duty: Use ball, butterfly, or gate valves.

2. Unlisted General-Duty Valves: For applications where UL-listed and FMG-approved valves are not required by NFPA 13.

a. Shutoff Duty: Use ball, butterfly, or gate valves.
b. Throttling Duty: Use ball or globe valves.

3.7 JOINT CONSTRUCTION

A. Refer to Division 21 Section "Common Work Results for Fire Suppression" for basic piping joint construction.

B. Threaded Joints: Comply with NFPA 13 for pipe thickness and threads. Do not thread pipe smaller than NPS 8 (DN 200) with wall thickness less than Schedule 40 unless approved by authorities having jurisdiction and threads are checked by a ring gage and comply with ASME B1.20.1.

C. Grooved Joints: Assemble joints with listed coupling and gasket, lubricant, and bolts.
1. Steel Pipe: Square-cut or roll-groove piping as indicated. Use grooved-end fittings and rigid, grooved-end-pipe couplings, unless otherwise indicated.
2. Dry-Pipe Systems: Use fittings and gaskets listed for dry-pipe service.

D. Dissimilar-Metal Piping Joints: Construct joints using dielectric fittings compatible with both piping materials.

1. NPS 2 and Smaller: Use dielectric unions, couplings, or nipples.
2. NPS 2-1/2 to NPS 4: Use dielectric flanges.
3. NPS 5 and Larger: Use dielectric flange insulation kits.

3.8 SERVICE-ENTRANCE PIPING

A. Connect fire-suppression piping to water-service piping of size and in location indicated for service entrance to building. Refer to Division 22 Section "Facility Water Distribution Piping" for exterior piping.

B. Install shutoff valve, backflow preventer, pressure gage, drain, and other accessories indicated at connection to water-service piping. Refer to Division 22 Section "Facility Water Distribution Piping" for backflow preventers.

C. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.9 PIPING INSTALLATION

A. Refer to Division 21 Section "Common Work Results for Fire Suppression" for basic piping installation.

B. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.

1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.

C. Install underground ductile-iron service-entrance piping according to NFPA 24 and with restrained joints.

D. Use approved fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

E. Install unions adjacent to each valve in pipes NPS 2 and smaller. Unions are not required on flanged devices or in piping installations using grooved joints.

F. Install flanges or flange adapters on valves, apparatus, and equipment having NPS 2-1/2 and larger connections.

G. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, sized and located according to NFPA 13.

H. Install sprinkler piping with drains for complete system drainage.

I. Install sprinkler zone control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

J. Install ball drip valves to drain piping between fire department connections and check valves. Drain to floor drain or outside building.

K. Install alarm devices in piping systems.

L. Hangers and Supports: Comply with NFPA 13 for hanger materials.

1. Install standpipe system piping according to NFPA 14.
2. Install sprinkler system piping according to NFPA 13.

M. Earthquake Protection: Install piping according to NFPA 13 to protect from earthquake damage.

N. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.

O. Drain dry-pipe sprinkler piping.

P. Pressurize and check dry-pipe sprinkler system piping and air-pressure maintenance devices.

Q. Fill wet-pipe sprinkler system piping with water.

R. Install flexible connectors on fire-pump and pressure-maintenance-pump supply and discharge connections and in fire-suppression piping where indicated.

3.10 VALVE INSTALLATION

A. Install listed fire-protection valves, unlisted general-duty valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.

B. Install listed fire-protection shutoff valves supervised-open, located to control sources of water supply except from fire department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water supply sources.

D. Specialty Valves:

1. Alarm Check Valves: Install in vertical position for proper direction of flow, including bypass check valve and retarding chamber drain-line connection.
2. Dry-Pipe Valves: Install trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gages, priming chamber attachment, and fill-line attachment.

    a. Air-Pressure Maintenance Devices for Dry-Pipe Systems: Install shutoff valves to permit servicing without shutting down sprinkler system; bypass valve for quick system filling; pressure regulator or switch to maintain system pressure; strainer; pressure ratings with 14- to 60-psig adjustable range; and 175-psig maximum inlet pressure.
    b. Install air compressor and compressed-air supply piping.
    c. Install compressed-air supply piping from building's compressed-air piping system.

3.11 SPRINKLER APPLICATIONS

A. Drawings indicate sprinkler types to be used. Where specific types are not indicated, use the following sprinkler types:

1. Rooms without Ceilings: Upright sprinklers.
2. Rooms with Suspended Ceilings: Concealed sprinklers.
3. Wall Mounting: Sidewall sprinklers.
4. Spaces Subject to Freezing: Upright, pendent, dry sprinklers; and sidewall, dry sprinklers as indicated.
5. Sprinkler Finishes:

    a. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.
    b. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.
    c. Flush Sprinklers: Bright chrome, with painted white escutcheon.
    d. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
    e. Residential Sprinklers: Dull chrome.

3.12 EXCESS-PRESSURE PUMP INSTALLATION

A. Install excess-pressure pumps, controls, devices, and supports for wet-pipe sprinkler system application.

3.13 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of narrow dimension of acoustical ceiling panels and tiles.

B. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing. Use dry-type sprinklers with water supply from heated space.

3.14 FIRE DEPARTMENT CONNECTION INSTALLATION

A. Install wall-type, fire department connections in vertical wall.

B. Install freestanding-type, fire department connections in level surface.

1. Install protective pipe bollards on two sides of each fire department connection. Refer to Division 05 Section "Metal Fabrications" for pipe bollards.

C. Install ball drip valve at each check valve for fire department connection.

3.15 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Connect water-supply piping to fire-suppression piping. Include backflow preventer between potable-water piping and fire-suppression piping. Refer to Division 22 Section "Domestic Water Piping Specialties" for backflow preventers.

D. Install ball drip valves at each check valve for fire department connection. Drain to floor drain or outside building.

E. Connect piping to specialty valves, hose valves, specialties, fire department connections, and accessories.

F. Connect excess-pressure pumps to the following piping and wiring:

1. Sprinkler system, hydraulically.
2. Pressure gages and controls, hydraulically.
3. Electrical power system.
4. Alarm device accessories for pump.
5. Fire alarm.

G. Connect compressed-air supply to dry-pipe sprinkler piping.

H. Connect air compressor to the following piping and wiring:

1. Pressure gages and controls.
2. Electrical power system.
3. Fire alarm devices, including low-pressure alarm.

I. Electrical Connections: Power wiring is specified in Division 26.

J. Connect alarm devices to fire alarm.

K. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

L. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

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

3.16 LABELING AND IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

3.17 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Energize circuits to electrical equipment and devices.
4. Start and run excess-pressure pumps.
5. Start and run air compressors.
6. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
7. Flush, test, and inspect standpipe systems according to NFPA 14, "System Acceptance" Chapter.
8. Coordinate with fire alarm tests. Operate as required.
9. Coordinate with fire-pump tests. Operate as required.
10. Verify that equipment hose threads are same as local fire department equipment.

B. Report test results promptly and in writing to Architect and authorities having jurisdiction.

3.18 CLEANING AND PROTECTION

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers with paint other than factory finish.

C. Protect sprinklers from damage until Substantial Completion.

3.19 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves.

END OF SECTION

SECTION 220500 - COMMON WORK RESULTS FOR PLUMBING

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. Transition fittings.
3. Dielectric fittings.
4. Mechanical sleeve seals.
5. Sleeves.
6. Escutcheons.
7. Grout.
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 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 in 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. ABS: Acrylonitrile-butadiene-styrene plastic.
2. CPVC: Chlorinated polyvinyl chloride plastic.
3. PE: Polyethylene plastic.

4. 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. Transition fittings.
2. Dielectric fittings.
3. Mechanical sleeve seals.
4. Escutcheons.

1.5 QUALITY ASSURANCE

A. Electrical Characteristics for Plumbing 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.

B. Performance criteria for specified equipment and materials shall take precedence over selected model numbers.

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.

1.7 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing 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 plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

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. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 22 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 22 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.

2.4 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

1. Manufacturers:

a. Cascade Waterworks Mfg. Co.
b. Dresser Industries, Inc.; DMD Div.

c. Ford Meter Box Company, Incorporated (The); Pipe Products Div.
d. JCM Industries.
e. Smith-Blair, Inc.
f. Viking Johnson.

2. Underground Piping NPS 1-1/2 and Smaller: Manufactured fitting or coupling.
3. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve-type coupling.
4. Aboveground Pressure Piping: Pipe fitting.

2.5 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. Capitol Manufacturing Co.
b. Central Plastics Company.
c. Eclipse, Inc.
d. Epco Sales, Inc.
e. Hart Industries, International, Inc.
f. Watts Industries, Inc.; Water Products Div.
g. 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. Central Plastics Company.
c. Epco Sales, Inc.
d. 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. Sioux Chief Manufacturing Co., Inc.
b. Victaulic Co. of America.

2.6 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: Compatible 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.

2.7 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.

2.8 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 Rough brass Polished chrome-plated and rough brass.

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

1. Finish: Polished chrome-plated Rough brass Polished chrome-plated and rough brass.

E. One-Piece, Floor-Plate Type: Cast-iron floor plate.

F. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 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 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 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 equipment and make other design decisions. 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, cast-brass, chrome plated deep-pattern type.
b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
c. Insulated Piping: One-piece, cast brass type with spring clips.
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 and Equipment Rooms: Split casting, cast-brass type with polished chrome-plated finish.
g. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

M. 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, plumbing wet-walls or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping rings.

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 Sealants" for materials and installation.

N. 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.

O. 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.

P. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

Q. Verify final equipment locations for roughing-in.

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

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 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. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 3 and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping 4” and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.
4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4 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 plumbing 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.

3.5 PAINTING

A. Painting of plumbing 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.

3.6 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 Division 03 Section "Cast-in-Place Concrete."

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05 Section "Metal Fabrications" for structural steel.

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

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

3.8 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor plumbing materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.9 ESCUTCHEON INSTALLATION

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

B. Escutcheons for New Piping:

1. Piping with Fitting or Sleeve Protruding from Wall: One piece, deep pattern.
2. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated.
3. Bare Piping at Ceiling Penetrations in Finished Spaces: One piece, cast brass with polished chrome-plated finish
4. Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated.
5. Bare Piping in Equipment Rooms: One piece, cast brass.
6. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

3.10 GROUTING

A. Mix and install grout for plumbing 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

SECTION 220519 - METERS AND GAGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Thermometers.
2. Meters
3. Gages.
4. Test plugs.

B. Related Sections:
1. Division 22 Section "Domestic Water Piping" for domestic and fire-protection water service meters inside the building.

1.3 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

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

1.4 SUBMITTALS

A. Product Data: For each type of product indicated; include performance curves.

PART 2 - PRODUCTS

2.1 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

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

1. Weiss Instruments Inc., 9VU 9” Vari-Angle.
2. Trerice, H. O. Co.
3. Palmer - Wahl Instruments Inc.
4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Case: Die-cast aluminum 9 inches long.

C. Tube: Red or blue reading, organic-liquid filled, with magnifying lens.

D. Tube Background: Satin-faced, nonreflective aluminum with black markings.

E. Window: Glass.

F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.

H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.2 LIGHT POWERED DIGITAL THERMOMETERS

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

1. Weiss Instruments Inc., DVU Digital Vari-Angle.
2. Trerice, H. O. Co.
3. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Case: ABS plastic or aluminum.

C. Display: 1/2 inch, or greater, LCD digits.

D. Sensor: Glass passivated thermistor.

E. Lux Rating: 10 Lux (one foot-candle).

F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.

H. Accuracy: Plus or minus 1 percent of reading or one degree.

2.3 THERMOWELLS

A. Manufacturers: Same as manufacturer of thermometer being used.

B. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.4 TURBINE INDUSTRIAL FLOW METERS: CITY WATER AND SUB-METER

A. Type: Turbine Industrial.
1. Flow Meter shall be complete with all installation hardware (spool) necessary to enable insertion and removal of the meter without system shutdown.

2. Fitment: Meter hall be installed in accordance with the manufacturer's installation guide including meter orientation and straight pipe recommendations. Applicable pipe size shall be from 1-1/2 to 12 inches.
3. Connections: The flow meter shall be able to operate at up to 150 psi and 120°F temperature.
4. Materials: Material shall be epoxy coated cast iron, EPDM o-ring seals, and plastic/bronze/aluminum housing.
5. Accuracy: Flow shall be ± 1% of rate. Repeatability shall be ± 0.25% of rate. A certificate of calibration shall be provided with each flow meter.
6. Output Signals: Dry-contacts for pulse output. A 'pulse' shall equate to "x" amount of gallons per pulse.
7. Installation: Coordinate manufacturer's recommended installation requirements with piping contractor to ensure proper installation.
8. Power: 24VDC power supply as required from Emergency source, where applicable.
9. All meters shall be RoHS complaint.

B. Preliminary acceptable Manufacturer: Badger Meters, model Disc or Turbo Series Meter with Dry-Contacts for pulse output. No exception.

2.5 PRESSURE GAGES

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

1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. Ernst Gage Co.
3. KOBOLD Instruments, Inc.
4. Miljoco Corp.
5. Trerice, H. O. Co.
6. Weiss Instruments, Inc.
7. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.

1. Case: Dry type, cast aluminum 4-1/2-inch diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Red metal.
7. Window: Glass
8. Ring: Brass or stainless steel
9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.

C. Pressure-Gage Fittings:

1. Valves: NPS 1/4 brass or stainless-steel needle type.
2. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.6 TEST PLUGS

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

1. Flow Design, Inc.
2. MG Piping Products Co.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Co.
6. Trerice, H. O. Co.
7. Watts Industries, Inc.; Water Products Div.

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F

D. Core Inserts: One or two self-sealing rubber valves.

1. Insert material for water service at 20 to 200 deg F shall be CR.
2. Insert material for water service at minus 30 to plus 275 deg F shall be EPDM.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install thermometers in the inlet and outlet of each domestic, hot-water storage tank, water heater and heat exchanger.

B. Install thermometers at the inlets and outlet of all master thermostatic mixing valves.

C. Install thermometers at suction and discharge of each pump.

D. Provide the following temperature ranges for thermometers:

1. Domestic Hot Water: 30 to 240 deg F, with 2-degree scale divisions
2. Domestic Cold Water: 0 to 100 deg F, with 2-degree scale divisions

3.2 GAGE APPLICATIONS

A. Install pressure gages for inlet and outlet of each pressure-reducing valve.

B. Install pressure gages at suction and discharge of each pump.

C. Install pressure gages at inlets and outlet of all master thermostatic mixing valves.

3.3 INSTALLATIONS

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

B. Install thermometers and adjust vertical and tilted positions.

C. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.

D. Install needle-valve and snubber fitting in piping for each pressure gage.

E. Install test plugs in tees in piping.

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

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

H. Install thermometers and gages adjacent to machines and equipment to allow service and maintenance for thermometers, gages, machines, and equipment.

I. Adjust faces of thermometers and gages to proper angle for best visibility.

J. Install insulation to fit tightly and cleanly against the tee stems for fittings and thermowells. Provide sleeve or extension where required for a clean installation.

END OF SECTION

SECTION 220523 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Bronze ball valves.
2. Bronze lift check valves.
3. Bronze swing check valves.
4. Iron swing check valves.
5. Iron center guided check valves.
6. Iron gate valves.
7. Balancing Valves.
8. Drain Valves

B. Related Sections:

1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.
2. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
3. Division 33 water distribution piping Sections for general-duty and specialty valves for site construction piping.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.4 SUBMITTALS

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

1.5 QUALITY ASSURANCE

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

B. ASME Compliance:

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

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

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use hand wheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to valve schedule articles for applications of valves.

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

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

D. Valve Actuator Types:
1. Handwheel: For valves other than quarter-turn types.
2. Handlever: For quarter-turn valves NPS 6 and smaller.

E. Valves in Insulated Piping: With valve stem extensions and the following features:

1. Gate Valves: With rising stem.
2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.

F. Valve-End Connections: Match pipe joining method

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

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

2.2 BRONZE BALL VALVES

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

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

a. Beeco.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Hammond Valve.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-110.
b. CWP Rating: 200 psig minimum, match plans for greater pressures.
c. Body Design: Two piece.
d. Body Material: Bronze.
e. Ends: SOLDER
f. Seats: PTFE or TFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel, vented.
i. Port: Full.

2.3 BRONZE LIFT CHECK VALVES

A. Lift Check Valves with Nonmetallic Disc:

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

a. Conbraco Industries, Inc.; Apollo Valves.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Hammond Valve.
d. Milwaukee Valve Company.
e. NIBCO INC.

f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: psig minimum, match plans for greater pressures.
c. Body Design: Vertical flow.
d. Body Material: ASTM B 61 or ASTM B 62, bronze.
e. Ends: SOLDER
f. Disc: NBR, PTFE, or TFE.

2.4 BRONZE SWING CHECK VALVES

A. Bronze Swing Check Valves with Bronze or non-metallic Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co.
b. Hammond Valve.
c. Kitz Corporation.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-80
b. CWP Rating: 200 minimum, match plans for greater pressures.
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

2.5 IRON SWING CHECK VALVES

A. Iron Swing Check Valves with Metal Seats:

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

a. Crane Co
b. Hammond Valve.
c. Kitz Corporation.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-71
b. CWP Rating: 200 psig. minimum, match plans for greater pressures.
c. Body Design: Clear or full waterway.

d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Match pipe system
f. Trim: Bronze.

2.6 IRON, CENTER-GUIDED CHECK VALVES

A. Class 125, Iron, Compact-Wafer, Center-Guided Check Valves with Metal Seat:

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

a. Crane Co
b. Hammond Valve.
c. Kitz Corporation.
d. Milwaukee Valve Company.
e. NIBCO INC.
f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-125.
b. CWP Rating: 200 psig. minimum, match plans for greater pressures.
c. Body Material: ASTM A 126, gray iron.
d. Style: Compact wafer.
e. Seat: Bronze.

2.7 IRON GATE VALVES

A. OS&Y, Iron Gate Valves:

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

a. Beeco.
b. Hammond Valve.
c. Crane Co.
d. Kitz Corporation.
e. Milwaukee Valve Company.
f. NIBCO INC.
g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

a. Standard: MSS SP-70
b. CWP Rating: 200 psig minimum, match plans for greater pressures.
c. Body Material: ASTM A 126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Disc: Solid wedge.
g. Packing and Gasket: Asbestos free.

2.8 BALANCING VALVES

A. Copper-Alloy Calibrated Balancing Valves

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

   a. ITT Industries; Bell & Gossett Div.
   b. NIBCO INC.
   c. Taco, Inc.
   d. Watts Industries, Inc.; Water Products Div.

2. Type: Ball or globe valve with two readout ports and memory setting indicator.
3. Body: bronze.
4. Size: Same as connected piping
5. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

B. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

2.9 DRAIN VALVES

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

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

B. Gate-Valve-Type, Hose-End Drain Valves

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

C. Stop-and-Waste Drain Valves

1. Standard: MSS SP-110 for ball valves or MSS SP-80 for gate valves.
2. Pressure Rating: 200-psig minimum CWP or Class 125.
3. Size: NPS 3/4.
4. Body: Copper alloy or ASTM B 62 bronze.
5. Drain: NPS 1/8 side outlet with cap.

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 balancing valves in locations where they can easily be adjusted.

F. 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.

G. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Center-Guided and Plate-Type Check Valves: In horizontal or vertical position, between flanges.
3. Lift Check Valves: With stem upright and plumb.

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.

B. Set field-adjustable flow set points of balancing valves.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

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

1. Shutoff Service:

    a. NPS 3 and smaller: Ball valve.
    b. NPS 4 and larger: OS&Y gate.
2. Throttling Service: Ball.
3. Sewage and sump basin discharge to have swing check valves with optional lever and weight or lever and spring, for quiet operation.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves with the following end connections:

1. NPS 3 and smaller: Match the piping system joining method.
2. NPS 4 and larger: Flanged.

3.5 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 3 and Smaller: Bronze ball valves

B. Pipe NPS 4 and larger: OS&Y gate valves

3.6 SANITARY-WASTE AND STORM-DRAINAGE VALVE SCHEDULE

A. Pipe NPS 2 and Smaller: Bronze with threaded ends

B. Pipe NPS 3 and larger: Iron with flanged ends.

END OF SECTION

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following hangers and supports for plumbing system piping and equipment:

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

B. Related Sections include the following:

1. Division 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-suppression piping.
3. Division 22 Section "Expansion Fittings and Loops for Plumbing Piping" for pipe guides and anchors.
4. Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment" for vibration isolation devices.

1.3 DEFINITIONS

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

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

C. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.5 SUBMITTALS

A. Product Data: For the following:

1. Steel pipe hangers and supports.
2. Thermal-hanger shield inserts.
3. Powder-actuated fastener systems.
4. Pipe positioning systems.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Available Manufacturers:

1. AAA Technology & Specialties Co., Inc.
2. Anvil
3. Bergen-Power Pipe Supports.
4. B-Line Systems, Inc.; a division of Cooper Industries.
5. Carpenter & Paterson, Inc.
6. Empire Industries, Inc.
7. ERICO/Michigan Hanger Co.
8. Globe Pipe Hanger Products, Inc.
9. Grinnell Corp.
10. GS Metals Corp.
11. National Pipe Hanger Corporation.
12. PHD Manufacturing, Inc.
13. PHS Industries, Inc.
14. Piping Technology & Products, Inc.
15. Tolco Inc.

C. Galvanized, Metallic Coatings: Pre-galvanized or hot dipped.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

E. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.4 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

B. Available Manufacturers:

1. B-Line Systems, Inc.; a division of Cooper Industries.
2. ERICO/Michigan Hanger Co.; ERISTRUT Div.
3. GS Metals Corp.
4. Power-Strut Div.; Tyco International, Ltd.
5. Thomas & Betts Corporation.
6. Tolco Inc.
7. Unistrut Corp.; Tyco International, Ltd.

C. Coatings: Manufacturer's standard finish unless bare metal surfaces are indicated.

D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.5 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Manufacturers:

1. Carpenter & Paterson, Inc.
2. ERICO/Michigan Hanger Co.
3. PHS Industries, Inc.
4. Pipe Shields, Inc.
5. Rilco Manufacturing Company, Inc.
6. Value Engineered Products, Inc.

C. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 552, Type II cellular glass with vapor barrier.

D. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 552, Type II cellular glass.

E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

F. For Clevis Hangers: Insert and shield shall cover lower 180 degrees of pipe.

G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.6 FASTENER SYSTEMS

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

1. Manufacturers:

a. Anvil.
b. B-Line Systems, Inc.; a division of Cooper Industries
c. Empire Industries, Inc.
d. Hilti, Inc.
e. ITW Ramset/Red Head.
f. MKT Fastening, LLC.
g. Powers Fasteners.

2.7 PIPE STAND FABRICATION

A. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

2.8 EQUIPMENT SUPPORTS

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

2.9 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

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

B. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.

C. Use copper hangers for all piping in contact with copper pipe.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use padded hangers for piping that is subject to scratching including glass pipe and painted pipe.

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).
2. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24 (DN 15 to DN 600), if little or no insulation is required.
3. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36 (DN 100 to DN 900), with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
4. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36 (DN 65 to DN 900), if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
5. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30 (DN 25 to DN 750), from 2 rods if longitudinal movement caused by expansion and contraction might occur.
6. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20 (DN 65 to DN 500), from single rod if horizontal movement caused by expansion and contraction might occur.
7. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42 (DN 50 to DN 1050), if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
8. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24 (DN 50 to DN 600), if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
9. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30 (DN 50 to DN 750), if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

G. 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 20 (DN 20 to DN 500).
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500), if longer ends are required for riser clamps.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.

4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb (340 kg).
    b. Medium (MSS Type 32): 1500 lb (680 kg).
    c. Heavy (MSS Type 33): 3000 lb (1360 kg).

10. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

J. 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.

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

L. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

M. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

N. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

3.2 HANGER AND SUPPORT INSTALLATION

A. Steel 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 building structure.

B. 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 above for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Stand Installation:

1. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.
2. Floor supported pipe supports: Manufactured adjustable pipe stanchions bolted to floor and pipes secured with U-bolts.

G. Pipe Positioning System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. Refer to Division 22 Section "Plumbing Fixtures" for plumbing fixtures.

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

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

J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

K. Install roller type hangers and supports on straight piping runs of 100 feet or more.

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

M. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 3 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.

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

O. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.

P. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.

a. Piping Operating below ambient air temperature.
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 according to 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. Insert Material: Length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 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 contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches max.

3.6 PAINTING

A. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections. Section "High-Performance Coatings" or as follows:

1. 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. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

2. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Stencils.
5. Valve tags.
6. Warning tags.

1.3 SUBMITTALS

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

B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-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-fourths 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. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus 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: Yellow.

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-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. 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.

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to full circumference of pipe.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, 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: At least 1-1/2 inches.

2.4 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.

1. Stencil Material: Aluminum.
2. Stencil Paint: Exterior, gloss, alkyd enamel, colors as indicated. Paint may be in pressurized spray-can form.
3. Identification Paint: Exterior, alkyd enamel in colors according to ASME A13.1 2007 unless otherwise indicated.
    a. Exposed waste and vent to be stenciled with yellow letters on cast iron and black letters on galvanized and copper.
    b. Exposed storm piping to be stenciled with white letters on cast iron and black letters on galvanized and copper.

2.5 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass beaded chain.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data.

2.6 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: 4 by 7 inches.
2. Fasteners: Brass grommet and wire Reinforced grommet and wire or string.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 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 Division 09 Section "Interior Painting High-Performance Coatings."

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands or rectangles , complying with ASME A13.1, on each piping system.

1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

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

1. Near each valve and control device.
2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. 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 20 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

D. Pipe Label Color Schedule:

1. Domestic Water Piping:

   a. Background Color: Blue.
   b. Letter Color: White.

2. Sanitary Waste and Storm Drainage Piping:

   a. Background Color: Black .
   b. Letter Color: Yellow.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

a. Cold Water: 2 inches, round.
b. Hot Water: 2 inches, round.

2. Valve-Tag Color:

a. Cold Water: Blue.
b. Hot Water: Red.

3. Letter Color:

a. Cold Water: White.
b. Hot Water: White.

3.5 WARNING-TAG INSTALLATION

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

END OF SECTION

SECTION 220700 – PLUMBING INSULATION

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Insulation Materials:
   a. Cellular glass.
   b. Mineral fiber.
2. Adhesives.
3. Sealants.
4. Factory-applied jackets.
5. Field-applied fabric-reinforcing mesh.
6. Field-applied cloths.
7. Field-applied jackets.
8. Tapes.
9. Securements.
10. Corner angles.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).

B. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail removable insulation at piping specialties, equipment connections, and access panels.
3. Detail application of field-applied jackets.

C. Qualification Data: For qualified Installer.

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

E. Field quality-control reports.

1.4 QUALITY ASSURANCE

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

B. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per 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 and inspecting agency.

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

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application and equipment Installer for equipment insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.

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

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

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

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

F. 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. Products: Subject to compliance with requirements, provide one of the following:

    a. Cell-U-Foam Corporation; Ultra-CUF.
    b. Pittsburgh Corning Corporation; Foamglas Super K.

2. Block Insulation: ASTM C 552, Type I.
3. Special-Shaped Insulation: ASTM C 552, Type III.
4. Board Insulation: ASTM C 552, Type IV.
5. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
6. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C 552, Type II, Class 2.
7. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

G. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. CertainTeed Corp.; Duct Wrap.
    b. Johns Manville; Microlite.
    c. Knauf Insulation; Duct Wrap.
    d. Manson Insulation Inc.; Alley Wrap.
    e. Owens Corning; All-Service Duct Wrap.

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

1. Products: Subject to compliance with requirements, provide one of the following:

    a. CertainTeed Corp.; Commercial Board.
    b. Fibrex Insulations Inc.; FBX.
    c. Johns Manville; 800 Series Spin-Glas.
    d. Knauf Insulation; Insulation Board.
    e. Manson Insulation Inc.; AK Board.
    f. Owens Corning; Fiberglas 700 Series.

I. Mineral-Fiber, Preformed Pipe Insulation:

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Fibrex Insulations Inc.; Coreplus 1200.

b. Johns Manville; Micro-Lok.
c. Knauf Insulation; 1000(Pipe Insulation.
d. Manson Insulation Inc.; Alley-K.
e. Owens Corning; Fiberglas Pipe Insulation.
f.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, without factory-applied jacket with factory-applied ASJ with factory-applied ASJ-SSL. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

J. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Products: Subject to compliance with requirements, provide one of the following:

a. CertainTeed Corp.; CrimpWrap.
b. Johns Manville; MicroFlex.
c. Knauf Insulation; Pipe and Tank Insulation.
d. Manson Insulation Inc.; AK Flex.
e. Owens Corning; Fiberglas Pipe and Tank Insulation.

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, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products, Division of ITW; CP-96.
b. Foster Products Corporation, H. B. Fuller Company; 81-33.

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

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products, Division of ITW; CP-82.
b. Foster Products Corporation, H. B. Fuller Company; 85-20.
c. ITW TACC, Division of Illinois Tool Works; S-90/80.
d. Marathon Industries, Inc.; 225.
e. Mon-Eco Industries, Inc.; 22-25.

2.3 SEALANTS

A. Joint Sealants:

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

    a. Childers Products, Division of ITW; CP-76.
    b. Foster Products Corporation, H. B. Fuller Company; 30-45.
    c. Marathon Industries, Inc.; 405.
    d. Mon-Eco Industries, Inc.; 44-05.
    e. Pittsburgh Corning Corporation; Pittseal 444.
    f. Vimasco Corporation; 750.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F.
5. Color: White or gray.

2.4 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. 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 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

    a. Products: Subject to compliance with requirements, provide one of the following:

        1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

2.5 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. with a thread count of 10 strands by 10 strands/sq. inch for covering pipe and pipe fittings.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. Vimasco Corporation; Elastafab 894.

2.6 FIELD-APPLIED CLOTHS

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

1. Products: Subject to compliance with requirements, provide one of the following:

a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.7 FIELD-APPLIED JACKETS

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

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Johns Manville; Zeston.
b. P.I.C. Plastics, Inc.; FG Series.
c. Proto PVC Corporation; LoSmoke.
d. Speedline Corporation; SmokeSafe.

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: Color as selected by Architect.
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

5. Factory-fabricated tank heads and tank side panels.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
b. Compac Corp.; 104 and 105.
c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

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

1. Products: Subject to compliance with requirements, provide one of the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.

b. Compac Corp.; 110 and 111.
c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.

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

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.

1. Products: Subject to compliance with requirements, provide one of the following:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
b. Compac Corp.; 130.
c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
d. Venture Tape; 1506 CW NS.

2. Width: 2 inches.
3. Thickness: 6 mils.
4. Adhesion: 64 ounces force/inch in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch in width.

2.9 SECUREMENTS

A. Bands:

1. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Products; Bands.
b. PABCO Metals Corporation; Bands.
c. RPR Products, Inc.; Bands.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316; 0.015 inch thick, 3/4 inch wide with wing or closed seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated.

a. Products: Subject to compliance with requirements, provide one of the following:

1) AGM Industries, Inc.; CWP-1.
2) GEMCO; CD.
3) Midwest Fasteners, Inc.; CD.

4) Nelson Stud Welding; TPA, TPC, and TPS.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.

   a. Products: Subject to compliance with requirements, provide one of the following:

      1) AGM Industries, Inc.; CWP-1.
      2) GEMCO; Cupped Head Weld Pin.
      3) Midwest Fasteners, Inc.; Cupped Head.
      4) Nelson Stud Welding; CHP.
      5)

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

   a. Products: Subject to compliance with requirements, provide one of the following:

      1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series T.
      2) GEMCO; Perforated Base.
      3) Midwest Fasteners, Inc.; Spindle.

   b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
   c. Spindle: Copper- or zinc-coated, low carbon steel Aluminum Stainless steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:

   a. Products: Subject to compliance with requirements, provide one of the following:

      1) GEMCO; Nylon Hangers.
      2) Midwest Fasteners, Inc.; Nylon Insulation Hangers.

   b. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
   c. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

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

   a. Products: Subject to compliance with requirements, provide one of the following:

      1) AGM Industries, Inc.; Tactoo Insul-Hangers, Series TSA.

2) GEMCO; Press and Peel.
3) Midwest Fasteners, Inc.; Self Stick.

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
c. Adhesive-backed base with a peel-off protective cover.
d.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

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

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

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

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

3.3 GENERAL INSTALLATION REQUIREMENTS

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

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and 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 as recommended by insulation material manufacturer 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.

3.4 PENETRATIONS

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

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on

each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 CELLULAR-GLASS INSULATION INSTALLATION

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 but 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.

3.7 MINERAL-FIBER INSULATION INSTALLATION

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 but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.8 FIELD-APPLIED JACKET INSTALLATION

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

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

B. Where 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.

C. 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.

D. 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.

E. 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.

3.9 FINISHES

A. Equipment and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.

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.

3.10 FIELD QUALITY CONTROL

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

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect 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.
2. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

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

3.11 PIPING INSULATION SCHEDULE, GENERAL

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

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.12 INDOOR PIPING INSULATION SCHEDULE

A. Domestic Cold Water:

1. NPS 1 Insert pipe size and Smaller: Insulation shall be one of the following:

a. Cellular Glass: 1/2 inches thick.
b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1/2 inch 1 inch Insert thickness thick.

2. NPS 1-1/4 Insert pipe size and Larger: Insulation shall be one of the following:

a. Cellular Glass: 1 inches thick.

b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

B. Domestic Hot and Recirculated Hot Water:

1. NPS 1-1/4 Insert pipe size and Smaller: Insulation shall be one of the following:

a. Cellular Glass: 1 inches thick.
b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

2. NPS 1-1/2 Insert pipe size and Larger: Insulation shall be one of the following:

a. Cellular Glass: 1 inches thick.
b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

C. Stormwater and Overflow:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 1 inches thick.
b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch Insert thickness thick.

D. Roof Drain and Overflow Drain Bodies:

1. All Pipe Sizes: Insulation shall be one of the following:

a. Cellular Glass: 1 inches Insert thickness thick.
b. Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch Insert thickness thick.

3.13 INDOOR, FIELD-APPLIED JACKET

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.

END OF SECTION

SECTION 220800 - COMMISSIONING OF PLUMBING SYSTEMS

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Work Includes:

1. General Contractor shall coordinate Work of employees and each relevant subcontractor to facilitate the complete commissioning of Plumbing Systems, as organized and guided by the owner-hired Commissioning Provider.
2. Subject to the specific contractor participation roles outlined herein and in Section 01 91 13, *General Commissioning Requirements*, General contractor shall provide all labor, materials, equipment, and services necessary or incidental to the completion of Work in this section.

a. Section Includes:
   1) Commissioning process requirements for plumbing systems, assemblies, and equipment.
   2) Requirements for documentation, testing, and training of plumbing systems.

B. Related Work: The following items are not included in this Section and are specified under the designated Sections:

1. Division 22 Sections.
2. Division 23 Sections related to Testing, Adjusting, and Balancing (TAB).

1.3 ACTION SUBMITTALS

A. Submit procedural documentation and formal test reports associated with the Work described in this section, for all testing contracted by the General Contractor or any of its subcontractors.

1.4 COMMISSIONING

A. This section governs the commissioning of Plumbing Systems.

B. The following systems and equipment shall be commissioned:

1. Domestic Water Heating Equipment.
2. Domestic Water Pumps.
3. Drainage, Sump, and Ejector Pumps.

PART 2 - PRODUCTS: NOT USED

PART 3 - EXECUTION:

3.1 Provide training of the Owner's operation and maintenance personnel. Coordinate scheduling with the Commissioning Provider.

3.2 Work with the Commissioning Provider always, and in cooperation with other members of the Commissioning Team, to ensure compliance and completion of the commissioningprocess.

END OF SECTION

SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
2. Encasement for piping.
3. Flexible connectors.

B. Related Section:

1. Division 22 Section "Facility Water Distribution Piping" for water-service piping outside the building from source to the point where water-service piping enters the building.

2. Division 22 Section “Common Work Results for Plumbing”.

1.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Domestic water piping and support and installation shall withstand effects of earthquake motions determined according to SEI/ASCE 7.

1.4 SUBMITTALS

A. Product Data: For the following products:

1. Transition fittings.
2. Dielectric fittings.
3. Flexible connectors.

B. Water Samples: Specified in "Cleaning" Article.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

B. Comply with NSF 61 for potable domestic water piping and components.

1.6 PROJECT CONDITIONS

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

1. Notify Architect and Construction Manager Owner no fewer than five days in advance of proposed interruption of water service.
2. Do not proceed with interruption of water service without Architect's and Construction Manager's written permission.

1.7 COORDINATION

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

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM 88, Type K and ASTM B 88, Type L water tube, drawn temper.

1. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.

2. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.

3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.

4. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

5. Copper Pressure-Seal-Joint Fittings:

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

1) Elkhart Products Corporation; Industrial Division.
2) NIBCO INC.
3) Viega; Plumbing and Heating Systems.

b. NPS 2 and Smaller: Wrought-copper fitting with EPDM-rubber O-ring seal in each end.
c. NPS 2-1/2 to NPS 4: Cast-bronze or wrought-copper fitting with EPDM-rubber O-ring seal in each end.

2.3 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105.

B. Form: Tube.

C. Material: LLDPE film of 0.008-inch minimum thickness.

D. Color: Black or Natural color.

2.4 TRANSITION FITTINGS

A. General Requirements:

1. Same size as pipes to be joined.
2. Pressure rating at least equal to pipes to be joined.
3. End connections compatible with pipes to be joined.

B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.

C. Sleeve-Type Transition Coupling: AWWA C219.

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

a. Cascade Waterworks Manufacturing.
b. Dresser, Inc.; Dresser Piping Specialties.
c. Ford Meter Box Company, Inc. (The).
d. JCM Industries.
e. Romac Industries, Inc.
f. Smith-Blair, Inc; a Sensus company.
g. Viking Johnson; c/o Mueller Co.

2.5 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:

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

a. Capitol Manufacturing Company.
b. Central Plastics Company.
c. EPCO Sales, Inc.
d. Hart Industries International, Inc.
e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
f. Zurn Plumbing Products Group; Wilkins Water Control Products.

2. Description:

a. Pressure Rating: 150 psig at 180 deg F.
b. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

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

    a. Capitol Manufacturing Company.
    b. Central Plastics Company.
    c. EPCO Sales, Inc.
    d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

    a. Factory-fabricated, bolted, companion-flange assembly.

    b. Pressure Rating: 150 psig 175 psig minimum 300 psig.
    c. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Kits:

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

    a. Advance Products & Systems, Inc.
    b. Calpico, Inc.
    c. Central Plastics Company.
    d. Pipeline Seal and Insulator, Inc.

2. Description:

    a. Nonconducting materials for field assembly of companion flanges.
    b. Pressure Rating: 150 psig Insert pressure.
    c. Gasket: Neoprene or phenolic.
    d. Bolt Sleeves: Phenolic or polyethylene.
    e. Washers: Phenolic with steel backing washers.

E. Dielectric Couplings:

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

    a. Calpico, Inc.
    b. Lochinvar Corporation.

2. Description:

    a. Galvanized-steel coupling.
    b. Pressure Rating: 300 psig at 225 deg F.
    c. End Connections: Female threaded.
    d. Lining: Inert and noncorrosive, thermoplastic.

F. Dielectric Nipples:

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

    a. Perfection Corporation; a subsidiary of American Meter Company.
    b. Precision Plumbing Products, Inc.
    c. Victaulic Company.

2. Description:

    a. Electroplated steel nipple complying with ASTM F 1545.
    b. Pressure Rating: 300 psig at 225 deg F.
    c. End Connections: Male threaded or grooved.
    d. Lining: Inert and noncorrosive, propylene.

2.6 SLEEVES

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

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

C. 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 setscrews.

2.7 SLEEVE SEALS

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

1. Advance Products & Systems, Inc.
2. Calpico, Inc.
3. Metraflex, Inc.
4. Pipeline Seal and Insulator, Inc.

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

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

2.8 WALL PENETRATION SYSTEMS

A. Available: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following or equal:

1. SIGMA.

B. Description: Wall-sleeve assembly, consisting of housing and gland, gaskets, and pipe sleeve.

1. Carrier-Pipe Deflection: Up to 5 percent without leakage.
2. Housing: Ductile-iron casting with hub, waterstop, anchor ring, and locking devices. Include gland, bolts, and nuts.
3. Housing-to-Sleeve Gasket: EPDM rubber.
4. Housing-to-Carrier-Pipe Gasket: AWWA C111, EPDM rubber.
5. Pipe Sleeve: AWWA C151, ductile-iron pipe or ASTM A 53/A 53M, Schedule 40, zinc-coated steel pipe.

PART 3 - EXECUTION

3.1 EARTHWORK

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

3.2 PIPING INSTALLATION

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

B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."

C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.

D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages and Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.

E. Install shutoff valve immediately upstream of each dielectric fitting.

F. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for pressure-reducing valves.

G. Install domestic water piping level without pitch and plumb.

H. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

I. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

J. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

K. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.

L. Install piping adjacent to equipment and specialties to allow service and maintenance.

M. Install piping to permit valve servicing.

N. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.

O. Install piping free of sags and bends.

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

Q. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.

R. Install pressure gages on suction and discharge piping from each plumbing pump and packaged booster pump. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages.

S. Install thermostats in hot-water circulation piping. Comply with requirements in Division 22 Section "Domestic Water Pumps" for thermostats.

3.3 JOINT CONSTRUCTION

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

B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, and fittings before assembly.

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

1. Apply appropriate tape or thread compound to external pipe threads.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.

D. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints" Chapter.

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

F. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.

G. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.4 TRANSITION FITTING INSTALLATION

A. Install transition couplings at joints of dissimilar piping.

B. Transition Fittings in Underground Domestic Water Piping:

1. NPS 1-1/2 and Smaller: Fitting-type coupling.
2. NPS 2 and Larger: Sleeve-type coupling.

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

3.5 DIELECTRIC FITTING INSTALLATION

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

B. Dielectric Fittings for NPS 2 Insert pipe size and Smaller: Use dielectric couplings or nipples unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges flange kits nipples.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment and machines to allow service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve; extend and connect to the following:

1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
3. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Comply with requirements in Division 22 plumbing fixture Sections for connection sizes.
4. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.7 SLEEVE INSTALLATION

A. General Requirements: Install sleeves for pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.

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

C. Permanent sleeves are not required for holes formed by removable PE sleeves.

D. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.

E. Install sleeves in new partitions, slabs, and walls as they are built.

F. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.

G. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.

H. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals wall penetration systems specified in this Section.

I. Seal space outside of sleeves in concrete slabs and walls with grout.

J. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

K. Install sleeve materials according to the following applications:

1. Sleeves for Piping Passing through Concrete Floor Slabs: Steel pipe.
2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Steel pipe.

    a. Extend sleeves 2 inches above finished floor level.
    b. For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

3. Sleeves for Piping Passing through Gypsum-Board Partitions:

    a. Steel pipe sleeves for pipes smaller than NPS 6.
    b. Galvanized-steel sheet sleeves for pipes NPS 6 and larger.
    c. Exception: Sleeves are not required for water supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.

4. Sleeves for Piping Passing through Concrete Roof Slabs: Steel pipe.
5. Sleeves for Piping Passing through Exterior Concrete Walls:

    a. Steel pipe sleeves for pipes smaller than NPS 6.
    b. Cast-iron wall pipe sleeves for pipes NPS 6 and larger.
    c. Install sleeves that are large enough to provide 1-inch annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.
    d. Do not use sleeves when wall penetration systems are used.

6. Sleeves for Piping Passing through Interior Concrete Walls:

    a. Steel pipe sleeves for pipes smaller than NPS 6.
    b. Galvanized-steel sheet sleeves for pipes NPS 6 and larger.

L. 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 in Division 07 Section "Penetration Firestopping" for firestop materials and installations.

3.8 SLEEVE SEAL INSTALLATION

A. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.

B. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.9 WALL PENETRATION SYSTEM INSTALLATION

A. Install wall penetration systems in new, exterior concrete walls.

B. Assemble wall penetration system components with sleeve pipe. Install so that end of sleeve pipe and face of housing are flush with wall. Adjust locking devices to secure sleeve pipe in housing.

3.10 IDENTIFICATION

A. Identify system components. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.

B. Label pressure piping with system operating pressure.

3.11 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Piping Inspections:

1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
2. During installation, notify authorities having jurisdiction at least one day before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

    a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
    b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

3. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

C. Piping Tests:

1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.

2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit a separate report for each test, complete with diagram of portion of piping tested.
3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
6. Prepare reports for tests and for corrective action required.

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

E. Prepare test and inspection reports.

3.12 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.

    a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
    b. Adjust calibrated balancing valves to flows indicated.

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

3.13 CLEANING

A. Clean and disinfect potable and non-potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures described in either AWWA C651 or AWWA C652 or follow procedures described below:

    a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
    b. Fill and isolate system according to either of the following:

        1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.

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

c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

B. Clean non-potable domestic water piping as follows:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Use purging procedures prescribed by authorities having jurisdiction or; if methods are not prescribed, follow procedures described below:

a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
b. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

C. Prepare and submit reports of purging and disinfecting activities.

D. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

3.14 PIPING SCHEDULE

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.

B. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

C. Under-building-slab, domestic water, building service piping shall be the following:

1. Soft copper tube, ASTM B 88, Type K; coper solder-joint fittings; and brazed copper pressure-seal fittings joints.

D. Aboveground domestic water piping shall be the following:

1. Hard copper tube, ASTM B 88, Type L cast- copper solder-joint fittings; and soldered joints.

2. Hard copper tube, ASTM B 88, Type L; copper pressure-seal-joint fittings; and pressure-sealed joints.

END OF SECTION

SECTION 221119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following domestic water piping specialties:

1. Vacuum breakers.
2. Backflow preventers.
3. Strainers.
4. Outlet boxes.
5. Hose bibbs.
6. Wall hydrants.
7. Water hammer arresters.

B. Related Sections include the following:

1. Division 22 Section "Meters and Gages For Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
2. Division 22 Section "Domestic Water Piping" for water meters.
3. Division 22 Section "Domestic Water Filtration Equipment" for water filters in domestic water piping.
4. Division 22 Section "Healthcare Plumbing Fixtures" for thermostatic mixing valves for sitz baths, thermostatic mixing-valve assemblies for hydrotherapy equipment, and outlet boxes for dialysis equipment.
5. Division 22 Section "Emergency Plumbing Fixtures" for water tempering equipment.
6. Division 22 Section "Drinking Fountains and Water Coolers" for water filters for water coolers.

1.3 PERFORMANCE REQUIREMENTS

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

1.4 SUBMITTALS

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

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field quality-control test reports.

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

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. NSF Compliance:

1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.1 VACUUM BREAKERS

A. Hose-Connection Vacuum Breakers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   b. MIFAB, Inc.
   c. Watts Industries, Inc.; Water Products Div.
   d. Woodford Manufacturing Company.
   e. Zurn Plumbing Products Group; Light Commercial Operation.

2. Standard: ASSE 1011.

2.2 BACKFLOW PREVENTERS

A. Intermediate Atmospheric-Vent Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Conbraco Industries, Inc.
   b. FEBCO; SPX Valves & Controls.
   c. Honeywell Water Controls.
   d. Watts Industries, Inc.; Water Products Div.
   e. Zurn Plumbing Products Group; Wilkins Div.

2. Standard: ASSE 1012.

B. Reduced-Pressure-Principle Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Watts Industries, Inc.; Water Products Div.
   b. Zurn Plumbing Products Group; Wilkins Div.

2. Standard: ASSE 1013.

C. Double-Check Backflow-Prevention Assemblies:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Watts Industries, Inc.; Water Products Div.
   b. Zurn Plumbing Products Group; Wilkins Div.

2. Standard: ASSE 1015.

D. Dual-Check-Valve Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Watts Industries, Inc.; Water Products Div.
   b. Zurn Plumbing Products Group; Wilkins Div.

2. Standard: ASSE 1024.

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Watts Industries, Inc.; Water Products Div.

2. Standard: ASSE 1032.

F. Double-Check, Detector-Assembly Backflow Preventers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Watts Industries, Inc.; Water Products Div.
   b. Zurn Plumbing Products Group; Wilkins Div.

2. Standard: ASSE 1048 and FMG approved or UL listed.

2.3 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum, unless otherwise indicated.

2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller;flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations, unless otherwise indicated.

2.4 OUTLET BOXES

A. Clothes Washer Outlet Boxes:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Guy Gray Manufacturing Co., Inc.
   b. Zurn Plumbing Products Group; Light Commercial Operation.

2.5 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:

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

   a. Woodford Manufacturing Company.
   b. Zurn Plumbing Products Group

2.6 Standard: ASME A112.21.3M WATER HAMMER ARRESTERS

A. Water Hammer Arresters:

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

   a. AMTROL, Inc.
   b. PPP Inc.
   c. Sioux Chief Manufacturing Company, Inc.
   d. Watts Drainage Products Inc.

2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Metal bellows or rubber diaphram.
4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.
2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.
3. Do not install bypass piping around backflow preventers.

C. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.

D. Install outlet boxes recessed in wall. Install 2-by-4-inch fire-retardant-treated-wood blocking wall reinforcement between studs. Fire-retardant-treated-wood blocking is specified in Division 06 Section "Rough Carpentry."

E. Install water hammer arresters in water piping according to PDI-WH 201.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 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."

3.3 FIELD QUALITY CONTROL

A. Perform the following tests and prepare test reports:

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

B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.4 ADJUSTING

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

B. Set field-adjustable temperature set points of temperature-actuated water mixing valves.

END OF SECTION

SECTION 221316.02 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following for soil, waste, and vent piping inside the building:

1. Pipe, tube, and fittings.
2. Special pipe fittings.
3. Encasement for underground metal piping.

B. Related Sections include the following:

1. Division 22 Section "Sanitary Sewerage Pumps."
2. Division 22 Section "Chemical Waste-Systems for Laboratory and Healthcare Facilities" for chemical-waste and vent piping systems.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

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

C. LLDPE: Linear, low-density polyethylene plastic.

D. NBR: Acrylonitrile-butadiene rubber.

E. PE: Polyethylene plastic.

F. PVC: Polyvinyl chloride plastic.

G. TPE: Thermoplastic elastomer.

1.4 PERFORMANCE REQUIREMENTS

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

1. Soil, Waste, and Vent Piping: 10-foot head of water.
2. Sanitary Sewer, Force-Main Piping: 50 psig.

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall be capable of withstanding the effects of seismic events determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures." Insert applicable code requirement.

1.5 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

1.6 QUALITY ASSURANCE

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

B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping; "NSF-drain" for plastic drain piping; "NSF-tubular" for plastic continuous waste piping; and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

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

A. Pipe and Fittings: ASTM A 74, Service class(es).

B. Caulk: Lead & Oakum

C. Gaskets: ASTM C 564, rubber.

2.4 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Sovent Stack Fittings: ASME B16.45 or ASSE 1043, hubless, cast-iron aerator and deaerator drainage fittings.

C. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.

1. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.

a. Manufacturers:

1) ANACO.
2) Clamp-All Corp.
3) Mission Rubber Co.
4) Tyler Pipe; Soil Pipe Div.

2.5 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade A or B, Standard Weight or Schedule 40, galvanized. Include ends matching joining method.

B. Drainage Fittings: ASME B16.12, galvanized, threaded, cast-iron drainage pattern.

C. Pressure Fittings:

1. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
2. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
3. Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, galvanized, standard pattern.
4. Cast-Iron Flanges: ASME B16.1, Class 125.
5. Cast-Iron, Flanged Fittings: ASME B16.1, Class 125, galvanized.

2.6 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end, unless grooved or flanged ends are indicated.

1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Flanges: ASME 16.1, Class 125, cast iron.

2.7 SPECIAL PIPE FITTINGS

A. Expansion Joints: Two or three-piece, ductile-iron assembly consisting of telescoping sleeve(s) with gaskets and restrained-type, ductile-iron, bell-and-spigot end sections complying with AWWA C110 or

AWWA C153. Select and assemble components for expansion indicated. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.

1. Manufacturers:

    a. EBAA Iron Sales, Inc.
    b. Romac Industries, Inc.
    c. Star Pipe Products; Star Fittings Div.

B. Wall-Penetration Fittings: Compound, ductile-iron coupling fitting with sleeve and flexing sections for up to 20-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.

1. Manufacturers:

    a. SIGMA Corp.

2.8 ENCASEMENT FOR UNDERGROUND METAL PIPING

A. Description: ASTM A 674 or AWWA C105, high-density, crosslaminated PE film of 0.004-inch or LLDPE film of 0.008-inch minimum thickness.

B. Form: Sheet or tube.

C. Color: Black or natural.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground, soil, waste, and vent piping NPS 3 and smaller Insert pipe size range shall be any of the following:
1. Hubless cast-iron soil pipe and fittings heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.
2. Type M Copper Tube, copper drainage fittings, and soldered joints.
3. Dissimilar Pipe-Material Couplings: Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

C. Aboveground, soil, waste and vent piping NPS 4 and larger Insert pipe size range shall be any of the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.

2. Hubless cast-iron soil pipe and fittings and heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.

D. Underground, soil, waste, and vent piping of all sizes shall be any of the following:

1. Service class, cast-iron soil piping; calking materials; and calked joints.

3.3 PIPING INSTALLATION

A. Sanitary sewer piping outside the building is specified in Division 22 Section "Facility Sanitary Sewers."

B. Basic piping installation requirements are specified in Division 22 Section "Common Work Results for Plumbing."

C. Install seismic restraints on piping. Seismic-restraint devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

D. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.

E. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.

F. Install underground, steel, force-main piping. Install encasement on piping according to ASTM A 674 or AWWA C105.

G. Install underground, ductile-iron, force-main piping according to AWWA C600. Install buried piping inside the building between wall and floor penetrations and connection to sanitary sewer piping outside the building with restrained joints. Anchor pipe to wall or floor. Install thrust-block supports at vertical and horizontal offsets.

1. Install encasement on piping according to ASTM A 674 or AWWA C105.

H. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."

1. Install encasement on piping according to ASTM A 674 or AWWA C105.

I. Install underground, ductile-iron, special pipe fittings according to AWWA C600.

1. Install encasement on piping according to ASTM A 674 or AWWA C105.

J. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing."

K. Install wall-penetration fitting at each service pipe penetration through foundation wall. Make installation watertight.

L. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.

M. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

N. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

O. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:

1. Sanitary, Waste and Vent: 2 percent downward in direction of flow for piping NPS 3 and smaller; 1 percent downward in direction of flow for piping NPS 4 and larger.

P. Install engineered soil and waste drainage and vent piping systems as follows:

1. Combination Waste and Vent: Comply with standards of authorities having jurisdiction.
2. Sovent Drainage System: Comply with ASSE 1043 and sovent fitting manufacturer's written installation instructions.
3. Reduced-Size Venting: Comply with standards of authorities having jurisdiction.

Q. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

R. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.4 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 22 Section "Common Work Results for Plumbing."

B. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

C. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

D. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.5 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment."

B. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Install individual, straight, horizontal piping runs according to the following:

    a. 100 Feet and Less: MSS Type 1, adjustable, steel clevis hangers.
    b. Longer Than 100 Feet: MSS Type 43, adjustable roller hangers.
    c. Longer Than 100 Feet, if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."

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

E. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2: 60 inches with 3/8-inch rod.
2. NPS 3: 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5: 60 inches with 5/8-inch rod.
4. NPS 6: 60 inches with 3/4-inch rod.
5. NPS 8 to NPS 12: 60 inches with 7/8-inch rod.

G. Install supports for vertical cast-iron soil piping every 15 feet.

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

1. NPS 1-1/4: 72 inches with 3/8-inch rod.
2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
3. NPS 2-1/2: 108 inches with 1/2-inch rod.
4. NPS 3 to NPS 5: 10 feet with 1/2-inch rod.
5. NPS 6: 10 feet with 5/8-inch rod.
6. NPS 8: 10 feet with 3/4-inch rod.

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

J. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.6 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 and larger.

D. Connect force-main piping to the following:

1. Sanitary Sewer: To exterior force main or sanitary manhole.
2. Sewage Pumps: To sewage pump discharge.

3.7 FIELD QUALITY CONTROL

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

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this

pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.8 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION

SECTION 221319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following sanitary drainage piping specialties:
   1. Cleanouts.
   2. Floor drains.
   3. Through-penetration firestop assemblies.
   4. Miscellaneous sanitary drainage piping specialties.
   5. Flashing materials.

B. Related Sections include the following:

   1. Division 22 Section "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.
   2. Division 22 Section "Plumbing Fixtures" for hair interceptors.
   3. Division 22 Section "Healthcare Plumbing Fixtures" for plaster sink interceptors.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. FOG: Fats, oils, and greases.

C. FRP: Fiberglass-reinforced plastic.

D. HDPE: High-density polyethylene plastic.

E. PE: Polyethylene plastic.

F. PP: Polypropylene plastic.

G. PVC: Polyvinyl chloride plastic.

1.4 SUBMITTALS

A. Product Data: For each type of product indicatedShop Drawings: Show fabrication and installation details for frost-resistant vent terminals.

   1. Wiring Diagrams: Power, signal, and control wiring.

B. Manufacturer Seismic Qualification Certification: Submit certification that grease interceptors, accessories, and components will withstand seismic forces defined in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control test reports.

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

1.5 QUALITY ASSURANCE

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

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic sanitary piping specialty components.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

B. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. In-line Metal Cleanouts:

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

a. MIFAB, Inc.

b. Watts Drainage Products Inc.
c. Zurn Plumbing Products Group.

2. Standard: ASME A112.36.2M.
3. Size: Same as connected drainage piping
4. Body Material: as required to match connected piping.

B. Metal Floor Cleanouts:

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

a. Watts Drainage Products Inc.
b. Mifab
c. Zurn Plumbing Products Group.

2. Standard: ASME A112.36.2M.
3. Size: Same as connected branch.

2.2 FLOOR DRAINS

A. Cast-Iron Floor Drains:

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

a. MIFAB, Inc.
b. Watts Drainage Products Inc.
c. Zurn Plumbing Products Group.

2. Standard: ASME A112.6.3.

2.3 THROUGH-PENETRATION FIRESTOP ASSEMBLIES

A. Through-Penetration Firestop Assemblies:

1. Manufacturers: Subject to compliance with requirements, manufactures offering products that may be incorporated into the work include the following criteria:
2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
3. Size: Same as connected soil, waste, or vent stack.
4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.

2.4 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:

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

2. Size: Same as connected waste piping, minimum 4”.

B. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

C. Sleeve Flashing Device:

1. Description: Manufactured, cast-iron fitting, with clamping device, that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized-steel pipe extension in top of fitting that will extend 2 inches above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

D. Stack Flashing Fittings:

1. Description: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.

E. Vent Caps:

1. Description: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and setscrews to secure to vent pipe.
2. Size: Same as connected stack vent or vent stack.

F. Frost-Resistant Vent Terminals:

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

G. Expansion Joints:

1. Standard: ASME A112.21.2M.
2. Body: Cast iron with bronze sleeve, packing, and gland.
3. End Connections: Matching connected piping.
4. Size: Same as connected soil, waste, or vent piping.

2.5 FLASHING MATERIALS

A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:

1. General Use: 4.0-lb/sq. ft., 0.0625-inch thickness.
2. Vent Pipe Flashing: 3.0-lb/sq. ft., 0.0469-inch thickness.
3. Burning: 6-lb/sq. ft., 0.0938-inch thickness.

B. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:

1. General Applications: 12 oz./sq. ft..
2. Vent Pipe Flashing: 8 oz./sq. ft..

C. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness, unless otherwise indicated. Include G90 hot-dip galvanized, mill-phosphatized finish for painting if indicated.

D. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.

E. Fasteners: Metal compatible with material and substrate being fastened.

F. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

G. Solder: ASTM B 32, lead-free alloy.

H. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

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

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

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

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

E. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

1. Position floor drains for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:

a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.

c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.

3. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

F. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.

G. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.

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

I. Assemble open drain fittings and install with top of hub 2 inches above floor.

J. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

K. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.

L. Install vent caps on each vent pipe passing through roof.

M. Install frost-resistant vent terminals on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.

N. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.

O. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.

P. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

Q. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
2. Copper Sheets: Solder joints of copper sheets.

D. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.

E. Set flashing on floors and roofs in solid coating of bituminous cement.

F. Secure flashing into sleeve and specialty clamping ring or device.

G. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 07 Section "Sheet Metal Flashing and Trim."

H. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

I. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.3 LABELING AND IDENTIFYING

A. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Division 22 Section "Identification for Plumbing Piping and Equipment."

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

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

3.5 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION

SECTION 221323 - SANITARY WASTE INTERCEPTORS

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 types of interceptors outside the building:

1. Grease interceptors.

1.3 DEFINITIONS

A. FRP: Fiberglass-reinforced plastic.

B. HDPE: High-density polyethylene plastic.

C. PE: Polyethylene plastic.

D. PP: Polypropylene plastic.

1.4 SUBMITTALS

A. Product Data: For each type of metal interceptor indicated. Include materials of fabrication, dimensions, rated capacities, retention capacities, operating characteristics, size and location of each pipe connection, furnished specialties, and accessories.

B. Coordination Drawings: Interceptors, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Interceptors.
2. Piping connections. Include size, location, and elevation of each.
3. Interface with underground structures and utility services.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 GREASE INTERCEPTORS

A. Grease Interceptor Capacity and Characteristics: See schedule on drawings for basis of design grease interceptor.

PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.2 INSTALLATION

A. Install interceptor inlets and outlets at elevations indicated.

B. Install interceptors according to ASTM C 891. Set level and plumb.

C. Install manhole risers from top of underground interceptors to manholes and gratings at finished grade.

D. Set tops of manhole frames and covers flush with finished surface in pavements. Set tops 3 inches above finish surface elsewhere, unless otherwise indicated.

E. Set tops of grating frames and grates flush with finished surface.

F. Clean and prepare metal surfaces to be field painted according to SSPC- PA 1. Paint the following metal surfaces according to SSPC-PA 1 and SSPC-Paint 16:

1. Metal Interceptors: All surfaces except baskets, screens, and strainers.
2. Plastic Interceptors: All metal surfaces except baskets, screens, and strainers.

G. Repair and restore protective coatings to original condition.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Make piping connections between interceptors and piping systems.

3.4 IDENTIFICATION

A. Identification materials and installation are specified in Division 31 Section "Earth Moving." Arrange for installation of green warning tapes directly over piping and at outside edges of underground interceptors.

1. Use warning tapes or detectable warning tape over ferrous piping.

2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

END OF SECTION

SECTION 221329 - SANITARY SEWERAGE PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following sewage pumps and accessories for sanitary drainage piping systems in buildings:
1. Submersible sewage pumps.
2. Sewage pump reverse-flow assemblies.
3. Sewage pump basins and pits.

B. Related Sections include the following:
1. Division 22 Section "Sump Pumps" for applications in storm-drainage systems.

1.3 SUBMITTALS

A. Product Data: For each type and size of sewage pump specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For each sewage pump to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of sewage pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

1.6 COORDINATION

A. Coordinate size and location of concrete bases and pits. Concrete, reinforcement, and formwork requirements are specified in Division 03 .

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to 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, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 WET-PIT-MOUNTED, VERTICAL SEWAGE PUMPS

A. Manufacturers:
1. Chicago Pump Company; a division of Yeomans Chicago Corporation.
2. Federal Pump Corp.
3. Paco Pumps, Inc.
4. Sterling Peerless; Sterling Fluid Systems Group.
5. Swaby Manufacturing Co.
6. Tramco Pump Company.
7. Weil Pump Company, Inc.
8. Weinman Div.; Crane Pumps & Systems.

B. Description: Factory-assembled and -tested, single-stage, centrifugal, end-suction sewage pumps complying with UL 778. Vertical, separately coupled, suspended pumps complying with HI 1.1-1.2 and HI 1.3 for wet-pit-volute sewage pumps and with reverse-flow assembly.

1. Pump Arrangement: Duplex.
2. Casing: Cast iron, with open inlet and threaded connection for NPS 2 and smaller and flanged connection for NPS 2-1/2 and larger discharge piping.
3. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, open or semiopen, nonclog design for solids handling; overhung, single suction, and keyed and secured to shaft.
4. Pump Shaft and Sleeve Bearings: Stainless-steel shaft with bronze sleeve bearings. Include oil-lubricated, intermediate sleeve bearings at 48-inch maximum intervals if basin depth is more than 48 inches, and grease-lubricated, ball-type thrust bearings.
5. Pump and Motor Shaft Coupling: Flexible, capable of absorbing torsional vibration and shaft misalignment.

C. Pump Discharge Piping: Manufacturer's standard galvanized-steel or bronze pipe.

D. Basin Cover: Cast iron or coated steel and strong enough to support pumps, motors, and controls. See Part 2 "Sewage Pump Basins" Article for requirements.

E. Cover Shaft Seal: Stuffing box, with graphite-impregnated braided-yarn rings and bronze packing gland.

F. Motor: Single-speed; grease-lubricated ball bearings. Comply with requirements in Division 22 Section "Common Motor Requirements for Plumbing Equipment."

1. Mounting: On vertical, cast-iron pedestal.

G. Controls: NEMA 250, Type 1 enclosure, pedestal-mounted float switches; with floats, float rods, and rod buttons. Include automatic alternator to alternate operation of pump units on successive cycles and to operate multiple units if one pump cannot handle load.

1. Float Guide: Pipe or other restraint for floats and rods in basins of depth greater than 60 inches .
2. High-Water Alarm: Cover-mounted, micropressure-switch alarm, with electric bell; 120-V ac, with transformer and contacts for remote alarm bell.

H. Capacities and Characteristics:

1. System Capacity: Refer to plans and Pump Schedules.
2. Number of Pumps: Refer to plans and Pump Schedules.
3. Each Pump:

a. Refer to plans and Pump Schedules. Refer to plans and Pump Schedules.

4. Alternator Control Required: Yes.

2.3 SUBMERSIBLE SEWAGE PUMPS

A. Submersible, Fixed-Position Effluent Pumps: Factory-assembled and -tested, duplex single-stage, centrifugal, end-suction, submersible, direct-connected effluent pumps complying with UL 778 and with HI 1.1-1.2 and HI 1.3 for submersible sewage pumps.

1. Manufacturers:
   a. ABS Pumps, Inc.
   b. Aermotor Pumps, Inc.
   c. Barnes; Crane Pumps & Systems.
   d. Bell & Gossett Domestic Pump; ITT Industries.
   e. Federal Pump Corp.
   f. Goulds Pumps; ITT Industries.
   g. Grundfos Pumps Corp.
   h. HOMA Pump Technology.
   i. Hydromatic Pumps; Pentair Pump Group (The).
   j. Liberty Pumps.
   k. Little Giant Pump Co.
   l. Metropolitan Industries, Inc.
   m. Stancor, Inc.
   n. Zoeller Company.

2. Casing: Cast iron, with open inlet, legs that elevate pump to permit flow into impeller, and vertical discharge with companion flange for piping connection.
3. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed or semiopen design for clear wastewater; overhung, single suction, and keyed and secured to shaft.
4. Pump and Motor Shaft: Stainless steel, with factory-sealed, grease-lubricated ball bearings and double mechanical seals.
5. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and

cable-sealing assembly for connection at pump. Comply with Division 22 Section "Common Motor Requirements for Plumbing Equipment."

a. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.

B. Submersible, Quick-Disconnect Effluent Pumps: Factory-assembled and -tested, duplex, single-stage, centrifugal, end-suction, submersible, direct-connected effluent pumps complying with UL 778 and with HI 1.1-1.2 and HI 1.3 for submersible sewage pumps and with SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook" for guide-rail supports.

1. Manufacturers:

a. ABS Pumps, Inc.
b. Flygt; ITT Industries.
c. HOMA Pump Technology.
d. Hydromatic Pumps; Pentair Pump Group (The).
e. Metropolitan Industries, Inc.
f. Myers, F. E.; Pentair Pump Group (The).

2. Casing: Cast iron, with open inlet, legs (or guide-rail supports) that elevate pump to permit flow into impeller, and vertical discharge with companion flange for piping connection. ASTM B 584, cast bronze; statically and dynamically balanced, closed or semiopen design for clear wastewater; overhung, single suction, and keyed and secured to shaft.
3. Pump and Motor Shaft: Stainless steel, with factory-sealed, grease-lubricated ball bearings[and double mechanical seals].
4. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof, power cable of length required and with grounding plug and cable-sealing assembly for connection at pump. Comply with Division 22 Section "Common Motor Requirements for Plumbing Equipment."

a. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.

5. Guide-Rail Supports: Include the following for each sewage pump:

a. Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
b. Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide-rail supports and stationary elbow.
c. Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
d. Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
e. Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.
f. Lifting Cable: Stainless steel; attached to pump and cover at manhole.

C. Submersible, Fixed-Position Sewage Pumps: Factory-assembled and -tested, duplex, single-stage, centrifugal, end-suction, submersible, direct-connected sewage pumps complying with UL 778 and with HI 1.1-1.2 and HI 1.3 for submersible sewage pumps.

1. Manufacturers:

a. ABS Pumps, Inc.
b. Aermotor Pumps, Inc.
c. Barnes; Crane Pumps & Systems.
d. EBARA International Corporation; Standard Pump Division.

e. Flygt; ITT Industries.
f. Goulds Pumps; ITT Industries.
g. Grundfos Pumps Corp.
h. HOMA Pump Technology.
i. Hydromatic Pumps; Pentair Pump Group (The).
j. Little Giant Pump Co.
k. Metropolitan Industries, Inc.
l. Stancor, Inc.
m. Sterling Peerless; Sterling Fluid Systems Group.
n. Swaby Manufacturing Co.
o. Tsurumi (America), Inc.
p. Weil Pump Company, Inc.
q. Weinman Div.; Crane Pumps & Systems.
r. Yeomans Chicago Corporation.
s. Zoeller Company.

2. Casing: Cast iron, with open inlet, legs that elevate pump to permit flow into impeller, and vertical discharge with companion flange for piping connection.
3. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, open or semiopen, nonclog design and capable of handling solids; overhung, single suction, and keyed and secured to shaft.
4. Pump and Motor Shaft: Stainless steel with factory-sealed, grease-lubricated ball bearings and double mechanical seals.
5. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump. Comply with Division 22 Section "Common Motor Requirements for Plumbing Equipment."

a. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.

D. Submersible, Quick-Disconnect Sewage Pumps: Factory-assembled and -tested, duplex, single-stage, centrifugal, end-suction, submersible, direct-connected sewage pumps complying with UL 778 and with HI 1.1-1.2 and HI 1.3 for submersible sewage pumps and with SWPA's "Submersible Sewage Pumping Systems (SWPA) Handbook" for guide-rail supports.

1. Manufacturers:

a. Chicago Pump Company; a division of Yeomans Chicago Corporation.
b. EBARA International Corporation; Standard Pump Division.
c. Flygt; ITT Industries.
d. Gorman-Rupp Company (The).
e. Goulds Pumps; ITT Industries.
f. HOMA Pump Technology.
g. Hydromatic Pumps; Pentair Pump Group (The).
h. KSB Inc.
i. Metropolitan Industries, Inc.
j. Stancor, Inc.
k. Sta-Rite Industries, Inc.
l. Swaby Manufacturing Co.
m. Tsurumi (America), Inc.
n. Weil Pump Company, Inc.
o. Weinman Div.; Crane Pumps & Systems.
p. Yeomans Chicago Corporation.
q. Zoeller Company.

2. Casing: Cast iron, with open inlet, legs (or guide-rail supports) that elevate pump to permit flow into impeller, and vertical discharge with companion flange for piping connection.
3. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, open or semiopen, nonclog design and capable of handling solids; overhung, single suction, and keyed and secured to shaft.
4. Pump and Motor Shaft: Stainless steel, with factory-sealed, grease-lubricated ball bearings and double mechanical seals.
5. Motor: Hermetically sealed, capacitor-start type; with built-in overload protection; lifting eye or lug; and three-conductor, waterproof power cable of length required and with grounding plug and cable-sealing assembly for connection at pump. Comply with Division 22 Section "Common Motor Requirements for Plumbing Equipment."

a. Moisture-Sensing Probe: Internal moisture sensor and moisture alarm.

6. Guide-Rail Supports: Include the following for each sewage pump:

a. Guide Rails: Vertical pipes or structural members, made of galvanized steel or other corrosion-resistant metal, attached to baseplate and basin sidewall or cover.
b. Baseplate: Corrosion-resistant metal plate, attached to basin floor, supporting guide rails and stationary elbow.
c. Pump Yoke: Motor-mounted or casing-mounted yokes or other attachments for aligning pump during connection of flanges.
d. Movable Elbow: Pump discharge-elbow fitting with flange, seal, and positioning device.
e. Stationary Elbow: Fixed discharge-elbow fitting with flange that mates to movable-elbow flange and support attached to baseplate.
f. Lifting Cable: Stainless steel; attached to pump and cover at manhole.

2.4 SEWAGE PUMP BASINS

A. Description: Factory fabricated basin with sump, pipe connections, and separate cover.

B. Sump: Fabricate watertight, with sidewall openings for pipe connections.

1. Material: Fiberglass.
2. Reinforcement: Mounting plates for pumps, fittings, guide-rail supports, and accessories.
3. Anchor Flange: Same material as or compatible with sump, cast in or attached to sump, in location and of size required to anchor basin in concrete slab.

C. Cover: Fabricate with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.

1. Material: Cast iron.
2. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.

D. Capacities and Characteristics:

1. Refer to plans and Pump Schedules.

2. Cover:

a. Material: Cast iron.
b. Refer to plans and Pump Schedules.

2.5 SEWAGE PUMP PITS

A. Description: Concrete pit with sump, pipe connections, curb frame, and separate cover.

B. Sump: Construct of watertight, cast-in-place, reinforced concrete with sidewall openings for pipe connections. Cast-in-place concrete, formwork, and reinforcement are specified in Division 03 Section "Miscellaneous Cast-in-Place Concrete."

1. Pipe Connections: Sleeved openings large enough for mechanical sleeve seals for drainage piping. Sleeves and mechanical sleeve seals are specified in Division 22 Section "Common Work Results for Plumbing" and drainage piping is specified in Division 22 Section "Sanitary Waste and Vent Piping."

C. Curb Frame and Cover:

1. Curb Frame Material: Galvanized steel or steel with bituminous coating.

2. Cover: Fabricate with openings having gaskets, seals, and bushings; for access to pumps, pump shafts, control rods, discharge piping, vent connections, and power cables.

a. Material: Cast iron.
b. Reinforcement: Steel or cast iron, capable of supporting foot traffic for basins installed in foot-traffic areas.

D. Capacities and Characteristics:

1. Refer to plans and Pump Schedules.

2.6 BUILDING AUTOMATION SYSTEM INTERFACE

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

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

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for plumbing piping to verify actual locations of sanitary drainage and vent piping connections before sewage pump installation.

3.2 CONCRETE

A. Install concrete bases of dimensions indicated for pumps and controllers. Refer to Division 22 Section "Common Work Results for Plumbing."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Cast-in-place concrete materials and placement requirements are specified in Division 03 .

3.3 INSTALLATION

A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

B. Install sewage pumps according to applicable requirements in HI 1.4.

C. Install pumps and arrange to provide access for maintenance including removal of motors, impellers, couplings, and accessories.

D. Suspend wet-pit-mounted, vertical sewage pumps from basin and pit covers. Make direct connections to sanitary drainage piping.

E. Set submersible sewage pumps on basin and pit floors. Make direct connections to sanitary drainage piping.

1. Anchor guide-rail supports to basin and pit bottoms and sidewalls or covers. Install pumps so pump and discharge pipe disconnecting flanges make positive seals when pumps are lowered into place.

F. Install sewage pump basins and connect to drainage and vent piping. Brace interior of basins according to manufacturer's written instructions to prevent distortion or collapse during concrete placement. Set basin cover and fasten to basin top flange. Install cover so top surface is flush with finished floor.

G. Construct sewage pump pits and connect to drainage and vent piping. Set pit curb frame recessed in and anchored to concrete. Fasten pit cover to pit curb flange. Install cover so top surface is flush with finished floor.

H. Install packaged, submersible sewage pump units and make direct connections to drainage and vent piping.

I. Install packaged, wastewater pump unit basins on floor or concrete base unless recessed installation is indicated. Make direct connections to drainage and vent piping.

J. Support piping so weight of piping is not supported by pumps.

3.4 CONNECTIONS

A. Piping installation requirements are specified in Division 22 Section "Sanitary Waste and Vent Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to sewage pumps to allow service and maintenance.

C. Connect sanitary drainage and vent piping to pumps. Install discharge piping equal to or greater than size of pump discharge piping. Install vent piping equal to or greater than size of pump basin vent connection. Refer to Division 22 Section "Sanitary Waste and Vent Piping."

1. Install flexible connectors adjacent to pumps in discharge piping.

2. Install check and shutoff valves on discharge piping from each pump. Install unions on pumps having threaded pipe connections. Install valves same size as connected piping. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves for sanitary waste piping.

D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify bearing lubrication.
3. Disconnect couplings and check motors for proper direction of rotation.
4. Verify that each pump is free to rotate by hand. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
5. Verify that pump controls are correct for required application.

B. Start pumps without exceeding safe motor power:

1. Start motors.
2. Open discharge valves slowly.
3. Check general mechanical operation of pumps and motors.

C. Test and adjust controls and safeties.

D. Remove and replace damaged and malfunctioning components.

1. Pump Controls: Set pump controls for automatic start, stop, and alarm operation as required for system application.
2. Set field-adjustable switches and circuit-breaker trip ranges as indicated, or if not indicated, for normal operation.

E. 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 outside normal occupancy hours for this purpose.

3.6 DEMONSTRATION

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

END OF SECTION

SECTION 223300 - ELECTRIC DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following electric water heaters:
   1. Commercial, storage electric water heaters.
   2. Compression tanks.
   3. Water heater accessories.

1.3 SUBMITTALS

A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Product Certificates: For each type of commercial and instantaneous electric water heater, signed by product manufacturer.

D. Manufacturer Seismic Qualification Certification: Submit certification that commercial water heaters, accessories, and components will withstand seismic forces defined in Division 22 Section "Vibration and Seismic Controls for Plumbing Piping and Equipment." Include the following:

   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
      b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Source quality-control test reports.

F. Field quality-control test reports.

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

H. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain same type of electric water heaters through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of electric water heaters and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. ASME Compliance: Where indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

E. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for all components that will be in contact with potable water.

1.5 COORDINATION

A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of electric water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including storage tank and supports.
b. Faulty operation of controls.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Period(s): From date of Substantial Completion:

1) Storage Tank: Five years.
2) Controls and Other Components: Five years.

b. Compression Tanks: One year(s).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 COMMERCIAL ELECTRIC WATER HEATERS

A. Commercial Electric Heaters: Comply with UL 1453 requirements for booster-type water heaters.

1. Manufacturers:

   a. Bradford White Corporation.
   b. Rheem Water Heater Div.; Rheem Manufacturing Company.
   c. Smith, A. O. Water Products Company.

2. Storage-Tank Construction: Steel.

   a. Tappings: ASME B1.20.1 pipe thread.
   b. Pressure Rating: 150 psig.
   c. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending lining material into tappings.

3. Factory-Installed Storage-Tank Appurtenances:

   a. Anode Rod: Replaceable magnesium.
   b. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
   c. Insulation: Comply with ASHRAE/IESNA 90.1.
   d. Jacket: Rectangular shaped, with stainless-steel front panel, unless otherwise indicated.
   e. Heating Elements: Electric, screw-in or bolt-on immersion type arranged in multiples of three.

   f. Temperature Control: Adjustable thermostat, to setting of at least 180 deg F.
   g. Safety Controls: High-temperature-limit and low-water cutoff devices or systems.
   h. Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3, combination temperature and pressure relief valve. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valve with sensing element that extends into storage tank.
   i. Gages: Combination temperature and pressure type or separate thermometer and pressure gage.

4. Special Requirements: NSF 5 construction.
5. Capacity and Characteristics: See schedule on drawings.

2.3 COMPRESSION TANKS

A. Description: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.

1. Manufacturers:

   a. AMTROL Inc.
   b. Watts Regulator Co.
   c. Wessels Co.

2. Construction:

   a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1, pipe thread.
   b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
   c. Air-Charging Valve: Factory installed.

3. Capacity and Characteristics: See schedule on drawings.

2.4 WATER HEATER ACCESSORIES

A. Combination Temperature and Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.

B. Pressure Relief Valves: ASME rated and stamped and complying with ASME PTC 25.3. Include pressure setting less than water heater working-pressure rating.

C. Water Heater Stand and Drain-Pan Units: High-density-polyethylene-plastic, 18-inch- high, enclosed-base stand complying with IAPMO PS 103 and IAS No. 2. Include integral or separate drain pan with raised edge and NPS 1 drain outlet with ASME B1.20.1 pipe thread.

D. Water Heater Stands: Water heater manufacturer's factory-fabricated steel stand for floor mounting and capable of supporting water heater and water. Include dimension that will support bottom of water heater a minimum of 18 inches above the floor.

E. Water Heater Mounting Brackets: Water heater manufacturer's factory-fabricated steel bracket for wall mounting and capable of supporting water heater and water.

F. Drain Pans: Corrosion-resistant metal with raised edge. Include dimensions not less than base of water heater and include drain outlet not less than NPS 3/4.

G. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

H. Water Regulators: ASSE 1003, water-pressure reducing valve. Set at 25-psig- maximum outlet pressure, unless otherwise indicated.

I. Shock Absorbers: ASSE 1010 or PDI WH 201, Size A water hammer arrester.

2.5 SOURCE QUALITY CONTROL

A. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test commercial water heater storage tanks before shipment to minimum of one and one-half times pressure rating.

C. Prepare test reports.

PART 3 - EXECUTION

3.1 WATER HEATER INSTALLATION

A. Install commercial water heaters on concrete bases.

1. Exception: Omit concrete bases for commercial water heaters if installation on structural stand, bracket, suspended platform, or direct on floor is indicated.

B. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

C. Install seismic restraints for commercial water heaters. Anchor to substrate.

D. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

E. Install water-heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 22 Section "Domestic Water Piping Specialties" for hose-end drain valves.

F. Install thermometer on outlet piping of water heaters. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

G. Install thermometers on inlet and outlet piping of household, collector-to-tank, solar-electric water heaters. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

H. Install pressure gage(s) on inlet and outlet of commercial electric water- heater piping. Refer to Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages.

I. Assemble and install inlet and outlet piping manifold kits for multiple water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each water heater. Include shutoff valve, thermometer in each water heater inlet and outlet, and throttling valve in each water heater outlet. Refer to Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty valves and to Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

J. Install water regulator, with integral bypass relief valve, in booster-heater inlet piping and water hammer arrester in booster-heater outlet piping.

K. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.

L. Fill water heaters with water.

M. Charge compression tanks with air.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial and instantaneous electric water heaters. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION

SECTION 224000 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following conventional plumbing fixtures and related components:

1. Faucets for lavatories, showers and sinks.
2. Flushometers.
3. Toilet seats.
4. Protective shielding guards.
5. Fixture supports.
6. Water closets.
7. Urinals.
8. Lavatories.
9. Commercial sinks.
10. Kitchen sinks.
11. Service basins.

B. Related Sections include the following:

1. Division 10 Section "Toilet, Bath, and Laundry Accessories."
2. Division 22 Section "Domestic Water Piping Specialities" for backflow preventers, floor drains, and specialty fixtures not included in this Section.
3. Division 22 Section "Domestic Water Filtration Equipment" for water filters.
4. Division 22 Section "Healthcare Plumbing Fixtures."
5. Division 22 Section "Emergency Plumbing Fixtures."
6. Division 22 Section "Security Plumbing Fixtures."
7. Division 22 Section "Drinking Fountains and Water Coolers."
8. Division 31 Section "Facility Water Distribution Piping" for exterior plumbing fixtures and hydrants.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

C. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.

D. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.

E. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

F. FRP: Fiberglass-reinforced plastic.

G. PMMA: Polymethyl methacrylate (acrylic) plastic.

H. PVC: Polyvinyl chloride plastic.

I. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.

1.4 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

D. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.

1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

D. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:

1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
2. Porcelain-Enameled, Formed-Steel Fixtures: ASME A112.19.4M.

3. Slip-Resistant Bathing Surfaces: ASTM F 462.
4. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
5. Stainless-Steel Commercial, Handwash Sinks: NSF 2 construction.
6. Vitreous-China Fixtures: ASME A112.19.2M.
7. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.
8. Water-Closet, Flushometer Tank Trim: ASSE 1037.

H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
1. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
2. Faucets: ASME A112.18.1.
3. Hose-Connection Vacuum Breakers: ASSE 1011.
4. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
5. NSF Potable-Water Materials: NSF 61.
6. Pipe Threads: ASME B1.20.1.
7. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
8. Supply Fittings: ASME A112.18.1.
9. Brass Waste Fittings: ASME A112.18.2.

I. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:

1. Atmospheric Vacuum Breakers: ASSE 1001.
2. Brass and Copper Supplies: ASME A112.18.1.
3. Manual-Operation Flushometers: ASSE 1037.
4. Brass Waste Fittings: ASME A112.18.2.
5. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.

1.6 WARRANTY

A. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures of unit shell.
b. Faulty operation of controls, blowers, pumps, heaters, and timers.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Period for Commercial Applications: Three year(s) from date of Substantial Completion.
3. Warranty Period for Residential Applications of Shells: Five years from date of Substantial Completion.
4. Warranty Period for Residential Applications of Pumps and Blowers: Five years from date of Substantial Completion.
5. Warranty Period for Residential Applications of Electronic Controls: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LAVATORY FAUCETS

A. Lavatory Faucets:

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

   a. Sloan Valve Co.
   b. Kohler Co.
   c. American Standard Companies, Inc.

2. Description: See schedule on drawings for basis of design products.

2.2 SINK FAUCETS

A. Sink Faucets:

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

   a. American Standard Companies, Inc.
   b. Sloan Valve Co.
   c. Kohler Co.

2. Description: See schedule on drawings for basis of design products.

2.3 FLUSHOMETERS

A. Flushometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Sloan Valve Company.
   b. American Standard Companies, Inc.
   c. Zurn Plumbing Products Group; Commercial Brass Operation.

2. Description: See schedule on drawings for basis of design products.
   a. All flushometers to be manual for all water closets and urinals.

2.4 TOILET SEATS

A. Toilet Seats:

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

a. American Standard Companies, Inc.
b. Sloan Valve Company
c. Zurn Plumbing Products Group; Commerical Brass Operation
d. Kohler Co.

2. Description: Toilet seat for water-closet-type fixture.

a. Material: Molded, solid plastic with antimicrobial agent.
b. Configuration: Open front without cover.
c. Size: Elongated.
d. Hinge Type: Check; Self-Sustaining
e. Class: Standard commercial.
f. Color: White.

2.5 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

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

a. Engineered Brass Co.
b. Insul-Tect Products Co.; a Subsidiary of MVG Molded Products.
c. McGuire Manufacturing Co., Inc.
d. Plumberex Specialty Products Inc.
e. TCI Products.
f. TRUEBRO, Inc.
g. Zurn Plumbing Products Group; Tubular Brass Plumbing Products Operation.

2. Description: Manufactured plastic wraps for covering plumbing fixture hot-water supply hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

B. Protective Shielding Piping Enclosures:

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

a. TRUEBRO, Inc.

2. Description: Manufactured plastic enclosure for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with ADA requirements.

2.6 FIXTURE SUPPORTS

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

1. Josam Company.
2. MIFAB Manufacturing Inc.
3. Tyler Pipe; Wade Div.
4. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.

5. Zurn Plumbing Products Group; Specification Drainage Operation.

B. Water-Closet Supports:

1. Description: Combination carrier designed for accessible mounting height of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

C. Urinal Supports:

1. Description: Type I, urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture for wall-mounting, urinal-type fixture. Include steel uprights with feet.
2. Accessible-Fixture Support: Include rectangular steel uprights.

D. Lavatory Supports:

1. Description: Type II, lavatory carrier with concealed arms and tie rod for wall-mounting, lavatory-type fixture. Include steel uprights with feet.
2. Accessible-Fixture Support: Include rectangular steel uprights.

2.7 WATER CLOSETS

A. Water Closets:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Sloan Valve Company
   b. Zurn Plumbing Products

2. Description: See schedule on drawings for basis of design products.

2.8 URINALS

A. Urinals:

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

   a. Sloan Valve Company

   b. American Standard Companies, Inc.
   c. Kohler Co.
   d. Zurn Plumbing Products

2. Description: See schedule on drawings for basis of design products.

2.9 LAVATORIES

A. Lavatories:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Sloan Valve Company
   b. Kohler Co.
   c. American Standard Companies, Inc.

2. Description: See schedule on drawings for basis of design products.

2.10 COMMERCIAL SINKS

A. Commercial Sinks:

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

   a. Kohler Co.
   b. American Standard
   c. Sloan Valve Co.

2. Description: See schedule on drawings for basis of design products.

2.11 KITCHEN SINKS

A. Kitchen Sinks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Standard
   b. Sloan Valve Com
   c. Kohler Co.

2. Description: See schedule on drawings for basis of design products.

2.12 SERVICE BASINS

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

   a. American Standard
   b. Crane Plumbing, L.L.C./Fiat Products.
   c. Florestone Products Co., Inc.

2. Description: See schedule on drawings for basis of design products.

PART 3 - EXECUTION

3.1 EXAMINATION

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

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

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

3.2 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.

1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.

C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

D. Install floor-mounting fixtures on closet flanges or other attachments to piping or building substrate.

E. Install wall-mounting fixtures with tubular waste piping attached to supports.

F. Install floor-mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.

G. Install counter-mounting fixtures in and attached to casework.

H. Install fixtures level and plumb according to roughing-in drawings.

I. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

1. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

J. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

K. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

L. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

M. Install toilet seats on water closets.

N. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

O. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

P. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

Q. Install shower flow-control fittings with specified maximum flow rates in shower arms.

R. Install traps on fixture outlets.

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

S. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."

T. Set service basins in leveling bed of cement grout. Grout is specified in Division 22 Section "Common Work Results for Plumbing."

U. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

E. Install fresh batteries in sensor-operated mechanisms.

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

C. Replace washers and seals of leaking and dripping faucets and stops.

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

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

END OF SECTION

SECTION 224700 - DRINKING FOUNTAINS AND WATER COOLERS

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 water coolers and related components:

1. Drinking fountains.
2. Pressure water coolers.
3. Water-station water coolers.
4. Remote water coolers.
5. Fixture supports.

1.3 DEFINITIONS

A. Accessible Water Cooler: Fixture that can be approached and used by people with disabilities.

B. Cast Polymer: Dense, cast-filled-polymer plastic.

C. Drinking Fountain: Fixture with nozzle for delivering stream of water for drinking.

D. Fitting: Device that controls flow of water into or out of fixture.

E. Fixture: Drinking fountain or water cooler unless one is specifically indicated.

F. Remote Water Cooler: Electrically powered equipment for generating cooled drinking water.

G. Water Cooler: Electrically powered fixture for generating and delivering cooled drinking water.

1.4 SUBMITTALS

A. Product Data: For each fixture indicated. Include rated capacities, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For fixtures to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for fixtures for people with disabilities.

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

D. ARI Standard: Comply with ARI's "Directory of Certified Drinking Water Coolers" for style classifications.

E. ARI Standard: Comply with ARI 1010, "Self-Contained, Mechanically Refrigerated Drinking-Water Coolers," for water coolers and with ARI's "Directory of Certified Drinking Water Coolers" for type and style classifications.

F. ASHRAE Standard: Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant, unless otherwise indicated.

PART 2 - PRODUCTS

2.1 PRESSURE WATER COOLERS

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

a. Elkay Manufacturing Co.
b. Halsey Taylor.
c. Haws Corporation.
d. Larco, Inc.
e. Oasis Corporation.
f. Sunroc Corp.
g.

2. Description: ARI 1010, Type PB, pressure with bubbler, Style FW, flush-to-wall water cooler.

a. Cabinet: All stainless steel.
b. Bubbler: One, with adjustable stream regulator, located on deck.
c. Control: Push lever .
d. Supply: NPS 3/8 with ball, gate, or globe valve.
e. Filter: One or more water filters complying with NSF 42 and NSF 53 for cyst and lead reduction to below EPA standards; with capacity sized for unit peak flow rate.
f. Drain: Grid with NPS 1-1/4 minimum horizontal waste and trap complying with ASME A112.18.2.
g. Cooling System: Electric, with precooler, hermetically sealed compressor, cooling coil, air-cooled condensing unit, corrosion-resistant tubing, refrigerant, corrosion-resistant-metal storage tank, and adjustable thermostat.

1) Capacity: 8 gph of 50 deg F cooled water from 80 deg F inlet water and 90 deg F ambient air temperature.
2) Electrical Characteristics: 360 Watt; 115-V ac; single phase; 60 Hz.

2.2 FIXTURE SUPPORTS

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

1. Josam Co.
2. MIFAB Manufacturing, Inc.
3. Tyler Pipe; Wade Div.
4. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
5. Zurn Plumbing Products Group; Specification Drainage Operation.

B. Description: ASME A112.6.1M, water cooler carriers. Include vertical, steel uprights with feet and tie rods and bearing plates with mounting studs matching fixture to be supported.
1. Type II: Bilevel, hanger-type carrier with three vertical uprights.
2. Supports for Accessible Fixtures: Include rectangular, vertical, steel uprights instead of steel pipe uprights.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before fixture installation. Verify that sizes and locations of piping and types of supports match those indicated.

B. Examine walls and floors for suitable conditions where fixtures are to be installed.

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

3.2 APPLICATIONS

A. Use carrier off-floor supports for wall-mounting fixtures, unless otherwise indicated.

B. Use mounting frames for recessed water coolers, unless otherwise indicated.

C. Set freestanding and pedestal drinking fountains on floor.

D. Set remote water coolers on floor, unless otherwise indicated.

E. Use chrome-plated brass or copper tube, fittings, and valves in locations exposed to view. Plain copper tube, fittings, and valves may be used in concealed locations.

3.3 INSTALLATION

A. Install off-floor supports affixed to building substrate and attach wall-mounting fixtures, unless otherwise indicated.

B. Install mounting frames affixed to building construction and attach recessed water coolers to mounting frames, unless otherwise indicated.

C. Install fixtures level and plumb. For fixtures indicated for children, install at height required by authorities having jurisdiction.

D. Install water-supply piping with shutoff valve on supply to each fixture to be connected to water distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 22 Section "General-Duty Valves for Plumbing Piping."

E. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.

F. Install pipe escutcheons at wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding pipe fittings. Escutcheons are specified in Division 22 Section "Common Work Results for Plumbing."

G. Seal joints between fixtures and walls and floors using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

3.5 FIELD QUALITY CONTROL

A. Water Cooler Testing: After electrical circuitry has been energized, test for compliance with requirements. Test and adjust controls and safeties.

1. Remove and replace malfunctioning units and retest as specified above.
2. Report test results in writing.

3.6 ADJUSTING

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

B. Adjust water cooler temperature settings.

3.7 CLEANING

A. After completing fixture installation, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

END OF SECTION

SECTION 230503 - **GENERAL PROVISIONS FOR HVAC WORK**

PART 1 - GENERAL

1.1 SUMMARY

A. The work under Division 23 "Heating, Ventilating, and Air Conditioning (HVAC)" shall include all labor, services, materials and equipment and performance of all work required for the installation of all mechanical work as shown on the Drawings and herein specified in the following Sections.

B. Should there be any discrepancies or a question of intent, refer the matter to the Architect/Engineer for decision before ordering any equipment or materials or before starting any related work.

C. Where work connects to that of another trade, or to piping or equipment in place, take measurements in the field to make connecting work come true and line up with the item being connected.

D. Where work specified under other Divisions of the Specifications connects to equipment, which is a part of Division 23, provide proper connection(s) to such equipment.

E. Minor items and accessories or devices reasonably inferable as necessary, to the complete and proper installation and operation of any system, shall be provided by the Trade Contractor for such system whether or not they are specifically called for by the Specifications or Drawings.

F. The Drawings and Specifications are to be taken together. Work specified and not shown, or work shown and not specified shall be performed or furnished as though mentioned in both Specifications and Drawings. If there is a discrepancy between the Drawings and Specifications as to the quantity or quality to be provided, the greater quantity or the better quality shall be provided.

1.2 DEFINITIONS

A. "Piping" includes, in addition to pipe, all fittings, valves, hangers, and other supports and accessories related to such piping.

B. "Ductwork" includes, in addition to ducts, all fittings, transitions, dampers, hangers and other supports and accessories related to such ductwork.

C. "Concealed" means hidden from sight in chases, furred spaces, shafts, hung ceilings, embedded in construction, in crawl spaces or buried.

D. "Exposed" means not installed underground or "concealed" as defined above.

E. "Invert Elevations" means the elevation of the inside bottom of pipe or duct.

F. "HVAC Work" is all of the work in Division 23.

1.3 QUALITY ASSURANCE

A. Each major component of equipment to have the manufacturer's name, address, model number and rating on a plate securely affixed in a conspicuous place.

B. Code Ratings, labels or other data which are die-stamped or otherwise affixed to the surface of the equipment shall be in visible location.

C. All equipment provided under Division 23 to perform with the least possible noise and vibration consistent with its duty. Quietness of operation of all equipment is a requirement. Any equipment, as determined by the Owner's Representative or Architect/Engineer to be producing objectionable noise or transmitting noise or vibration to the building to be repaired or removed and replaced.

D. All workmanship shall be first class in every respect and shall be performed only by skilled mechanics.

E. Shutdown and Notifications:

1. It is imperative that service interruptions on the various existing utilities be held to an absolute minimum. Wherever possible provide suitable temporary services or connections, where continuity of service for essential systems can be maintained by this means. It will be the Owner's final prerogative to decide which systems are to be considered as essential, and to establish the maximum allowable shutdown time, if any, for each system.
2. Owner will require not less than 72 hours advance notice, in writing, that an interruption of service in any system is desired. Such notice shall identify the system or systems involved, and shall be submitted in duplicate, one copy of which will be signed and returned by the Owner's authorized representative stating whether the requested shutdown will be permitted or not.

A. Existing Utilities:

1. Location of utilities as shown on the drawings has been determined from the best available information and is given for convenience; however, Owner does not assume responsibility in the event that during construction, utilities other than those shown may be encountered, and that the actual location of those which are shown may be different from the location as shown on the plans.
2. Assume responsibility for interference with or damage to any existing utilities, and repair or replace same with the least possible delay.

F. Layout and establish the lines and levels necessary for work.

G. The following Standards shall be used where referenced by the following abbreviations:

1. AABC: Associated Air Balance Council
2. ADC: Air Diffusion Council
3. AGA: American Gas Association
4. AIA: American Institute of Architects
5. AMCA: Air Moving and Conditioning Association
6. ANSI: American National Standards Institute
7. ARI: Air Conditioning and Refrigeration Institute
8. ASE: Association of Safety Engineers
9. ASHRAE: American Society of Heating, Refrigeration and Air Conditioning Engineers
10. ASME: American Society of Mechanical Engineers
11. ASPE: American Society of Plumbing Engineers
12. ASTM: American Society of Testing and Materials
13. AWPB: American Wood Preserves Bureau
14. AWS: American Welding Society
15. AWWA: American Water Works Association
16. CSA: Canadian Standards Association
17. CISPI: Cast Iron Soil Pipe Institute
18. EIA: Electronic Industries Association
19. EPA: Environmental Protection Agency
20. FDA: Food and Drug Administration
21. FM: Factory Mutual Insurance Association
22. HIS: Hydraulic Institute Standards
23. IRI: Industrial Risk Insurers

24. IBR: Institute of Boiler and Radiator Manufacturers
25. IEEE: Institute of Electrical and Electronics Engineers
26. MCAA: Mechanical Contractors' Association of America
27. NIST: National Institute of Standards and Testing
28. NEBB: National Environmental Balancing Bureau
29. NEC: National Electric Code
30. NECA: National Electric Contractors Association
31. NEMA: National Electrical Manufacturers Association
32. NFPA: National Fire Protection Association
33. NSC: National Safety Council
34. NSF: National Sanitation Foundation
35. OSHA: Occupational Safety & Health Administration
36. SAE: Society of Automotive Engineers
37. SBI: Steel Boiler Institute Industry
38. SMACNA: Sheet Metal and Air Conditioning Contractors National Association
39. TIMA: Thermal Insulation Manufacturers Association
40. UL: Underwriters' Laboratories
41. USDA: United States Department of Agriculture

H. Project Certification:

1. Each trade shall submit a project certification, guaranteeing that this project was constructed and will operate in accordance with the performance requirements of the Drawings and Specifications. This certification shall be signed by a principal of the firm and shall be delivered to the Architect/Engineer prior to final payment.

I. Drawings:

1. The Drawings are diagrammatic in nature and show general arrangement of the equipment, piping, ductwork, accessories, etc. Because of the small scale of the Drawings, it is not possible to show each offsets, fittings, and accessories, which may be required. Carefully investigate the structural conditions, Architectural Drawings, Equipment Drawings, and the finished conditions of the work and arrange such work accordingly, furnish any fittings, pipe accessories that may be required to meet such conditions.
2. Any changes from the plans necessary to make the work conform to building as constructed and to fit work of other trades, or to conform to rules of the governing authorities and regulations, shall be met without extra cost to the Using Agency.
3. The layout of the piping, ductwork, equipment, etc., as shown on the Drawings shall be checked and exact locations shall be determined by the dimensions of equipment approved and Contractor shall obtain the Architect’s approval for revised layout before the apparatus is installed. Consult the Architectural, Structural, and Equipment Drawings for the dimensions, locations of partitions, locations and sizes of structural supports, foundations, etc.
4. Refer to the Architectural Plans for details and large-scale Drawings and to approved Shop Drawing of equipment furnished under other Contracts or Sections of the Specifications for exact location of service connections. The equipment Shop Drawings will be furnished to the Contractor before roughing in. Contractor shall not install any piping or ductwork for said equipment until they have received approved Coordination Drawings for same.

J. Minor Deviations:

1. The dimensions of equipment hereinafter specified or indicated on the Drawings are intended to establish the outlines and characteristics of such equipment in general. Minor deviations in dimensions will be permitted to allow the manufacturers specified to bid on their nearest stock equipment, provided the specified ratings are met or exceeded.

2. Where manufacturers' catalog numbers or types are mentioned in the Specifications or indicated on the Drawings, they are intended to be used as a guide only and shall not be interpreted as taking precedence over the basic rating and duty specified. In all cases, manufacturers shall verify the duty specified with particular characteristics of the equipment they intend to offer for approval and shall also pay the additional charges as may be required under other Divisions.

K. Interferences:

1. Before making any installation, the work of the trades must be coordinated and the necessary changes shall be made to avoid interferences or improper effect on work to be performed by any other Section. In the event that interferences develop, the Architect's decision will be final and no additional compensation will be allowed for moving of misplaced piping, ducts, conduit and/or equipment.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Unless otherwise specified, all material and equipment incorporated in the work under the contract shall be new.

B. Material and equipment specified by one or more manufacturer's name, trade name and/or model number does not limit a bidder from bidding on other equipment providing the procedure set forth in the Conditions of the Contract and hereinafter specified is followed.

C. The various mechanical systems have been engineered and designed on equipment name and catalog numbers specified or designated on the Drawings.

D. A Contractor who intends to furnish equipment listed as approved equal shall proceed as follows:

1. Obtain Architect/Engineer's approval of said equipment.
2. Be fully responsible for said equipment.
3. Include in the Base Bid, all cost for any changes that may be required in his work and/or work of other trades for the proper installation and functioning of said equipment.

PART 3 - EXECUTION

1.2 ALTERATIONS IN PRESENT BUILDING AND SITE

A. Take particular note of the revisions and alterations of existing services, utilities, etc., due to the new construction as indicated on the Drawings and/or as required by alterations to the existing building.

1. Maintaining of Present Services: Maintain all services in the existing building. This shall include all temporary or permanent piping connections, etc., required to provide and maintain services to the present buildings and the equipment served. In the case of change over piping and ductwork or where new service connections are to be made to existing services and service interruptions can in no way be avoided, the service interruptions shall be with the minimum of inconvenience to the Owner. If the Owner’s Representative directs that such work be performed during premium time hours then the Contractor shall be reimbursed for the premium time portion of the direct labor cost of the workmen actually performing the work. All costs (except for premium time portion of labor costs) incurred in order to comply with the foregoing shall be included in the Contractor's original bid for the work and without additional costs to the Board.
2. Remove or reroute, as required, all services at existing buildings to be demolished.

1.3 DISPOSITION OF REMOVED EQUIPMENT

A. Where existing materials or equipment are specified to be removed from service, the Trade Contractor shall take possession of same and remove them from the site promptly, except as specified below or unless otherwise noted on Drawings.

B. All salvageable material and equipment, including but not necessarily limited to, electrical fixtures, conduit, wiring, plumbing fixtures, heating units, piping, valves, etc., shall be removed and maintained in as good condition as possible and turned over to the Owner. However, if the Owner decides any such materials are of no value, then they shall become the property of the Contractor who shall remove such discarded work from the premises and dispose of same.

1.4 INSTALLATION

A. Each Trade Contractor shall be responsible for all of his work fitting into place in a satisfactory and neat workmanlike manner acceptable to the Architect/Engineer.

B. Confer with other Trade Contractors regarding the location and size of pipes, equipment, fixtures, conduit, ducts, openings, switches, outlets, etc., in order that there may be no interference between the installation of the progress of the work of any Trade Contractor on the project. The Architectural Drawings shall take precedence over the Mechanical and Electrical Drawings.

C. The Mechanical Drawings are diagrammatic and shall be followed as closely as actual construction of the building and the work of other trade contractors will permit. All changes from Drawings necessary to make the work of each Contractor conform to the building construction and the work of other trade contractors shall be done at the appropriate Trade Contractor's expense.

D. Unless explicitly stated to the contrary, each Trade Contractor shall furnish and install each item of equipment or material hereinafter specified, complete with all necessary fittings, supports, trim, piping, insulation, etc., as required for a complete and operating installation.

E. All equipment and materials shall be installed according to the manufacturer's instructions unless otherwise specifically directed by the Trade Contract Documents. All piping, valves, connections, and other like items recommended by the manufacturer or required for proper operation shall be provided without additional cost to the Board.

F. All references to Contractors in Specifications and Drawings shall refer to the respective Trade Contractor performing that portion of the work.

G. In general, all piping, ductwork and similar items shall be installed concealed from view above the ceiling, in partitions, shafts, chases, unless otherwise indicated.

H. Locations of items not definitely fixed by dimensions are approximate only and exact locations necessary to secure the best conditions and results shall be determined at the site, subject to review.

I. Where pipes are in partitions, furred out spaces and chases, obtain information as to their exact location and size and install work so as to be entirely concealed in the allotted space. If conflicts arise making this impossible, obtain instructions from the Architect/Engineer before proceeding with the work.

J. Wherever two or more pipes are to be installed in parallel, or parallel to the piping of other trades, the piping shall be installed with sufficient space between pipes to allow for the proper application of pipe covering, painting and servicing.

K. Furnish advance information on locations and sizes of frames, boxes, sleeves and openings needed for the work, and also furnish information and shop drawings necessary to permit installation of other work without delay.

L. Where there is evidence that parts of the Mechanical Work will interfere with other work, assist in working out space conditions and/or the structure, make necessary adjustments to accommodate the work.

M. Mechanical Work installed before coordinating with other work so as to cause interference with other work shall be changed to correct such condition without additional cost to the Using Agency.

N. In no case shall any pipe, conduit, duct, or item of equipment be installed where it is supported on or suspended from another pipe, conduit, duct or item of equipment.

O. Where an item or task is specified to be provided "under this Section," it shall be understood that, that item or task is the responsibility of the trade responsible for that Section, but the work must be performed by qualified workmen of the appropriate trade.

P. Accessibility:

1. Install Mechanical work to permit removal (without damage to other parts) of coils, heat exchangers, pumps, fan shafts and wheels, belt guards, sheaves and drives, and other parts requiring periodic replacement or maintenance.
2. Arrange pipes, ducts, and equipment to permit ready access to valves, cocks, traps, starters, motors, dampers, control components, and to clear the openings of swinging and overhead doors and of access panels.
3. Change dimensions of ductwork when required to meet job conditions but maintain the same equivalent cross-sectional area.
4. Provide access panels in equipment, ducts, and like items for inspection of interiors and proper maintenance.

END OF SECTION

SECTION 230505 - BASIC HVAC MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED WORK

A. Materials Installed but furnished by others: Refer to other sections for requirements.

B. Furnished, but installed by others: Refer to other sections for requirements.

1.2 SUMMARY

A. Section includes the following:

1. Piping materials and installation instructions common to most piping systems.
2. Concrete base construction requirements.
3. Escutcheons.
4. Mechanical sleeve seals.
5. Equipment nameplate data requirements.
6. Nonshrink grout for equipment installations.
7. Field-fabricated metal and wood equipment supports.
8. Installation requirements common to equipment specification sections.
9. Cutting and patching.
10. Touchup painting and finishing.
11. Access Panels
12. Cleaning

B. Pipe and pipe fitting materials are specified in Division 23.

1.3 DEFINITIONS

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

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 rubber materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.
2. EPDM: Ethylene-propylene-diene terpolymer rubber.
3. PE: Polyethylene plastic.

4. PVC: Polyvinyl chloride plastic.

1.4 SUBMITTALS

A. Refer to Division 01 Section “Submittal Procedures” for administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other miscellaneous submittals.

B. Product Data: For dielectric fittings, flexible connectors, mechanical sleeve seals, access panels and identification materials and devices.

C. Coordination Drawings: For access panel and door locations.

D. Coordination Drawings: Detail major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Show space requirements for installation and access. Indicate if sequence and coordination of installations are important to efficient flow of the Work. Use BIM software for coordination. Include the following:

1. Planned piping layout, including valve and specialty locations and valve-stem movement.
2. Planned duct systems layout, including elbow radii and duct accessories.
3. Clearances for installing and maintaining insulation.
4. Clearances for servicing and maintaining equipment, accessories, and specialties, including space for disassembly required for periodic maintenance.
5. Equipment and accessory service connections and support details.
6. Exterior wall and foundation penetrations.
7. Fire-rated wall and floor penetrations.
8. Sizes and location of required concrete pads and bases.
9. Scheduling, sequencing, movement, and positioning of large equipment into building during construction.
10. Floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
11. Reflected ceiling plans to coordinate and integrate installation of air outlets and inlets, light fixtures, communication system components, sprinklers, and other ceiling-mounted items.
12. Access panel locations in ceilings/walls/floors.

E. As-Built Drawings: Provide drawings in PDF and CAD showing as built conditions of all mechanical equipment, ducts, piping, temperature control devices, and accessories.

1.5 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies:

1. American Society for Testing and Materials

a. ASTM A 53-98: Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
b. ASTM B 32-96: Specification for Solder Metal
c. ASTM B 813-93: Specification for Liquid and Paste Fluxes for Soldering Applications of Copper and Copper Alloy Tube
d. ASTM B 828-98: Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings
e. ASTM C 1107-97: Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)
f. ASTM C 1173-97: Specification for Flexible Transition Couplings for Underground Piping Systems
g. ASTM D 1785-96b: Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120

h. ASTM D 2235-96a: Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings
i. ASTM D 2564-96a: Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
j. ASTM D 2672-96a: Specification for Joints for IPS PVC Pipe Using Solvent Cement
k. ASTM D 2855-96: Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
l. ASTM D 3139-98: Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
m. ASTM F 402-93: Practice for Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermostatic Pipe and Fittings
n. ASTM F 493-97: Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings
o. ASTM F 656-96a: Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings

2. American Water Works Association

a. AWWA C110-98: Ductile-Iron and Gray-Iron Fittings, 3 In. through 48 In. (76 mm through 1219 mm), for Water and Other Liquids
b. AWWA C219-97: Bolted, Sleeve-Type Couplings for Plain-End Pipe

3. American Welding Society

a. AWS A5.8-92: Specification for Filler Metals for Brazing and Braze Welding
b. AWS D1.1-98: Structural Welding Code--Steel
c. AWS D10.12-89: Recommended Practices and Procedures for Welding Low Carbon Steel Pipe
d. Brazing Handbook. 1991.

4. ASME International

a. ASME B1.20.1-83 (Reaffirmed 1992): Pipe Threads, General Purpose (Inch)
b. ASME B16.21-92: Nonmetallic Flat Gaskets for Pipe Flanges
c. ASME B18.2.1-96: Square and Hex Bolts and Screws--Inch Series
d. ASME B31 Series: Code for Pressure Piping
e. 1998 ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications"

5. Copper Development Association Inc.

a. Copper Tube Handbook. 1995.

6. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.

a. MSS SP-107-91: Transition Union Fittings for Joining Metal and Plastic Products

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

C. 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.

D. Equipment of higher electrical characteristics, physical dimensions, capacities, and ratings may be furnished provided such proposed equipment is approved in writing and connecting mechanical and electrical services, circuit breakers, conduit, motors, bases, and equipment spaces are increased. Additional costs shall be approved in advance by appropriate Contract Modification for these increases. If minimum energy ratings or efficiencies of equipment are specified, equipment must meet design and commissioning 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 prevent entrance of dirt, debris, and moisture.

B. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, if stored inside.

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

1.7 SEQUENCING AND SCHEDULING

A. Coordinate phasing and sequencing of all work with the Owner and Building Engineer.

B. Coordinate mechanical equipment installation with other building components.

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

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

E. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning before closing in building.

F. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

G. Coordinate requirements for access panels and doors if mechanical items requiring access are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."

H. Coordinate installation of identifying devices after completing covering and painting, if devices are applied to surfaces. Install identifying devices before installing acoustical ceilings and similar concealment.

I. Coordinate connection of electrical services.

J. Coordinate locations of mechanical equipment with other trades so as to not obstruct maintenance access or code required clearances.

1.8 WARRANTY

A. Provide warranty on materials and labor for 18 months starting from date of delivery, or one year from date of substantial completion, whichever is longer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Mechanical Sleeve Seals:

a. Calpico, Inc.
b. Metraflex Co.
c. Thunderline/Link-Seal.

2. Metal, Flexible Connectors:

a. Grinnell Corp.; Grinnell Supply Sales Co..
b. Mercer Rubber Co.
c. Metraflex Co.

3. Rubber, Flexible Connectors:

a. General Rubber Corp.
b. Metraflex Co.
c. Red Valve Co., Inc.

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, 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. PVC Piping: ASTM D 2564. 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.

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

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. 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.

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.

2.5 MECHANICAL SLEEVE SEALS

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

1. Sealing Elements: EPDM 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. Include two for each sealing element.
3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.6 FLEXIBLE CONNECTORS

A. General: Fabricated from materials suitable for system fluid and that will provide flexible pipe connections. Include 125-psig minimum working-pressure rating, unless higher working pressure is indicated, and ends according to the following:

1. 2-Inch NPS and Smaller: Threaded.
2. 2-1/2-Inch NPS and Larger: Flanged.

B. Stainless-Steel-Hose/Steel Pipe, Flexible Connectors: Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include steel nipples or flanges, welded to hose.

C. Stainless-Steel-Hose/Stainless-Steel Pipe, Flexible Connectors: Corrugated, stainless-steel, inner tubing covered with stainless-steel wire braid. Include stainless-steel nipples or flanges, welded to hose.

D. Couplings may be used to provide allowance for controlled pipe movement, expansion, contraction, and or deflection to absorb movement for thermal changes, setting or seismic action and also vibration attenuation.

2.7 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 water-stop, 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. Under-deck Clamp: Clamping ring with set screws.

2.8 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: Rough brass.

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

1. Finish: Rough brass.

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

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

G. One-Piece, Floor-Plate Type: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 ACCESS PANELS

A. General: Refer to Division 08 Section, "Access Doors and Frames," for access panel manufacturers and other requirements.

PART 3 - EXECUTION

3.1 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. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
    c. Insulated Piping: One-piece, stamped-steel type with spring clips.
    d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
    e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type and set screw.
    f. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed hinge and set screw.
    g. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw.
    h. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

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

N. Permanent sleeves are not required for holes formed by removable PE sleeves.

O. 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 Sealants" for materials and installation.

P. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

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.

Q. 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.

R. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.

S. Verify final equipment locations for roughing-in.

3.2 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. Note internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.
2. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
3. Align threads at point of assembly.
4. Tighten joint with wrench. Apply wrench to valve end into which pipe is being threaded.
5. 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: Align flange surfaces parallel. Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. 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 using torque wrench.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. PVC Pressure Piping: Join schedule number ASTM D 1785, 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.
3. PVC Non-pressure Piping: Join according to ASTM D 2855.

J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.

K. Plastic Non-pressure Piping Gasketed Joints: Join according to ASTM D 3212.

L. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.3 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

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to provide maximum possible headroom, if mounting heights are not indicated.

B. Install equipment according to approved submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to Architect.

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

D. Install mechanical 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.

E. Install equipment giving right of way to piping installed at required slope.

F. Install flexible connectors on equipment side of shutoff valves, horizontally and parallel to equipment shafts if possible.

3.5 PAINTING AND FINISHING

A. Refer to Division 09 Section "Painting" for paint materials, surface preparation, and application of paint.

B. Do not paint piping specialties with factory-applied finish.

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

3.6 CUTTING AND PATCHING

A. Cut, channel, chase, and drill floors, walls, partitions, ceilings, and other surfaces necessary for mechanical installations. Perform cutting by skilled mechanics of trades involved.

B. Repair cut surfaces to match adjacent surfaces.

3.7 CLEANING

A. Coordinate general cleanup with the work as specified in Division 1.

3.8 ACCESS PANELS

A. Where control valves, shut-off valves, drip traps, heating coils, dampers, pull boxes or other specialties, which require service or adjustment, are installed above inaccessible type furred ceilings or within furred walls, the Trade Contractor whose equipment is involved shall furnish and install access panels as required.

B. Each Trade shall confer with other trades with respect to access panel locations, and shall wherever practical group valves, traps, dampers, etc. in such a way as to be accessible from a single panel and eliminate as many access panels as possible.

3.9 ERECTION

A. Provide all necessary rigging, scaffolding, tools, tackle, labor and other like items necessary for the complete installation of the equipment.

B. Adapt his work to job conditions and install his work to clear beams, joists and light fixtures, adjusting risers, avoiding interferences with windows and openings, raising or lowering work to permit the passing of ductwork or the work of other trades, all as required or as job conditions dictate, without additional costs to the Owner.

C. Trade Contractor shall not rig, tie to, or rest weight upon any part of the building or make use of any stairway until specific permission is obtained.

1. Permission to rig to or make use of any part of the building premises shall not relieve the contractor of responsibility for any damage.

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

E. Field Welding: Comply with AWS D1.1, "Structural Welding Code--Steel."

3.10 ERECTION OF WOOD SUPPORTS AND ANCHORAGE

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorage to support and anchor mechanical materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.11 OPENINGS

A. Where temporary openings are necessary thru walls and partitions of the building for the entry or installation of tanks, fans, or other machinery or apparatus, or for driveways and other facilities, the permanent work of the mechanical trades at said openings shall be temporarily omitted and installed after equipment is brought into the building or after temporary facilities are removed.

B. Refer to other Sections of the Specifications for framing of openings for ducts, grilles, registers, etc., in walls, partitions, floors, roofs, etc. The trade for each service shall be responsible for locating and providing the proper dimensions for all required openings.

1. Space between ducts and wall or floor openings shall be sealed as specified in Division 07 Section "Penetration Firestopping."

C. No cutting or drilling of any building structural members will be permitted, unless the specific extent and limits are approved, in writing, by the Architect.

END OF SECTION

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED WORK

A. Specified elsewhere:

1. 23 05 15 Motors - Variable Frequency Controllers.
2. 23 05 48 Vibration Controls for HVAC
3. 23 05 93 Testing, Adjusting and Balancing for HVAC
4. 26 09 13 Electrical Power Monitoring and Control
5. 26 29 13 Enclosed Controller

1.2 SUMMARY

A. Section includes basic requirements for factory- and field-installed motors.

1.3 DEFINITIONS

A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.

B. Field-Installed Motor: A motor installed at Project site and not factory installed as an integral component of motorized equipment.

1.4 SUBMITTALS

A. Product Data for Field-Installed Motors: For each type and size of motor, provide nameplate data and ratings; shipping, installed, and operating weights; enclosure type and mounting arrangements; size, type, and location of winding terminations; conduit entry and ground lug locations; and information on coatings or finishes.

B. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around field-installed motors. Show motor layout, mechanical power transfer link, driven load, and relationship between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

C. Operation and Maintenance Data: For field-installed motors to include in emergency, operation, and maintenance manuals.

D. Training Reports: Submit reports on training documenting dates and attendance.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.6 DELIVERY, STORAGE AND HANDLING

A. Follow manufacturer's instructions for storage and handling of motors.

1.7 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices and features that comply with the following:

1. Compatible with the following:

a. Magnetic controllers.
b. Multispeed controllers.
c. Reduced-voltage controllers.

2. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.
3. Matched to torque and horsepower requirements of the load.
4. Matched to ratings and characteristics of supply circuit and required control sequence.

1.8 WARRANTY

A. Written manufacturer's warranty covering parts and labor for a period of one year from substantial completion, or eighteen months from shipment, whichever is longer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Motors:

a. Baldor.
b. General Electric.
c. Lincoln Motors.
d. Marathon.
e. Reliance.
f. U.S. Motors.

2.2 MOTOR REQUIREMENTS

A. Motor requirements apply to factory- and field-installed motors except as follows:

1. Different ratings, performance, or characteristics for motor are specified in another Section.
2. Motorized-equipment manufacturer requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

2.3 MOTOR CHARACTERISTICS

A. Motors 1/2 HP and Larger: Three phase.

B. Motors Smaller Than 1/2 HP: Single phase.

C. Frequency Rating: 60 Hz.

D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected. 208V motors shall be rated for continuous operation at 200V.

E. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.

F. Duty: Continuous duty at ambient temperature of 105 deg F and at altitude of 3300 feet above sea level.

G. 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.

H. Enclosure: Open dripproof.

2.4 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Premium, as defined in NEMA MG 1.

C. Stator: Copper windings, unless otherwise indicated.

1. Multispeed motors shall have separate winding for each speed.

D. Rotor: Squirrel cage, unless otherwise indicated.

E. Bearings: Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading.

F. Temperature Rise: Match insulation rating, unless otherwise indicated.

G. Insulation: Class F, unless otherwise indicated.

H. 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.

I. Enclosure: Cast iron for motors 7.5 hp and larger; rolled steel for motors smaller than 7.5 hp.

1. Finish: Gray enamel.

2.5 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Inrush 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: Motors shall be inverter-duty. Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Designed with critical vibration frequencies outside operating range of controller output.
2. Temperature Rise: Matched to rating for Class B insulation.
3. Insulation: Class F.

4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
5. Provide with shaft grounding ring – Aegis or approved equal.

C. Rugged-Duty Motors: Totally enclosed, with 1.25 minimum service factor, greased bearings, integral condensate drains, and capped relief vents. Windings insulated with non-hygroscopic material.

1. Finish: Chemical-resistant paint over corrosion-resistant primer.

D. Source Quality Control for Field-Installed Motors: Perform the following tests on each motor according to NEMA MG 1:

1. Measure winding resistance.
2. Read no-load current and speed at rated voltage and frequency.
3. Measure locked rotor current at rated frequency.
4. Perform high-potential test.

2.6 SINGLE-PHASE MOTORS

A. Type: One of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.
2. Split-phase start, capacitor run.
3. Capacitor start, capacitor run.

B. Shaded-Pole Motors: For motors 1/20 hp and smaller only.

C. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

D. Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, pre-lubricated-sleeve type for other single-phase motors.

PART 3 - EXECUTION

3.1 EXAMINATION

3.2 CONTRACTOR STARTUP AND REPORTING

A. Prepare for acceptance tests.

1. Align motors, bases, shafts, pulleys, and belts. Tension belts according to manufacturer's written instructions.
2. Verify bearing lubrication.
3. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.
4. Test interlocks and control and safety features for proper operation.
5. Verify that current and voltage for each phase comply with nameplate rating and NEMA MG 1 tolerances.

B. Perform the following field tests and inspections and prepare test reports:

1. Perform electrical tests and visual and mechanical inspections including optional tests and inspections stated in NETA ATS on factory- and field-installed motors. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.3 DEMONSTRATION AND COMMISSIONING

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

1. Train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining chillers. The training will occur after the startup report has been provided to the owner and the trainer will provide two (2) Installation and Operations manuals for the use of the owner's personnel during training.
2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational trouble shooting. If the IOM does not include a written trouble shooting guide one will be provided.
3. Schedule training with CDB, through Architect, with at least seven days' advance notice.

B. Demonstrate proper operation of equipment to commissioning agent or designated using agency's personnel. The scope of the demonstration will include functional performance requirements under both local and building automation control, as well as any commissioning requirements in Division 01 or 23.

END OF SECTION

SECTION 230515 - MOTORS - VARIABLE FREQUENCY CONTROLLERS

PART 1 - GENERAL

1.1 RELATED WORK

A. Specified elsewhere:

1. 23 05 13 Common Motor Requirements For HVAC Equipment
2. 23 09 20 Building Automation System-BAS
3. 26 09 13 Electrical Power Monitoring and Control
4. 26 29 13 Enclosed Controllers

1.2 SUMMARY

A. Section includes solid-state, pulse-width modulated, variable frequency controllers and variable frequency drives for speed control of three-phase, squirrel-cage induction motors.

1.3 DEFINITIONS

A. EMS: Energy Management System.

B. IGBT: Integrated gate bipolar transistor.

C. LAN: Local area network.

D. PID: Control action, proportional plus integral plus derivative.

E. PWM: Pulse-width modulated.

F. VFC: Variable frequency controller and variable frequency drive.

1.4 PERFORMANCE REQUIREMENTS

A. Design – Environmental: Equipment shall be rated for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:

1. Temperature Range, Ambient: 32 deg F to 105 deg F.
2. Relative Humidity: Less than 90 percent (noncondensing).
3. Altitude: Not exceeding 3300 feet.
4. Conditions: Winter: -10 deg F DB; Summer: 95 deg F DB / 75 deg F WB.

B. Noise: The VFC shall not produce motor noise in excess of the manufacturers published noise standards for 60 Hz operation.

1.5 SUBMITTALS

A. Product Data: For each type of VFC. Include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

B. Shop Drawings:

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. Include the following:

    a. Each installed unit's type and details.
    b. Nameplate legends.
    c. Short-circuit current rating of integrated unit.
    d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.

2. Wiring Diagrams: Power, signal, and control wiring for VFCs. Provide schematic wiring diagram for each type of VFC.

C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs where pipe and ducts are prohibited. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Qualification Data: For manufacturer and testing agency.

E. Field Quality-Control Test Reports: Submit reports documenting the activities performed. These reports are to be submitted two weeks after startup is completed.

F. Operation and Maintenance Data: For VFCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. Include the following:

1. Routine maintenance requirements for VFCs and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
3. A table listing the installed VFC drives set up parameters, alarm and trip setting.
4. Complete parts list with stock numbers, including spare parts.

G. Training Reports: Submit reports on training documenting dates and attendance.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Award the work to a single firm that specializes in the production of variable frequency drives, with not less than 5 years experience in the production of variable frequency drives similar in design and performance to those required for the Project, and whose work has resulted in a history of successful in-service performance. The manufacturer shall have sufficient production capacity, and have organized quality control and testing procedures, to be capable of producing the equipment required for the Project without causing a delay in the Work. The manufacturer shall maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. 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 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.

C. Source Limitations: Obtain all VFCs required for the Project through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Regulatory Requirements: Comply with the Chicago Building Code, including requirements for components and installation.

F. Comply with IEEE 519-1992, "Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems."

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store VFCs in manufacturer's original protective packaging, with original labels detailing contents intact. Store VFCs indoors, off of ground, under cover, in clean, dry location with uniform temperature and humidity to prevent condensation. Protect VFCs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.8 COORDINATION

A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances, including clearances required for maintenance, and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Deliver setting templates in time to allow casting of anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

D. Coordinate features of VFCs, installed units, and accessory devices with pilot devices and control circuits to which they connect.

E. Coordinate features, accessories, and functions of each VFC and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.9 COORDINATION WITH ENERGY MANAGEMENT SYSTEM

A. General: The equipment specified in this Section is required to be interfaced with the Energy Management System (EMS) as specified in Division 23 Section "Building Automation System." Provide all devices, hardware, programming, startup and commissioning required to establish the interface.

B. Coordinate with EMS supplier for their review and acceptance of the communications interface to be provided. Include evidence of the coordination and review process with the required submittals for this Section.

C. Provide a list of all read/write and read-only points available through the user interface. Provide software, hardware or paperwork that the contractor installing the EMS will require in order to accomplish the interface.

D. The equipment supplier is solely responsible for the proper performance of their equipment provided the correct information is provided through the communications interface.

E. Provide a prefunctional checklist, startup checklist and demonstration report to the Engineer, Commissioning Agent, or Board Authorized Representative for acceptance of system.

F. Provide a startup technician on-site during the establishment of the interface. Coordinate this activity with the EMS installer.

G. BACNet or LonWorks compliant manufacturer-provided controls

1. Provide any information necessary to allow the BACNet compliant device to be directly connected to the existing network, and send/receive information to the system installed under Division 23 sections.
2. The EMS shall then read and present the information made available by the equipment manufacturer, and transmit information receivable by the equipment manufacturer. This shall be accomplished by user configuration of point information, but shall not require recompiling or downloading of control programs.

H. Non-BACNet or LonWorks compliant manufacturer-provided controls:

1. Provide programming and hardware necessary to integrate information from the equipment into the EMS.
2. Provide the owner and EMS installer with all documentation necessary to receive point information required by Division 23 sections in a communications method compatible with the EMS.

1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components or equipment that fail in materials or workmanship within the specified warranty period. Manufacturer's warranty shall include parts, labor, travel costs, and living expenses incurred by the manufacturer in providing onsite service and repair or replacement.

1. Warranty Period: Three years from the date of Substantial Completion or Preliminary Acceptance.

1.11 EXTRA MATERIALS

A. Furnish extra materials that match products installed in the quantity indicated, in manufacturer's protective packaging, with manufacturer's original labels describing contents intact.

1. Indicating Lights: Two of each type installed.

1.12 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 9100 Commissioning. Testing of these systems is required, in cooperation with the CDB and the Commissioning Authority. Refer to Section 01 9100 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.
2. Danfoss.
3. Yaskawa.

2.2 VARIABLE FREQUENCY CONTROLLERS

A. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.

1. Provide unit suitable for operation of premium-efficiency motor as defined by NEMA MG 1.

B. All PWM AC Variable Frequency Drives of 40 hp and above shall be equipped with harmonic mitigation equipment to prevent power system problems resulting from high levels of reflected harmonic distortion. Provide harmonic mitigation for drives less than 40 hp where required to meet IEEE 519.

1. The harmonic mitigation equipment shall treat all of the characteristic low frequency harmonics generated by a 3-phase, diode bridge rectifier load (5th, 7th, 11th, 13th, etc.).
2. The characteristic harmonics shall be suppressed without the need for individual tuning or the requirement to phase shift against other harmonic sources.
3. Harmonic mitigation shall be by passive inductor/capacitor network or internal phase shifting transformer. Active electronic components shall not be used.
4. Power factor shall be 0.98 lagging to 0.95 leading in operating range from full to half load.
5. To ensure compatibility with engine generators, the harmonic mitigation equipment must never introduce a capacitive reactive power (KVAR) that is greater than 15% of its kVA rating.
6. The harmonic mitigation equipment shall not resonate with system impedances or attract harmonic currents from other harmonic sources.
7. The harmonic mitigation equipment in combination with the Variable Frequency Drive shall meet all requirements of IEEE 519 for individual and total harmonic voltage and current distortion. The Point of Common Coupling (PCC) for all voltage and current harmonic calculations and measurements shall be the input terminals to the harmonic mitigation equipment.
8. Total Harmonic Voltage Distortion (THVD) shall meet the requirements of Table 10.2 of IEEE 519 by not exceeding 5% and by limiting the individual harmonic voltage distortion to less than 3%. These limits shall apply while operating on either utility supply or generator supply when applicable. The harmonic mitigation equipment vendor shall not be responsible for pre-existing voltage distortion caused by other harmonic sources.
9. Total Demand Distortion (TDD) of the current at the input terminals of the harmonic mitigation equipment shall not exceed the limits as defined in Table 10.3 of IEEE 519. For Isc/IL ratio < 20, TDD must be less than 5%. For all other Isc/IL ratios, the TDD must not exceed 8% even when Table 10.3 allows for more relaxed limits. For single-phase applications, the TDD must not exceed 12%.
10. The full load efficiency of the harmonic mitigation equipment / VFD combination shall be greater than 96%. The harmonic mitigation equipment itself shall have efficiency no less than 99%.

C. Design and Rating: Match load type such as fans, blowers, and pumps, and type of connection used between motor and load, such as direct or through a power-transmission connection.

D. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.

E. Unit Operating Requirements:

1. Input ac voltage ranges of 208 V, plus or minus 10 percent or 480 V, plus or minus 10 percent as indicated on equipment schedules.
2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
3. Minimum Efficiency: 96 percent at 60 Hz, full load.
4. Minimum Displacement Primary-Side Power Factor: 96 percent.
5. Overload Capability: 1.2 times the base load current for 60 seconds; 1.8 times the base load current for 3 seconds.
6. Starting Torque: 100 percent of rated torque or as indicated.

7. Speed Regulation: Plus, or minus 1 percent.

F. Isolated Control Interface: To allow controller to follow control signal over an 11:1 speed range.

1. Electrical Signal: 4 to 20 mA at 24 V.

G. Internal Adjustability Capabilities:

1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 2 to a minimum of 22 seconds.
4. Deceleration: 2 to a minimum of 22 seconds.
5. Current Limit: 50 to a minimum of 110 percent of maximum rating.

H. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors.
2. Under- and overvoltage trips; inverter over-temperature, overload, and overcurrent trips.
3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class 10 performance.
4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
5. Instantaneous line-to-line and line-to-ground overcurrent trips.
6. Loss-of-phase protection.
7. Reverse-phase protection.
8. Short-circuit protection.
9. Motor over temperature fault where motor is equipped with RTD.

I. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.

J. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

K. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.

L. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

M. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

N. Input Line Conditioning: dc bus link reactors, isolation transformers, active and passive harmonic filters, and phase shifting transformers.

O. VFC Output Filtering: Line inductors, output limit filters, sine wave filters, and motor termination filters shall be provided where the motor to drive conductor lengths exceed manufacturer's recommended lengths.

P. Status Lights: Door-mounted LED indicators shall indicate the following conditions:

1. Power on.

2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

Q. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

R. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (VDC).
9. Set-point frequency (Hz).
10. Motor output voltage (V).

S. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the EMS or other control systems:

    a. 0 to 10-V dc.
    b. 0-20 or 4-20 mA.
    c. Potentiometer using up/down digital inputs.
    d. Fixed frequencies using digital inputs.
    e. RS485.
    f. Keypad display for local hand operation.

3. Output Signal Interface:

    a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:

        1) Output frequency (Hz).
        2) Output current (load).
        3) DC-link voltage (VDC).
        4) Motor torque (percent).
        5) Motor speed (rpm).
        6) Set-point frequency (Hz).

4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

    a. Motor running.
    b. Set-point speed reached.
    c. Fault and warning indication (overtemperature or overcurrent).

d. PID high- or low-speed limits reached.

T. Communications: Provide an RS485 interface allowing VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via EMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.

U. Integral Disconnecting Means: NEMA AB 1, molded-case switch with lockable handle.

V. Operation and Maintenance Features:

1. Current-Voltage-Frequency Indicating Devices: Mount meters or digital readout device and selector switch flush in controller door and connect to indicate controller output.
2. Manual Bypass: Magnetic contactor arranged to safely transfer the motor from the controller to the power line, or from the line to the controller while the motor is at zero speed. Include VFC-bypass selector switch and indicator lights to indicate mode selection. The operator shall have full control of the bypass starter by operation of the selector switch.
3. Integral Main Disconnect: Circuit breaker connected to shut down all power to both the controller and the bypass. Interlock breaker with cabinet door.
4. Auxiliary Motor Contactors: Electrically interlocked. One contactor connected between the controller output and the motor, controlled by the controller regulator; and one between the bypass power line and the motor, providing across-the-line starting capability in the bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either mode.
5. Isolating Circuit Breaker: Arranged to electrically isolate the variable-speed controller to permit safe trouble-shooting and testing of the controller, both energized and de-energized, while the motor is operating in the bypass mode.
6. Form C output contacts for run and fault conditions.
7. Terminal strip for N.C. safety shutdown contacts.
8. N.C. input for remote start/stop control in Auto mode.

2.3 ENCLOSURES

A. Indoors: NEMA 250, Type 1.

B. Outdoors: NEMA 3R.

2.4 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Standard Displayed information, display shall be interchangeable for all VFCs installed:

1. Output frequency (Hz).
2. Set-point frequency (Hz).
3. Motor current (amperes).
4. DC-link voltage (VDC).
5. Motor torque (percent).
6. Motor speed (rpm).
7. Motor output voltage (V).

8. Fault history with analytical data.

E. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

F. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107.

2.5 FINISH

A. Finish: Manufacturer's standard paint finish, applied to factory-assembled and -tested VFCs.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

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

3.2 PREPARATION

A. Harmonic Analysis: Obtain the electrical system one-line diagram from the contract document, provide a harmonic analysis demonstrating that the proposed VFDs (along with harmonic mitigation equipment provided) conform with IEEE 519-1992, "Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems."

3.3 SELECTION

A. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, minimum clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

B. Select features of each VFC to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.

C. Select horsepower rating of controllers to suit motor controlled.

3.4 INSTALLATION

A. Anchor each VFC assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface.

B. Install VFCs on walls or floor supports with concrete bases.

C. VFD's are not to be installed inside air handlers or air plenums due to the potentially high humidity or temperatures.

3.5 CONCRETE BASES

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

3.6 IDENTIFICATION

A. Identify VFCs, components, and control wiring according to Division 23 Section "Mechanical Identification."

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.7 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices according to Division 26 sections. Power and control wiring shall not be run in the same conduit, and shall follow manufacturer's recommendations.

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic-control devices where applicable.

1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
2. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.8 CONNECTIONS

A. Install conduit and ground equipment in accordance with Division 26 sections.

3.9 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Using Agency's maintenance personnel to adjust, operate, and maintain variable frequency controllers. Refer to Division 01 Section "Testing and Inspection."

B. Conduct a minimum of 4 hours of training in operation and maintenance of equipment.

C. Schedule training with at least seven days' advance notice.

D. Training of the owner's operation and maintenance personnel is required in cooperation with the Commissioning Authority. The instruction shall be scheduled in coordination with the Commissioning Authority after submission and approval of formal training plans. Refer to Demonstration and Training, Section 01 7900, for contractor training requirements. Refer to Section 01 9100 and the Commissioning Plan for further contractor training requirements.

3.11 CLEANING

A. Remove paint splatters and other spots, dirt and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally using methods and materials as recommended by manufacturer.

3.12 CONTRACTOR STARTUP AND REPORTING

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Reports: Prepare written reports certified by testing organization of tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include records of repairs and adjustments made. Harmonic compliance shall be verified with onsite field measurements of both the voltage and current harmonic distortion at the input terminals of the harmonic mitigating equipment with and without the equipment operating. A recording type Fluke 41 or equivalent harmonics analyzer displaying individual and total harmonic currents and voltages must be utilized.

C. Manufacturer’s Field Service: Engage a factory-authorized service representative to perform the following:

1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Assist in field testing of equipment including pretesting and adjusting of solid-state controllers.
3. Prepare written reports.

D. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS. 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.

E. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 9100 Commissioning.

3.13 DEMONSTRATION AND COMMISSIONING

A. Engage a factory-authorized service representative to train Using Agency's maintenance personnel to adjust, operate, and maintain air handling units.

1. Train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining the equipment. The training will occur after the startup report has been provided to the owner and the trainer will provide two (2) Installation and Operations manuals for the use of the Owner's personnel during training.
2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational troubleshooting. If the IOM does not include a written troubleshooting guide one shall be provided.
3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

B. Demonstrate proper operation of equipment to commissioning agent or Owner's designated personnel. The scope of the demonstration will include functional performance requirements under both local and building automation control as well as any commissioning requirements in Divisions 01 and 23 sections.

C. System functional performance testing is part of the Commissioning Process as specified in Section 01 9100. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Thermometers.
2. Gages.
3. Test plugs.
4. Thermowells.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated; include scale range, ratings, and calibrated performance curves, certified where indicated. Submit a meter and gauge schedule showing manufacturer's figure number, scale range, location, and accessories for each meter.

B. Shop Drawings: Schedule for thermometers and gages indicating manufacturer's number, scale range, and location for each.

C. Product Certificates: For each type of thermometer and gage, signed by product manufacturer.

1.3 QUALITY ASSURANCE

A. Comply with applicable portions of American Society of Mechanical Engineers (ASME) and Instrument Society of America (ISA) standards pertaining to construction and installation of meters and gages, including the following:

1. ASME B40.3, "Bimetallic Actuated Thermometers."
2. ASME B40.5, "Snubbers."
3. ASME B40.100 , "Pressure Gauges and Gauge Attachments."
4. ASTM E 1, "Liquid-in-Glass Thermometers."

B. Design Criteria: The Drawings indicate types, sizes, capacities, ranges, profiles, connections, and dimensional requirements of meters and gages and are based on the specific manufacturer types and models indicated. Meters and gages having equal performance characteristics by other manufacturers may be considered, provided that deviations do not change the design concept or intended performance as judged by the Architect. The burden of proof for equality of meters and gages is on the proposer.

1.4 DELIVERY, STORAGE AND HANDLING

A. Follow manufacturer's instructions for job site storage and protection of materials during construction.

PART 2 - PRODUCTS

2.1 MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS BY ONE OF THE MANUFACTURERS INDICATED UNDER ALL CATEGORIES.

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

1. Palmer - Wahl Instruments Inc.
2. Trerice, H. O. Co.

3. Weiss Instruments, Inc.
4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Duct-Type, Liquid-in-Glass Thermometers:

1. Miljoco Corp.
2. Palmer - Wahl Instruments Inc.
3. Trerice, H. O. Co.
4. Weiss Instruments, Inc.

C. Direct-Mounting, Vapor-Actuated Dial Thermometers:

1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.

D. Remote-Mounting, Vapor-Actuated Dial Thermometers:

1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.

E. Bimetallic-Actuated Dial Thermometers:

1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.

F. Thermowells:

1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.

G. Pressure Gages:

1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.

H. Test Plugs:

1. MG Piping Products Co.
2. Trerice, H. O. Co.
3. Watts Industries, Inc.; Water Products Div.

2.2 METAL-CASE, LIQUID-IN-GLASS THERMOMETERS

A. General: Provide liquid-in-glass thermometers complying with ASTM E1.

B. Case: Die-cast aluminum, 9 inches long.

C. Tube: Red reading, organic-liquid filled, with magnifying lens.

D. Tube Background: Satin-faced, non-reflective aluminum with permanently etched scale markings.

E. Window: Glass.

F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.

H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.3 DUCT-TYPE, LIQUID-IN-GLASS THERMOMETERS

A. Case: Die-cast aluminum, 7 inches long.

B. Tube: Red reading, organic filled, with magnifying lens.

C. Tube Background: Satin-faced, non-reflective aluminum with permanently etched scale markings.

D. Window: Glass.

E. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

F. Stem: Metal, for installation in mounting bracket and of length to suit installation.

G. Mounting Bracket: Flanged fitting for attachment to duct and made to hold thermometer stem.

H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.4 DIRECT-MOUNTING, VAPOR-ACTUATED DIAL THERMOMETERS

A. Case: Drawn steel or cast aluminum metal or plastic, 4-1/2-inch diameter.

B. Element: Bourdon tube or other type of pressure element.

C. Movement: Mechanical, connecting element and pointer.

D. Dial: Satin-faced, non-reflective aluminum with permanently etched scale markings.

E. Pointer: Red metal.

F. Window: Glass.

G. Ring: Metal.

H. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

I. Thermal System: Organic liquid-filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation.

J. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.5 REMOTE-MOUNTING, VAPOR-ACTUATED DIAL THERMOMETERS

A. Case: Dry type, drawn steel or cast aluminum, 4-1/2-inch diameter with holes for panel mounting.

B. Element: Bourdon tube or other type of pressure element.

C. Movement: Mechanical, connecting element and pointer.

D. Dial: Satin-faced, non-reflective aluminum with permanently etched scale markings.

E. Pointer: Red metal.

F. Window: Glass.

G. Ring: Metal.

H. Connector: Bottom union type.

I. Thermal System: Organic liquid-filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation.

J. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.6 BIMETALLIC-ACTUATED DIAL THERMOMETERS

A. Description: Direct-mounting, bimetallic-actuated dial thermometers complying with ASME B40.3.

B. Case: Dry type, stainless steel with 5-inch diameter.

C. Element: Bimetal coil.

D. Dial: Satin-faced, non-reflective aluminum with permanently etched scale markings.

E. Pointer: Red metal.

F. Window: Glass.

G. Ring: Stainless steel.

H. Connector: Adjustable angle type.

I. Stem: Metal, for thermowell installation and of length to suit installation.

J. Thermal System: Organic liquid-filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation.

K. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.7 THERMOWELLS

A. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

B. Stem length: Extend 2 inches into the fluid or into the center of the pipe. Extension for insulated pipe shall be 2 inches nominal, but not less than the thickness of the insulation.

C. Provide threaded cap nut with chain permanently fastened to well and cap.

2.8 PRESSURE GAGES

A. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.

1. Case: Dry type, drawn steel or cast aluminum, 4-1/2-inch diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Satin-faced, non-reflective aluminum with permanently etched scale markings.
6. Pointer: Red metal.
7. Window: Glass.
8. Ring: Metal.
9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.

B. Pressure-Gage Fittings:

1. Valves: NPS 1/4 brass or stainless-steel needle type.
2. Syphons: NPS 1/4 coil of brass tubing with threaded ends.
3. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.9 TEST PLUGS

A. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

B. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

C. Core Inserts: One or two self-sealing rubber valves.

1. Insert material for air, water, oil, or gas service at 20 to 200 deg F shall be CR.
2. Insert material for air or water service at minus 30 to plus 275 deg F shall be EPDM.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A. Install liquid-in-glass thermometers in the following locations and elsewhere as noted:

1. Outside-air, return-air, and mixed-air ducts.
2. As indicated on Drawings.

B. Install direct-mounting, vapor-actuated dial thermometers in the following locations and elsewhere as noted:

1. As indicated on Drawings.

C. Install bimetallic-actuated dial thermometers in the following locations:

1. As indicated on Drawings.

D. Install dry-case-type, vapor-actuated dial thermometers at suction and discharge of each pump and as indicated on Drawings.

E. Provide the following temperature ranges for thermometers:

1. Air Ducts: Minus 40 to plus 110 deg F, with 2-degree scale divisions (Minus 40 to plus 43 deg C, with 1-degree scale divisions).

3.2 GAGE APPLICATIONS

A. Install dry-case-type pressure gages for discharge of each pressure-reducing valve.

B. Install gages as indicated on Drawings.

3.3 INSTALLATIONS

A. Install direct-mounting thermometers and adjust vertical and tilted positions.

B. Install remote-mounting dial thermometers on panel, with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length.

C. Install thermowells with socket extending to center of pipe and in vertical position in piping tees where thermometers are indicated.

D. Duct Thermometer Support Flanges: Install in wall of duct where duct thermometers are indicated. Attach to duct with screws.

E. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.

F. Install remote-mounting pressure gages on panel.

G. Install needle-valve and snubber fitting in piping for each pressure gage for fluids (except steam).

H. Install needle-valve and syphon fitting in piping for each pressure gage for steam.

I. Install test plugs in tees in piping. Provide a test plug at every thermometer and pressure gage location, and where indicated on the Drawings.

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

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

3.4 CONNECTIONS

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

B. Apply conductive pate to the thermometer or temperature sensor prior to installing it in the thermowell.

3.5 ADJUSTING

A. Calibrate meters according to manufacturer's written instructions, after installation.

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

END OF SECTION

SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 WORK INCLUDES

A. Contractor Shall Provide:

1. Valves shown and herein specified.

1.2 RELATED WORK

A. Specified elsewhere:

1. Section 23 05 53 “Identification for HVAC Piping and Equipment” for valve tags and schedules.

1.3 SUMMARY

A. Section includes the following general-duty valves for HVAC piping:

1. Copper-alloy ball valves.
2. Ferrous-alloy butterfly valves.
3. Bronze check valves.
4. Ferrous-alloy wafer check valves.
5. Bronze gate valves.

1.4 DEFINITIONS

A. The following are standard abbreviations for valves:

1. CWP: Cold working pressure.
2. EPDM: Ethylene-propylene-diene terpolymer rubber.
3. NBR: Acrylonitrile-butadiene rubber.
4. PTFE: Polytetrafluoroethylene plastic.
5. SWP: Steam working pressure.
6. TFE: Tetrafluoroethylene plastic.

1.5 SUBMITTALS

A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.6 QUALITY ASSURANCE

A. ASME Compliance: ASME B31.9 for building services piping valves.

B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

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

1.7 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

B. Bronze ball valves:

1. Conbraco Industries, Inc.; Apollo Div.
2. Crane Co.; Crane Valve Group; Stockham Div.
3. NIBCO INC.
4. Watts Industries, Inc.; Water Products Div.

C. Ferrous-alloy butterfly valves:

1. Crane Co.; Crane Valve Group; Stockham Div.
2. Milwaukee Valve Company.
3. NIBCO INC.
4. Watts Industries, Inc.; Water Products Div.

D. Bronze check valves:

1. Crane Co.; Crane Valve Group; Stockham Div.
2. Milwaukee Valve Company.
3. NIBCO INC.
4. Watts Industries, Inc.; Water Products Div.

E. Ferrous-alloy wafer check valves:

1. Crane Co.; Crane Valve Group; Stockham Div.
2. NIBCO INC.
3. Watts Industries, Inc.; Water Products Div.

F. Bronze gate valves:

1. Crane Co.; Crane Valve Group; Stockham Div.
2. Milwaukee Valve Company.
3. NIBCO INC.

2.2 VALVES, GENERAL

A. Refer to PART 3 "Valve Applications" Article for applications of valves.

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

C. Valve Sizes: Same as upstream pipe, unless otherwise indicated.

D. Valve Actuators:

1. Gear Drive: For quarter-turn valves NPS 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Lever Handle: For quarter-turn valves NPS 6 and smaller, except plug valves.
4. Wrench: For plug valves with square heads. Furnish Using Agency with 1 wrench for every 10 plug valves, for each size square plug head.

E. Valves in insulated piping shall have 2-inch stem extensions and the following features:

1. Gate valves shall be rising stem type.
2. Ball valves shall have extended operating handle of no-thermal conductive material, protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation, and memory stops that are fully adjustable after insulation is applied.
3. Butterfly valves shall have extended necks.

F. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.

G. Valve bypass and drain connections shall follow MSS SP-45.

2.3 BRONZE BALL VALVES

A. Ball Valves, 4 Inches and Smaller: MSS SP-110, Class 150, 600-psi CWP, ASTM B 584 bronze body and bonnet, 2-piece construction; chrome-plated brass ball, standard port for 1/2-inch valves and smaller and conventional port for 3/4-inch valves and larger; blowout proof; bronze or brass stem; teflon seats and seals; threaded or soldered end connections:

1. Operator: Steel handwheel.
2. Stem Extension: For valves installed in insulated piping.
3. Memory Stop: For operator handles.

2.4 FERROUS-ALLOY BUTTERFLY VALVES

A. General: MSS SP-67, Type I, for tight shutoff, with disc and lining suitable for potable water, unless otherwise indicated. 200-psi CWP, 150-psi maximum pressure differential, ASTM A 126 cast-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals, wafer, lug, or grooved style:

1. Disc Type: Nickel-plated ductile iron, Aluminum bronze, elastomer-coated ductile iron or epoxy-coated ductile iron.
2. Operator for Sizes 2 Inches to 6 Inches: Standard lever handle with memory stop.

3. Operator for Sizes 8 Inches to 24 Inches: Gear operator with position indicator.
4. Operator for Sizes 8 Inches and Larger, 96 Inches or Higher above Floor: Chain-wheel operator.

2.5 BRONZE CHECK VALVES

A. Swing Check Valves, 2-1/2 Inches and Smaller: MSS SP-80; Class 125, 200-psi CWP, or Class 150, 300-psi CWP; horizontal swing, Y-pattern, ASTM B 62 cast-bronze body and cap, rotating bronze disc with rubber seat or composition seat, threaded or soldered end connections:

B. Swing Check Valves, 3 Inches and Larger: MSS SP-71, Class 125, 200-psi CWP, ASTM A 126 cast-iron body and bolted cap, horizontal-swing bronze disc, flanged or grooved end connections.

2.6 WAFER CHECK VALVES

A. Class 125, 200-psi CWP, ASTM A 126 cast-iron body, bronze disc/plates, stainless-steel pins and springs, Buna N seals, installed between flanges.

2.7 BRONZE GATE VALVES

A. Gate Valves, 2-1/2 Inches and Smaller: MSS SP-80; Class 125, 200-psi cold working pressure (CWP), or Class 150, 300-psi CWP; ASTM B 62 cast-bronze body and bonnet, solid-bronze wedge, copper-silicon alloy rising stem, teflon-impregnated packing with bronze packing nut, threaded or soldered end connections; and with aluminum or malleable-iron handwheel.

2.8 BRONZE GLOBE VALVES

A. Globe Valves, 2-1/2 Inches and Smaller: MSS SP-80; Class 125, 200-psi CWP, or Class 150, 300-psi CWP; ASTM B 62 cast-bronze body and screwed bonnet, rubber, bronze, or teflon disc, silicon bronze-alloy stem, teflon-impregnated packing with bronze nut, threaded or soldered end connections; and with aluminum or malleable-iron handwheel.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance. Proceed with installation only after unsatisfactory conditions have been corrected.

B. 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.

C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. 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.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE APPLICATIONS

A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:

1. Shutoff Service: Ball or butterfly valves.
2. Throttling Service: Ball butterfly valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP class or CWP ratings may be substituted.

C. System Piping: Use the following types of valves:

1. Ball Valves, NPS 2 and Smaller: 600-psig CWP rating, copper alloy.
2. Butterfly Valves, NPS 2-1/2 and Larger: Flanged, 150-psig CWP rating, ferrous alloy, with EPDM liner.
3. Swing Check Valves, NPS 2 and Smaller: Type 4, Class 125, bronze.
4. Swing Check Valves, NPS 2-1/2 and Larger: Type II, Class 125, gray iron.
5. Wafer Check Valves, NPS 2-1/2 and Larger: Single-plate, wafer, Class 125 or 150 ferrous alloy.
6. Gate Valves, NPS 2 and Smaller: Type 2, Class 125, bronze.
7. Gate Valves, NPS 2-1/2 and Larger: Type I, Class 125, OS&Y, bronze-mounted cast iron.
8. Globe Valves, NPS 2 and Smaller: Type 2, Class 150, bronze.
9. Globe Valves, NPS 2-1/2 and Larger: Type I, Class 125, bronze-mounted cast iron.

D. Select valves, except wafer and flangeless types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Solder-joint or threaded ends, except provide valves with threaded ends for heating hot water, steam, and steam condensate services.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged or threaded ends.
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 or threaded ends.

3.3 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

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

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

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

F. Install chainwheel operators on valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor elevation.

G. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.

3.4 JOINT CONSTRUCTION

A. Refer to Division 23 Section "Basic HVAC Materials and Methods" for basic piping joint construction.

B. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.5 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.

END OF SECTION

SECTION 230529 - HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED WORK

A. Specified elsewhere:

1. 05 12 00 Structural Steel Framing.
2. 23 05 48 Vibration Controls For HVAC.

1.2 SUMMARY

A. Section includes the following hangers and supports for mechanical system piping and equipment:
1. Steel pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Thermal-hanger shield inserts.
5. Fastener systems.
6. Rooftop Pipe Supports.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry Inc.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 SUBMITTALS

A. Product Data: For the following:
1. Steel pipe hangers and supports.
2. Thermal-hanger shield inserts.
3. Powder-actuated fastener systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
1. Trapeze pipe hangers. Include Product Data for components.
2. Metal framing systems. Include Product Data for components.
3. Rooftop Pipe Supports. Include Product Data for components.
4. Equipment supports.

1.5 PERFORMANCE REQUIREMENTS

A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.

1.6 WARRANTY

A. Provide warranty on materials and labor for 18 months starting from date of delivery, or one year from date of substantial completion, whichever is longer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Steel Pipe Hangers and Supports:

a. Anvil
b. B-Line Systems, Inc.; a division of Cooper Industries.
c. Carpenter & Paterson, Inc.

2. Powder-Actuated Fasteners:

a. Hilti, Inc.
b. ITW Ramset/Red Head.

3. Mechanical-Expansion Anchors:

a. B-Line Systems, Inc.; a division of Cooper Industries.
b. Hilti, Inc.
c. ITW Ramset/Red Head.

4. Rooftop Pipe Supports:

a. Pate
b. RPS
c. Thybar

5. Thermal-Hanger Shield Inserts:

a. Carpenter & Paterson, Inc.
b. PHS Industries, Inc.
c. Pipe Shields, Inc.

2.2 STEEL PIPE HANGERS AND SUPPORTS

A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to PART 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

B. Corrosion Protection: Hangers and components shall be galvanized or painted with carbo-zinc #11.

C. Threads: All threads shall be UNC unless otherwise specified.

D. Heat Transmission: Supports, guides and anchors shall limit the amount of heat transmitted to the structural steel. Temperature of supporting parts shall be based on a 100°F per inch temperature gradient from the outside pipe surface.

2.3 TRAPEZE PIPE HANGERS

A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.4 FASTENER SYSTEMS

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

B. Mechanical-Expansion Anchors: Insert-wedge-type zinc-coated steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

2.5 ROOFTOP PIPE SUPPORTS

A. Description: Provide factory-fabricated steel sheet structural mounting supports. Construction shall include a welded 18-gauge galvanized steel shell, base plate and removable counterflashing. Support shall include a factory-installed wood nailer and internal bulkhead reinforcement. End sections shall be fully mitered. Support shall be compatible with insulated roof decks and include a 3 inch cant and variable step to match deck insulation thickness. The pipe roller assembly shall have galvanized 18 inches long continuous threaded rods to permit 12 inch vertical adjustments and a galvanized removable pipe retainer bracket.

2.6 THERMAL-HANGER SHIELD INSERTS

A. Description: 100 psig minimum, compressive-strength insulation insert encased in sheet metal shield.

B. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with vapor barrier.

C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate.

D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.7 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified 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. Hangers installed outdoors shall have two coats of rust inhibitor paint after installation and adjustment.

D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

E. Use padded hangers for piping that is subject to scratching.

F. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated stationary pipes, NPS 1/2 to NPS 30.
2. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
3. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
4. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20, from single rod if horizontal movement caused by expansion and contraction might occur.

G. 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 20.

H. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F piping installations.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
4. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
5. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
6. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
7. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
8. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.

9. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
10. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb (340 kg).
    b. Medium (MSS Type 32): 1500 lb (680 kg).
    c. Heavy (MSS Type 33): 3000 lb (1360 kg).

11. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
12. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
13. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

J. 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.

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

L. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

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

N. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

3.2 HANGER AND SUPPORT INSTALLATION

A. Steel 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 building structure.

B. 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 above for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
3. Trapeze bars shall be tightly secured to structural members at two points with bolts or other similar mechanical fasteners. Hangers from bar joist and fabricated truss members shall be located at the panel points of the structural members. C-clamp type hangers attached to one side of double-angle bottom members are not allowed. Point loads shall not exceed the lesser of:

    a. Manufacturer’s certified recommendation for the component parts.

b. The following maximum point loads, and maximum hanger spacings as herein specified, for structural elements in any direction; except as specifically approved by the Structural Engineer of Record:

Structural Element Type	Maximum Hanger Point Load (lb)
Metal deck without concrete topping	50
Composite metal deck slab with concrete topping	50
Steel Beams:	
All channels, W4 through W8	100
W10 through W14	200
W16 through W24	400
W27 through W36	750
Built-up structural steel trusses	250
Reinforced post-tensioned concrete elements:	
Slabs up to 6 inches thick	150
Slabs over 6 inches thick	250
Joists 8 inches wide	250
Beam/girders 8 inches wide	500

C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.

D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.

E. Fastener System Installation:

1. Drive screws, pins, studs, etc., of the type which are secured in place by means of explosive force may be used as a means of securing any of the hangers subject to the following:

    a. The stud, pin or fastener shall be caused to have a velocity not in excess of 300 feet per second when measured 6-1/2 feet from the muzzle of the tool by accepted ballistic test methods.
    b. Only workmen qualified by instructions of the manufacturers representative and/or licensed by the state and local authorities shall be assigned to use a powder actuated fastening tool.
    c. Where practical, tools of only one manufacturer shall be used on a project.
    d. Only cartridges and fasteners supplied by the manufacturer of the tool shall be used to operate that tool.
    e. Powder actuated fastening tools shall be handled with the same care as firearms.
    f. All safety devices incorporated in the tool by the manufacturer shall be used at all times.

g. Acceptable types of powder actuated fastening tools are:

1) Piston Tool - Low Velocity Type - is a tool utilizing a piston, activated by the power of a blank cartridge furnished by the manufacturer for use with it, to drive a stud, pin or fastener into a work surface.
2) Powder Assisted Hammer Drive Tool - Low Velocity Type - is a tool utilizing a captive piston, activated by a blow from a 4 lb. hammer supplemented by the power of a blank cartridge furnished by the manufacturer for use with the tool, to drive a stud, pin or fastener into a work surface.

2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

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

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

H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

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

J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

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

L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.

M. Insulated Piping: Comply with the following:
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 according to ASME B31.1 for power piping and 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.

5. Insert Material: Length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.3 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.4 METAL FABRICATIONS

A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.

B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 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 contours of welded surfaces match adjacent contours.

3.5 ADJUSTING

A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches.

3.6 PAINTING

A. Touch Up: 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.
2. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish. Hangers installed outdoors shall have two coats of rust inhibitor paint after installation and adjustment.
3. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.

B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 Section "Painting."

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 230548 - VIBRATION CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED WORK

A. Specified elsewhere:

1. 23 05 29 Hangers and Supports for HVAC Piping & Equipment
2. 23 31 13 Metal Ducts

1.2 SUMMARY

A. This Section includes the following:

1. Vibration isolation for piping, duct and equipment.
2. Equipment isolation bases.
3. Flexible piping connections.
4. Resilient pipe anchors and guides.

1.3 SUBMITTALS

A. Catalog cut sheets that include rated load, rated deflection, and overload capacity for each vibration isolation device.

B. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports.

C. Submit details of equipment bases including dimensions, structural member sizes and support point locations.

D. Submit details of isolation hangers for ceiling hung equipment, piping and ductwork.

E. Submit details of mountings for floor-supported equipment, piping and ductwork.

F. All hanger, mounting or pad drawings shall indicate deflections and model numbers as well as any other requirements in the specifications.

G. Spring diameters, rated loads and deflections, heights at rated load and closed height shall be provided for all springs shown in the submittals in tabular form.

H. Provide complete flexible connector details.

1.4 QUALITY ASSURANCE

A. The isolation materials manufacturer shall be responsible for the proper selection of spring rates to accomplish the specified minimum static deflections for all spring and pay type isolators based on the weight distribution of equipment to be isolated.

B. The isolation materials manufacturer shall be responsible for the structural design of steel beam bases and concrete inertia bases to support mechanical equipment scheduled or specified to receive a supplementary base.

C. Furnish a complete set of final Shop Drawings of all mechanical equipment to receive vibration isolation devices to the vibration isolation materials manufacturer. These Drawings will be the basis upon which the selection of vibration isolators and design of supplementary bases will be completed. The Shop Drawings to be furnished shall include operating weight of the equipment to be isolated and the distribution of weight to the support points.

D. Furnish a complete layout of piping and ductwork to be isolated, including vertical risers, showing size or weight and support points of the piping system to the vibration isolation materials manufacturer for selection and layout of isolation hangers.

1.5 DELIVERY, STORAGE AND HANDLING

A. Store equipment in accordance with manufacturer's instructions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Mason Industries.
2. Amber Booth Company, Inc.
3. Kinetics Noise Control, Inc.
4. Vibration Mountings and Controls, Inc.

2.2 VIBRATION ISOLATOR SELECTION

A. Noise and vibration isolator types, minimum operating static deflections, and supplemental bases shall be provided for individual mechanical equipment units according to selection criteria delineated in Table 1 incorporated as part of this specification or as tabulated in the equipment schedules of the project Drawings.

B. Isolator types are scheduled to establish minimum standards. At the Contractor's option labor saving accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevations during installation and initial system filling operations, and similar installation advantages, provided isolators supplied incorporate and specified isolator type, and do not degrade the noise and vibration isolation of equipment mounted.

C. Supplemental equipment base types tabulated can be deleted for unitary packaged air handling equipment having a rigid frame and casing providing a distortion free platform for attachment of vibration isolators.

D. Isolators exposed to the outdoors shall have weather-proof finish on all parts.

2.3 NEOPRENE MOUNTINGS

A. Neoprene mountings shall have a minimum static deflection of 0.35". All metal surfaces shall be neoprene covered and have friction pads both top and bottom. Bolt holes shall be provided on the bottom and a tapped hole and cap screw on top. Steel rails shall be used above the mountings under equipment such as small vent sets to compensate for the overhang. Mountings shall be type ND or rails type DNR as manufactured by Mason Industries, Inc.

2.4 SPRING ISOLATORS

A. General: Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4"(6mm) neoprene acoustical friction pad between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Installed and operating heights shall be equal. The ratio of the spring diameter divided by the compressed spring height shall be no less than 0.8. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include spring diameters, deflection, compressed spring height and solid spring height. Mountings shall be type SLF, as manufactured by Mason Industries, Inc.

B. Equipment with Significant Weight Variations: Equipment with significant variations in the operating and installed weight, and equipment exposed to the wind shall be mounted on spring mountings as described above. Provide a neoprene acoustical pad within a rigid-sided housing with vertical limit stops to prevent spring extension when weight is removed. Also provide temporary steel spacers between the upper and lower housings. Housings shall serve as blocking during erection. When the equipment is at full operating weight, the springs shall be adjusted to assume the weight and the spacers removed, without changing the installed and operating heights. All restraining bolts shall have large rubber grommets to provide cushioning in the vertical as well as horizontal modes. The hole through the bushing shall be a minimum of 0.75" larger in diameter than the restraining bolt. Horizontal clearance on the sides between the spring assembly and the housing shall be a minimum of 0.5" to avoid bumping and interfering with the spring action. Vertical limit stops shall be out of contact during normal operation. When there is no provision for direct mounting, cooling tower mounts are to be located between the supporting steel and the roof, or the grillage and dunnage as shown on the drawings. Housings and springs shall be powder coated and hardware electro-galvanized. Mountings shall be SLR as manufactured by Mason Industries, Inc.

2.5 HANGERS

A. General: Hangers shall consist of rigid steel frames containing minimum 1-1/4" thick neoprene elements at the top, a steel spring with general characteristics as described in Paragraph 2.4, and shall be seated in a steel washer-reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. In order to maintain stability the boxes shall not be articulated. The neoprene element shall not be stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc from side to side before contacting the cup bushing. Submittals shall include a hanger drawing showing the 30° capability. Hangers shall be type 30N as manufactured by Mason Industries, Inc.

B. Spring Locks: Hangers shall be precompressed and locked at the rated deflection by means of a resilient upstop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30° capability. Hangers shall be type PC30N as manufactured by Mason Industries, Inc.

C. Hangers shall be manufactured with minimum characteristics as described in Paragraph 2.4, but without the neoprene element. Springs shall be seated in a steel washer reinforced neoprene cup that has a neoprene bushing projecting through the bottom hole to prevent rod hanger contact. Spring diameters and the lower hole sizes shall be large enough to allow the hanger rod to swing through a 30° arc from side to side before contacting the cup bushing. For ducts suspended by flat strap iron, the hanger assembly shall be modified by the manufacturer with an eye on top of the box and on the bottom of the spring hanger rod to allow for bolting to the hanger straps. Submittals shall include a scale drawing of the hanger showing the 30° capability. Hangers for rods shall be Type 30 or for straps W30 as manufactured by Mason Industries, Inc.

2.6 HORIZONTAL THRUST RESTRAINTS

A. When total air thrust exceeds 10% of the isolated weight, floor mounted or suspended air handling equipment shall be protected against excessive displacement by the use of horizontal thrust restraints. The restraint shall consist of a modified spring mounting. Restraint springs shall have the same deflection as the isolator springs. The assembly shall be preset at the factory and adjusted in the field to allow for a maximum of 1/4" movement from stop to maximum thrust. The assemblies shall be furnished with rod and angle brackets for attachment to both the equipment and duct work or structure. Attach restraints at the centerline of thrust and symmetrically on both sides of the unit. Horizontal thrust restraints shall be WB as manufactured by Mason Industries, Inc.

2.7 STEEL BASES

A. General: Vibration isolation manufacturer shall furnish integral structural steel bases. Rectangular bases are standard for all equipment. Centrifugal refrigeration machines and pump bases may require T or L shapes. Pump bases for split case pumps shall be of the dimensions to support suction and discharge elbows. All perimeter members shall be steel beams with a minimum depth equal to 1/10 of the longest dimension of the base. Base depth shall not exceed 14" if the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Provide height saving brackets in all mounting locations for a base clearance of 1". Bases shall be type WF as manufactured by Mason Industries, Inc.

B. Partial Bases: Vibration isolation manufacturer shall provide steel members welded to height saving brackets to cradle equipment having legs or bases that do not require a complete supplementary base. Members shall have sufficient rigidity to prevent distortion of equipment. Inverted saddles shall be type ICS, as manufactured by Mason Industries, Inc.

C. Floating Bases: Manufacturer shall furnish rectangular steel concrete pouring forms for floating concrete bases. Bases for split case pumps shall be of sufficient size to provide support for suction and discharge elbows. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6". The base depth need not exceed 12" unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include minimum concrete reinforcing consisting of 1/2" bars welded in place on 6" centers running both ways in a layer 1-1/2" above the bottom. Furnish forms with steel templates to hold the anchor bolt sleeves and anchor bolts while pouring concrete. Employ height-saving brackets in all mounting locations to maintain a 1" clearance below the base. Wooden formed bases are not acceptable. Base shall be type BMK or K as manufactured by Mason Industries, Inc.

2.8 VIBRATION ISOLATION CURBS

A. Curb mounted rooftop equipment shall be mounted on spring isolation curbs. The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive to resiliently resist wind forces. All directional neoprene snubber bushings shall be a minimum of 1/4" thick. Steel springs shall be laterally stable and rest on 1/4" thick neoprene acoustical pads. Hardware shall be plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curbs waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2" of insulation. Curb shall be type RSC as manufactured by Mason Industries, Inc.

2.9 FLEXIBLE STAINLESS STEEL HOSE

A. Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3" and larger shall be flanged. Smaller sizes may have male nipples. Minimum lengths shall be as tabulated:

Flanged

3" x 14" (75 x 350mm)	6" x 20" (150 x 500mm)	12" x 28" (300 x 700mm)
4" x 15" (100 x 375mm)	8" x 22" (200 x 550mm)	14" x 30" (350 x 750mm)
5" x 19" (125 x 475mm)	10" x 26" (250 x 650mm)	16" x 32" (400 x 800mm)

Male Nipples

1/2" x 9" (12 x 225mm)	1-1/4" x 12" (32 x 300mm)	2" x 14" (50 x 350mm)
3/4" x 10" (19 x 250mm)	1-1/2"x 13" (38 x 325mm)	2-1/2" x 18" (64 x 450mm)
1" x 11" (25 x 275mm)		

B. At equipment, hoses shall be installed on the equipment side of the shut off valves horizontal and parallel to the equipment shafts wherever possible. Hoses shall be type BSS as manufactured by Mason Industries, Inc.

2.10 SPLIT SEALS

A. Split Seals consist of pipe halves with minimum 3/4" thick neoprene sponge cemented to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall or ceiling if the seal is not in place prior to the construction of the building member. Seals shall project a minimum of 1" past either face of the wall. Where temperatures exceed 240°F, 10 lb. density fiberglass may be used in lieu of the sponge. Seals shall be Type SWS as manufactured by Mason Industries, Inc.

2.11 HORIZONTAL PIPE ISOLATION

A. The first four pipe hangers in the main lines near the mechanical equipment shall be as described Paragraph 2.5B. Hangers supporting piping 2" and larger in all other locations throughout the building shall be isolated by hangers as described in Paragraph 2.5A. Floor supported piping shall rest on isolators as described in Paragraph 2.5B. Heat exchangers and expansion tanks are considered part of the piping run. The first four isolators from the isolated equipment shall have the same static deflection as specified for the mountings under the connected equipment. If piping is connected to equipment located in basements and hangs from ceilings under occupied spaces the first four hangers shall have 0.75" deflection for pipe sizes up to and including 3", 1-1/2" deflection for pipe sizes over 3" and up to and including 6", and 2-1/2" deflection thereafter. Where piping connects to mechanical equipment install expansion joints as shown in Paragraph 2.10 or stainless hoses as shown in Paragraph 2.11. All piping passing through the equipment walls, floors or ceilings shall be protected against sound leakage by means of an acoustical seal, as described in Paragraph 2.12.

2.12 VERTICAL PIPE ISOLATION

A. Support vertical risers by spring isolators, designed to support the riser filled with water, if it is a water line. Assigned loads must be within the building design limits at the support points. Neutral central resilient anchors close to the center of the run shall direct movement up and down. The anchors shall be capable of holding an upward force equal to the water weight when the system is drained. If one level cannot accommodate this force, anchors can be located on 2 or 3 adjacent floors. Resilient guides shall be spaced and sized properly depending on the pipe diameter. Submittals must include the initial load, initial deflection, change in deflection, final load and change in load at all spring and anchor support locations, as well as guide spacing. The initial spring deflection shall be a minimum of 0.75", or four times the thermal movement at the isolator location, whichever is greater. Calculations shall include pipe stress at end conditions and branch off locations and the manufacturer must include installation instructions. Submittal must be stamped and signed by a licensed professional engineer in the employ of the vibration vendor for at least 5 years. Proper provision shall be made for seismic protection in seismic zones. The isolator manufacturer shall be the same firm supplying the mechanical contract. Support

spring mountings, anchors, and telescoping guides shall be in accordance with previous paragraphs of this section.

2.13 DUCT ISOLATION

A. All air ducts with a cross section of 2 square feet or larger shall be isolated from the building structure by hangers as shown in Paragraph 2.5C or floor supports with a minimum deflection of 0.75". Isolators shall continue for 50' from the equipment. If air velocity exceeds 1000 fpm, hangers or supports shall continue for an additional 50' or as shown on the drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

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

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

3.2 GENERAL

A. All vibration isolators must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

B. Installation of vibration isolators must not cause any change of position of equipment, piping or duct work resulting in stresses or misalignment.

C. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.

D. The contractor shall not install any equipment, piping, duct or conduit which makes rigid connections with the building. This includes, but is not limited to, slabs, beams, columns, studs and walls.

E. Coordinate work with other trades to avoid rigid contact with the building.

F. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the architects/engineer's attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible contractor's expense.

G. Bring to the architects/engineer's attention any discrepancies between the specifications and the field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the responsible contractor's expense.

H. Correct, at no additional cost, all installations which are deemed defective in workmanship and materials at the contractor's expense.

I. Hand built elastomeric expansion joints may be used when pipe sizes exceed 24" or specified movements exceed specified capabilities.

J. Where piping passes through walls, floors or ceilings the vibration isolation manufacturer shall provide seals as described in this specification.

K. Locate isolation hangers as near to the overhead support structure as possible.

L. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust when thrust forces exceed 10% of the equipment weight. Horizontal thrust restraints shall be in accordance with this specification.

M. Rooftop equipment isolators must be bolted to the equipment and structure. Mountings must be designed to resist 100 mph wind loads.

3.3 VIBRATION ISOLATION OF PIPING

A. Horizontal pipe shall be installed in accordance with 2.12 Horizontal Pipe Isolation.

B. Risers shall be installed in accordance with 2.13 Riser Isolation.

3.4 VIBRATION ISOLATION OF DUCTWORK

A. All duct runs shall be installed in accordance with 2.14 Duct Isolation.

3.5 ISOLATOR SCHEDULE

	Basement Slab Or Slab On Grade		Upper Floors	
Equipment	*Paragraph*	*Min Static Deflect*	*Paragraph*	*Min Static Deflect*
Packaged Air Handling Units				
Rooftop Units	-	-	2.9	1.0
Condensing Units				
			2.4B	2.0
Power Roof Exhausters Roof Mounted			2.8	1.0

END OF SECTION

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED WORK

A. Specified elsewhere:

1. 23 05 23 General-Duty Valves for HVAC Piping

1.2 SUMMARY

A. Section Includes:

1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Valve tags.
6. Warning tags.
7. Sample Schedules.

1.3 SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label. An electronic copy and hard copy will be provided to the using agency before preliminary acceptance. Furnish extra copies (in addition to mounted copies) for Maintenance.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals. An electronic copy and hard copy will be provided to the using agency before preliminary acceptance. Furnish extra copies (in addition to mounted copies) for Maintenance.

1.4 QUALITY ASSURANCE

A. Follow manufacturer's recommended installation procedures.

B. As applicable, comply with ASME A13.1 "Scheme for the Identification of Piping System"

1.5 DELIVERY, STORAGE AND HANDLING

A. Store materials in a dry and secure area on-site and protect against dirt and moisture damage

B. Do not apply or install damaged materials.

1.6 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with locations of access panels and doors.

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

1.7 WARRANTY

A. Provide warranty on materials and labor for 18 months starting from date of delivery, or one year from date of substantial completion, whichever is longer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Seton
2. Brady
3. Best
4. Milwaukee

2.2 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch or Stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Letter Size: 4 by 2 inch. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
3. Fasteners: Stainless-steel self-tapping screws.
4. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

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

2.3 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: Yellow.

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-fourths the size of principal lettering.

G. Fasteners: Stainless-steel 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. Coordinate with Architect and CDB for specific warning label information to be included.

2.4 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction. Do not provide labels for bare pipes conveying fluids at temperatures of 125 °F or higher.

B. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, 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: At least 1-1/2 inches high.

2.5 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-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, 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.
2. Lettering Size: At least 1-1/2 inches high.

2.6 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch or Stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass beaded chain.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-tag schedule shall be included in operation and maintenance data. See Sample Valve Tag Schedule at the end of this Specification.

2.7 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.

1. Size: 4 by 7 inches.
2. Fasteners: Reinforced grommet and wire.
3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 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 Division 09 Section " Painting”

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

1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
4. 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 25 feet along each run. Reduce intervals to 15 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. LP Gas Piping

   a. Background Color: Yellow.
   b. Letter Color: Black.

2. Refrigerant Piping:

   a. Background Color: White.
   b. Letter Color: Black.

3. Condensate Drain Piping:

   a. Background Color: White.
   b. Letter Color: Black.

3.4 DUCT LABEL INSTALLATION

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

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

B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

A. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:

   a. Refrigerant: 2 inches, round..

2. Valve-Tag Color:

   a. Refrigerant: Natural.

3. Letter Color:

   a. Condenser Water: Black.
   b. Refrigerant: Black.

c. Gas: Black.

3.6 WARNING-TAG INSTALLATION

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

3.7 SAMPLE SCHEDULES

A. The following tables are examples of schedules required to be submitted by the Contractor. Examples of the kinds of information to be included are in the first row in these tables.

CHILLED-WATER, VALVE-TAG SCHEDULE

VALVE NUMBER	VALVE TYPE	VALVE SIZE	VALVE LOCATION	NORMAL OPERATING POSITION	REMARKS
CHWS-1	GATE	NPS 2	MECHANICAL ROOM M-1	OPEN	

EQUIPMENT LABEL SCHEDULE

EQUIPMENT IDENTIFICATION	EQUIPMENT LOCATION	SPECIFICATION SECTION		REMARKS
		NUMBER	TITLE	
AHU-1	MECHANICAL ROOM M-215	23 xx xx		MODULAR INDOOR AIR-HANDLING UNITS

3.8 CLEANING

A. Follow manufacturer’s instructions for surface preparation prior to application or installation.

B. Follow Manufacturer’s instructions for cleaning labels and tags.

END OF SECTION

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED WORK

A. Specified elsewhere:

1. 23 08 00 Commissioning of HVAC.

B. Materials Installed but furnished by others: NA

C. Furnished, but installed by others: NA

1.2 SUMMARY

A. This Section includes work related to TAB where the TAB contractor is under direct contract to the Owner. Under no circumstances shall the TAB contractor be a sub-contractor to the General or Mechanical Contractor.

B. Section includes procedural requirements for testing, adjusting, and balancing (TAB) of new systems to achieve the required flows within the limits of the fan and the motor HP. The testing, adjusting, and balancing work includes producing design objectives for the following:

1. Air Systems:

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

2. Miscellaneous Systems:

a. Motors.
b. Condensing Units.

3. HVAC equipment quantitative-performance settings.

1.3 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 Firm: Entity responsible for performing and reporting TAB procedures.

F. TAB Specialist: Entity engaged by TAB Firm to perform TAB work.

1.4 SUBMITTALS

A. Qualification Data: Within 45 days of Notice to Proceed, submit documentation for the TAB contractor and the Project's TAB team members.

B. Contract Documents Examination Report: Within 30 days of Notice to Proceed, submit the Contract Documents Examination Report.

C. TAB Plan: Within 60 days of Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. Certified TAB reports. Submit two copies of the TAB reports prepared as specified in this specification on approved forms certified by the TAB contractor.

E. LEED Submittal:

1. Air-Balance Report for LEED Prerequisite EQ 1: Documentation of work performed for ASHRAE 62.1-2007, Section 7.2.2, "Air Balancing."

F. Sample report forms. Submit two copies of the sample TAB report forms

G. Instrument calibration reports, including the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC, NEBB, or TABB.

1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC, NEBB or TABB.
2. TAB Technician: Employee of the TAB contractor and who is certified by AABC, NEBB or TABB as a TAB technician.

B. TAB Conference: Prior to the start of the TAB work, and at Contractor's direction, coordinate a meeting at the Site to review the TAB strategies and procedures plan and to develop a mutual understanding of the details of the work involved. The meeting shall include the Architect, the Owner, [the Commissioning Authority (CxA),] the TAB field supervisor, and the TAB technicians. Provide at least seven days' advance notice of meeting date and time.

1. Agenda Items:

a. The Contract Documents examination report.
b. The TAB plan.
c. Coordination and cooperation of trades and subcontractors.
d. Coordination of documentation and communication flow.
e. Submittal distribution requirements.
f. Work Schedule and Project-Site requirements.

C. Certification of TAB Reports: Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard TAB forms from NEBB, AABC or TABB as well as providing any additional information required by this specification.

E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

F. Engineers reserves the right to select at random 10% of the TAB report data for field verification witnessed by the commission agent. The TAB contractor will be given sufficient notice of the date of field verification. The same instruments that were used when the original test was recorded shall be used. A failure of more than 10% of the selected field verification items shall result in a repeat of the testing of the entire system at the TAB contractor's expense. The repeated work is also subject to field verification.

1.6 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.

B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

C. Perform TAB after leakage and pressure tests on air distribution systems have been satisfactorily completed.

1.7 WARRANTY

A. Provide warranty in accordance with AABC, NEBB or TABB standards:

1. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents.
2. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents.
3. Guarantee shall include the following provisions:

    a. The certified TAB firm has tested and balanced systems according to the Contract Documents.
    b. Systems are balanced to optimum performance capabilities within design and installation limits.

1.8 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 9100 Commissioning. Testing of these systems is required, in cooperation with the Using Agency and the Commissioning Authority. Refer to Section 01 9100 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents and field conditions to become familiar with Project requirements and to discover conditions that may preclude proper TAB of systems and equipment.

B. Examine systems for installed 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 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 used for return air to verify that they meet the leakage class of connected ducts as specified in Division 23 Section "Metal Ducts," and are properly separated from adjacent areas. Verify that penetrations in plenum walls are properly sealed or, as required, fire-stopped.

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 filters and verify that bearings are greased, belts are aligned and tight, 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 screens are clean and proper perforations are provided. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine equipment for installation and properly operating safety interlocks and controls.

M. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

A. Prepare a TAB Plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:

1. Permanent electrical-power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.

6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

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," ASHRAE 111, NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing," and this Section.

1. Comply with requirements in ASHRAE 62.1-2007, Section 7.2.2, "Air Balancing."

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.

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.

E. HVAC system lineup. The contractor will test the system in the normal system lineups.

1. A hydronic system with two chillers designed to run at the same time, the system will be balanced with pumps flowing to both chillers. All pump data will also be collected when the pump is flowing to only one chiller.
2. Air systems will be balanced while aligned for minimum outside air flow and the position of the outside air dampers will be recorded for the minimum position.
3. It s not acceptable to balance air systems when the normal boundaries, doors, walls, or ductwork are not in their design configuration.

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. Crosscheck 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. Check for proper sealing of air duct system.

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 and within the limits of the motor HP. All fans shall deliver the design air flow capacity at actual static pressure up to design static. Fan sheaves shall be replaced as necessary to obtain desired results.

1. Measure total airflow.

a. Where sufficient space in ducts is unavailable for Pitot-tube-traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:

a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
b. Measure static pressure directly at the fan outlet or through the flexible connection.
c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
5. 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.
6. 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 will occur. 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, sub-main ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of sub-main and branch ducts.

a. Where sufficient space in sub-main and branch ducts is unavailable for Pitot-tube-traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
3. Re-measure each sub-main and branch duct after all have been adjusted. Continue to adjust sub-main and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within 5% tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within 5% tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.

A. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.6 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

1. Minimum outside air flow rate must be verified under three conditions, with the OA damper position recorded in each configuration.

a. System operating with all boxes at minimum primary air flow.
b. System at maximum supply flow (diversity may not allow all boxes to be open).
c. System flow halfway between box minimum and maximum.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure 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.
3. Measure total system airflow. Adjust to within 5% indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

6. Re-measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record final fan-performance data.

3.7 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.8 TEMPERATURE-CONTROL VERIFICATION

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Check free travel and proper operation of control devices such as damper and valve operators.

F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow flow measurements. Note the speed of response to input changes.

G. Check the interaction of electrically operated switch transducers.

H. Check the interaction of interlock and lockout systems.

I. Check main control supply-air pressure and observe compressor and dryer operations.

J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or nongrounded power supply.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.9 TOLERANCES

A. Set HVAC system air flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 5 percent.
2. Air Outlets and Inlets: Plus or minus 5 percent.

3.10 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

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.

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 contractor.
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. Duct, outlet, and inlet sizes.
3. Pipe and valve sizes and locations.
4. Terminal units.
5. Balancing stations.
6. 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 air flow 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. Cooling coil static-pressure differential in inches wg.
    g. Heating coil static-pressure differential in inches wg.

h. Outdoor airflow in cfm.
i. Return airflow in cfm.
j. Outdoor-air damper position.
k. Return-air damper position.

B. 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.
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. Air flow 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. W
i. Refrigerant expansion valve and refrigerant types.
j. Refrigerant suction pressure in psig.
k. Refrigerant suction temperature in deg F.

F. Gas- Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btu/h.
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and rpm.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Center-to-center dimensions of sheave, and amount of adjustments in inches.

2. Test Data (Indicated and Actual Values):

a. Total air flow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

G. 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.

H. 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 air flow rate in cfm.
h. Indicated velocity in fpm.
i. Actual air flow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

I. 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. Air flow rate in cfm
b. Air velocity in fpm
c. Preliminary air flow rate as needed in cfm
d. Preliminary velocity as needed in fpm
e. Final air flow rate in cfm
f. Final velocity in fpm
g. Space temperature in deg F
h.

J. Compressor and Condenser Reports: For refrigerant side of unitary systems, stand-alone refrigerant compressors, air-cooled condensing units, include the following:

1. Unit Data:

a. Unit identification.
b. Location.
c. Unit make and model number.
d. Compressor make.
e. Compressor model and serial numbers.
f. Refrigerant weight in lb.
g. Low ambient temperature cutoff in deg F.

2. Test Data (Indicated and Actual Values):

a. Inlet-duct static pressure in inches wg.
b. Outlet-duct static pressure in inches wg.
c. Entering-air, dry-bulb temperature in deg F.
d. Leaving-air, dry-bulb temperature in deg F.
e. Control settings.
f. Unloader set points.

g. Low-pressure-cutout set point in psig.
h. High-pressure-cutout set point in psig.
i. Suction pressure in psig.
j. Suction temperature in deg F.
k. Condenser refrigerant pressure in psig.
l. Condenser refrigerant temperature in deg F.
m. Oil pressure in psig.
n. Oil temperature in deg F.
o. Voltage at each connection.
p. Amperage for each phase.
q. Kilowatt input.
r. Crankcase heater kilowatt.
s. Number of fans.
t. Condenser fan rpm.
u. Condenser fan airflow rate in cfm.
v. Condenser fan motor make, frame size, rpm, and horsepower.
w. Condenser fan motor voltage at each connection.
x. Condenser fan motor amperage for each phase.

K. Condenser Test Reports: For condensers, include the following:

1. Unit Data:

a. Unit identification.
b. Make and type.
c. Model and serial numbers.
d. Nominal cooling capacity in tons.
e. Refrigerant type and weight in lb.
f. Number and type of fans.
g. Fan motor make, frame size, rpm, and horsepower.
h. Fan motor voltage at each connection.

2. Air Data (Indicated and Actual Values):

a. Duct airflow rate in cfm.
b. Inlet-duct static pressure in inches wg.
c. Outlet-duct static pressure in inches wg.
d. Average entering-air, wet-bulb temperature in deg F.
e. Average leaving-air, wet-bulb temperature in deg F.
f. Ambient wet-bulb temperature in deg F.

C. Air-to-Air Heat-Recovery Unit Reports:

3. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and type.
e. Model and serial numbers.

4. Motor Data:

a. 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. Sheave dimensions, center-to-center, and amount of adjustments in inches.

5. If fans are an integral part of the unit, include the following for each fan:

a. Make and type.
b. Arrangement and size.
c. Sheave make, size in inches, and bore.
d. Sheave dimensions, center-to-center, and amount of adjustments in inches.

6. Test Data (Indicated and Actual Values):

a. Total exhaust airflow rate in cfm.
b. Purge exhaust airflow rate in cfm.
c. Outside airflow rate in cfm.
d. Total exhaust fan static pressure in inches wg.
e. Total outside-air fan static pressure in inches wg.
f. Pressure drop on each side of recovery wheel in inches wg.
g. Exhaust air temperature entering in deg F.
h. Exhaust air temperature leaving in deg F.
i. Outside-air temperature entering in deg F.
j. Outside-air temperature leaving in deg F.
k. Calculate sensible and total heat capacity of each airstream in MBh.

L. 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 INSPECTIONS

A. Initial Inspection:

1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
2. Check the following for each system:

a. Measure airflow of at least 5 percent of air outlets.
b. Measure water flow of at least 5 percent of terminals.
c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
d. Verify that balancing devices are marked with final balance position.
e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by the Engineer.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of the Board Authorized Representative.
3. The engineer 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.
4. 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."
5. 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.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:

1. 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, Engineer may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. 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

SECTION 230700 - HVAC INSULATION

PART 1 - GENERAL

1.1 RELATED WORK

A. Specified elsewhere:
   1. Section 23 31 13 “Metal Ducts" .

B. Materials Installed but furnished by others: NA

C. Furnished, but installed by others: NA

1.2 SUMMARY

A. Section Includes:

   1. Insulation Materials:
      a. Flexible elastomeric.
      b. Mineral fiber.
      c. Polyisocyanurate.

   2. Fire-rated insulation systems.
   3. Insulating cements.
   4. Adhesives.
   5. Mastics.
   6. Lagging adhesives.
   7. Sealants.
   8. Factory-applied jackets.
   9. Field-applied jackets.
   10. Identification
   11. Tapes.
   12. Securements.
   13. Corner angles.

1.3 DEFINITIONS

A. Hot Surfaces: Normal operating temperatures of 100 deg F or higher.

B. Dual-Temperature Surfaces: Normal operating temperatures that vary from hot to cold.

C. Cold Surfaces: Normal operating temperatures less than 75 deg F.

D. Thermal Resistivity: "R-values" represent the reciprocal of thermal conductivity (K-value). Thermal conductivity is the rate of heat flow through a homogeneous material exactly 1 inch thick. Thermal resistivities are expressed by the temperature difference in degrees F between two exposed faces required to cause one Btu to flow through one square foot of material, in one hour, at a given mean temperature.

E. Density: Is expressed in lb/cu. ft.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include thermal conductivity, thermal resistivity (R-value), thickness, and jackets (both factory and field applied, if any).

B. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties, equipment connections, and access panels.
6. Detail application of field-applied jackets.
7. Detail application of Identification
8. Detail application at linkages of control devices.
9. Detail field application for each equipment type.
10. Detail outdoor duct insulation installation.

C. Samples: For each type of insulation jacket, and identification indicated. Identify each Sample, describing product and intended use.

1. Sample Sizes:

a. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
b. Sheet Form Insulation Materials: 12 inches square.
c. Jacket Materials for Pipe: 12 inches long by NPS 2.
d. Sheet Jacket Materials: 12 inches square.
e. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

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

E. LEED Submittals:

1. Product Data for Credit EQ 4.1: For adhesives and sealants installed within the building interior, submit one of the following:

a. Documentation indicating compliance 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," including 2004 Addenda.
b. Documentation indicating compliance with the VOC limits established in South Coast Air Quality Management District (SCAQMD) Rule #1168.

1.5 QUALITY ASSURANCE

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

B. Fire-Test-Response Characteristics: Except where indicated otherwise, insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by UL or another testing and inspecting agency acceptable to the authorities having jurisdiction. Identify materials with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors:

a. Flame-Spread Index: 25 or less.
b. Smoke-Developed Index: 50 or less.

2. Insulation Installed Outdoors:

a. Flame-Spread Index: 75 or less.
b. Smoke-Developed Index: 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Project site in original packages and containers with seals unbroken and bearing manufacturer's original labels, including manufacturer's name, product name, and directions for storing, handling, and use.

B. Store materials in a clean, dry, fully enclosed, conditioned space where they will be protected against damage from moisture, humidity, temperature extremes, direct sunlight, surface contamination, and other causes.

1. Remove damaged or wet insulation from Project site.

1.7 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

1.9 WARRANTY

A. Provide warranty on materials and labor for 18 months starting from date of delivery, or one year from date of Preliminary Acceptance or Substantial Completion, whichever is longer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers and Products: Subject to compliance with requirements, provide one of the following products for each of the products identified:

1. Flexible Elastomeric Insulation:

    a. Aeroflex USA Inc.; Aerocel.
    b. Armacell LLC; AP Armaflex.
    c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

2. Mineral-Fiber Blanket Insulation:

    a. CertainTeed Corp.; Duct Wrap.
    b. Johns Manville; Microlite.
    c. Owens Corning; All-Service Duct Wrap.

3. Mineral-Fiber Board Insulation:

    a. CertainTeed Corp.; Commercial Board.
    b. Fibrex Insulations Inc.; FBX.
    c. Johns Manville; 800 Series Spin-Glas.
    d. Knauf Insulation; Insulation Board.
    e. Manson Insulation Inc.; AK Board.
    f. Owens Corning; Fiberglas 700 Series.

4. Mineral-Fiber, Preformed Pipe Insulation:

    a. Fibrex Insulations Inc.; Coreplus 1200.
    b. Johns Manville; Micro-Lok.
    c. Knauf Insulation; 1000 Pipe Insulation.
    d. Owens Corning; Fiberglas Pipe Insulation.

5. Mineral-Fiber, Pipe and Tank Insulation:

    a. CertainTeed Corp.; CrimpWrap.
    b. Johns Manville; MicroFlex.
    c. Knauf Insulation; Pipe and Tank Insulation.
    d. Manson Insulation Inc.; AK Flex.
    e. Owens Corning; Fiberglas Pipe and Tank Insulation.

6. Polyisocyanurate Insulation:

    a. Apache Products Company; ISO-25.
    b. Dow Chemical Company (The); Trymer.
    c. Duna USA Inc.; Corafoam.
    d. Elliott Company; Elfoam.

7. Mineral-Fiber Insulating Cement:

    a. Insulco, Division of MFS, Inc.; Triple I.
    b. P. K. Insulation Mfg. Co., Inc.; Super-Stik.

8. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement:

a. Insulco, Division of MFS, Inc.; SmoothKote.
b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.
c. Rock Wool Manufacturing Company; Delta One Shot.

9. Polyisocyanurate,Adhesive:

a. Childers Products, Division of ITW; CP-96.
b. Foster Products Corporation, H. B. Fuller Company; 81-33.

10. Flexible Elastomeric and Polyolefin Adhesive:

a. Aeroflex USA Inc.; Aeroseal.
b. Armacell LCC; 520 Adhesive.
c. Foster Products Corporation, H. B. Fuller Company; 85-75.
d. RBX Corporation; Rubatex Contact Adhesive.

11. Mineral-Fiber Adhesive:

a. Childers Products, Division of ITW; CP-82.
b. Foster Products Corporation, H. B. Fuller Company; 85-20.
c. ITW TACC, Division of Illinois Tool Works; S-90/80.

12. ASJ Adhesive, and FSK Adhesive:

a. Childers Products, Division of ITW; CP-82.
b. Foster Products Corporation, H. B. Fuller Company; 85-20.
c. ITW TACC, Division of Illinois Tool Works; S-90/80.

13. PVC Jacket Adhesive:

a. Dow Chemical Company (The); 739, Dow Silicone.
b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
c. Speedline Corporation; Speedline Vinyl Adhesive.

14. Vapor-Barrier Mastic:

a. Childers Products, Division of ITW; CP-35.
b. Foster Products Corporation, H. B. Fuller Company; 30-90.
c. ITW TACC, Division of Illinois Tool Works; CB-50.
d. Vimasco Corporation; 749.

15. Lagging Adhesives:

a. Childers Products, Division of ITW; CP-52.
b. Foster Products Corporation, H. B. Fuller Company; 81-42.
c. Vimasco Corporation; 136.

16. Joint Sealants for Cellular-Glass, Phenolic, and Polyisocyanurate Products:

a. Childers Products, Division of ITW; CP-76.
b. Foster Products Corporation, H. B. Fuller Company; 30-45.
c. Pittsburgh Corning Corporation; Pittseal 444.
d. Vimasco Corporation; 750.

17. Metal Jacket Flashing Sealants:

a. Childers Products, Division of ITW; CP-76-8.
b. Foster Products Corporation, H. B. Fuller Company; 95-44.
c. Vimasco Corporation; 750.

18. ASJ Flashing Sealants and PVC Jacket Flashing Sealants:

a. Childers Products, Division of ITW; CP-76.

19. PVC Jacket:

a. Johns Manville; Zeston.
b. P.I.C. Plastics, Inc.; FG Series.
c. Proto PVC Corporation; LoSmoke.
d. Speedline Corporation; SmokeSafe.

20. Metal Jacket:

a. Childers Products, Division of ITW; Metal Jacketing Systems.
b. IDC Corporation.
c. RPR Products, Inc.; Insul-Mate.

21. Identification:

a. Seton.
b. Brady.
c. Best.
d. Milwaukee.

22. ASJ Tape:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
b. Compac Corp.; 104 and 105.
c. Ideal Tape Co., Inc., an American Biltrite Company; 428 AWF ASJ.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

23. FSK Tape:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
b. Compac Corp.; 110 and 111.
c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/SQ.

24. PVC Tape:

a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0555.
b. Compac Corp.; 130.
c. Ideal Tape Co., Inc., an American Biltrite Company; 370 White PVC tape.
d. Venture Tape; 1506 CW NS.

25. Bands:

a. Childers Products; Bands.
b. IDC Corporation.
c. RPR Products, Inc.; Bands.

26. Insulation Pins and Hangers:

    a. AGM Industries, Inc.; CWP-1.
    b. GEMCO; Cupped Head Weld Pin.
    c. Midwest Fasteners, Inc.; Cupped Head.
    d. Nelson Stud Welding; CHP

27. Wire:

    a. C & F Wire.
    b. Childers Products.
    c. PABCO Metals Corporation.
    d. RPR Products, Inc.

2.2 INSULATION MATERIALS

A. Comply with requirements in PART 3 schedule articles for where insulating materials shall be applied.

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

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

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

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

F. Flexible Elastomeric: 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 Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

H. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. For equipment applications, provide insulation with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

I. Mineral-Fiber, Preformed Pipe Insulation:

J. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied FSK jacket complying with ASTM C 1393, Type II or Type IIIA Category 2. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg For less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

K. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.

    1. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F at 75 deg F after 180 days of aging.
    2. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to 1-1/2 inches as tested by ASTM E 84.

3. Fabricate shapes according to ASTM C 450 and ASTM C 585.
4. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.

    a. Pipe Applications: ASJ.
    b. Equipment Applications: ASJ.

2.3 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

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

2.4 ADHESIVES

A. Adhesives, General: All adhesives and mastics installed within the building envelope shall be shown to comply either 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," including 2004 Addenda, or with the VOC limits established in South Coast Air Quality Management District (SCAQMD) Rule #1168.

    1. Aerosol adhesives shall comply with Green Seal Standard for Commercial Adhesives GS-36 (2000).

B. Compatibility: 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.

C. Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.

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

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

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

G. PVC Jacket Adhesive: Compatible with PVC jacket.

H. Mastics: Comply with MIL-C-19565C, Type II. Materials shall be compatible with insulation materials, jackets, and substrates.

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

        a. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 permat 43-mildry film thickness.
        b. Service Temperature Range: Minus 20 to plus 180 deg F
        c. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
        d. Color: White.

2.5 Lagging Adhesives: Comply with MIL-A-3316C Class I, Grade A. Materials shall be compatible with insulation materials, jackets, and substrates.

    a. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.

b. Service Temperature Range: Minus 50 to plus 180 deg F.
c. Color: White.

2.6 SEALANTS

A. Sealants, General: All sealants installed within the building envelope shall be shown to comply either 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," including 2004 Addenda, or with the VOC limits established in South Coast Air Quality Management District (SCAQMD) Rule #1168.

B. 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.

C. 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.

D. ASJ Flashing Sealants 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.

2.7 JACKETS

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

B. Field-Applied Jackets: Comply with ASTM C 921, Type I, unless otherwise indicated. Field-applied jackets shall be provided on all piping below 8 ft. height.

1. PVC Jackets: 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.

a. Adhesive: As recommended by jacket material manufacturer.
b. Color: White.
c. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

1) 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. Factory-fabricated tank heads and tank side panels.

2. Metal Jackets:

a. Stainless-Steel Jackets: ASTM A 167 or ASTM A 240.

1) Sheet and roll stock ready for shop or field sizing.
2) Material, finish, and thickness are indicated in field-applied jacket schedules.
3) Moisture Barrier for Indoor Applications: 1-mil-thick, heat-bonded polyethylene and kraft paper.
4) Moisture Barrier for Outdoor Applications: 2.5-mil-thick Polysurlyn.
5) Factory-Fabricated Fitting Covers: Fabricated from the same material, finish, and thickness as jacket. Provide factory-fabricated covers for preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows; tee covers; flange and union covers; end caps; beveled collars; and valve covers. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

b. Aluminum Jackets: Comply with ASTM B 209, Alloy 3003, Temper H-14.

1) Sheet and roll stock ready for shop or field sizing.
2) Finish and thickness are indicated in field-applied jacket schedule.
3) Moisture Barrier for Indoor Applications: 3-mil thick Polysurlyn.
4) Moisture Barrier for Outdoor Applications: 3-mil thick Polysurlyn.
5) Factory-Fabricated Fitting Covers: Fabricated from the same material, finish, and thickness as jacket. Provide factory-fabricated covers for preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows; tee covers; flange and union covers; end caps; beveled collars; and valve covers. Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.8 IDENTIFICATION

A. General: Products specified are manufacturer’s standard products of categories and types required for each application as referenced in other Division 23 Sections. Where more than single type is specified for listed application, selection is Installer’s option but provide single selection for each product category.

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

1. Seton.
2. Brady.
3. Best.
4. Milwaukee.

C. Snap-On Plastic Pipe Markers: Manufacturer's standard pre-printed, semi-rigid snap-on, color-coded pipe markers.

1. Lettering: Use piping system terms as indicated and abbreviate only as necessary for each application length.
2. Arrows: Either integrally with piping system service lettering (to accommodate both directions), or as separate unit, on each pipe marker to indicate direction of flow.

D. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in mechanical identification, with corresponding designations indicated. Use numbers, letters, and terms indicated for proper identification, operation, and maintenance of mechanical systems and equipment.

1. Multiple Systems: Where multiple systems of same name are indicated, identify individual system number as well as service.

E. Color Coding:

	Background	Lettering
1. Air Conditioning Condensate	Grey	White
2. Refrigerant Suction/ Hot Gas	Clear	Black
3.		

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.

2.10 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.020-inchthick, 3/4-inchwide with wing or closed seal.
2. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following:

    a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
    b. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
    c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

4. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following:

    a. Baseplate: Perforated, nylon sheet, 0.030 inch thick by 1-1/2 inches in diameter.
    b. Spindle: Nylon, 0.106-inch- diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches.
    c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

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

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

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

    a. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

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

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

D. Wire: 0.062-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. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240, Type 304 or Type 316.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

A. 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, if any. Comply with requirements for heat tracing that apply to insulation.

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

3.3 INSTALLATION – GENERAL

A. Install insulation materials, accessories, and finishes according to the manufacturer's written instructions with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and 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. Keep insulation materials dry during application and finishing.

E. Install insulation with least number of joints practical.

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

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

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

I. Install vapor barriers on insulated pipes, ductwork, and equipment having surface operating temperatures below 60 deg F.

J. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

K. 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.

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

M. 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.
    b. Exception: Do not staple longitudinal laps on insulation applied to piping systems with a surface temperature at or below 35 deg F.

4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.
6. At penetrations in jackets for thermometers, and pressure gages, fill and seal voids with vapor barrier coating.

N. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

O. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

P. 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.

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

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

3.4 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 in accordance with requirements of approved and tested assembly indicated. 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 Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated.

a. 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.
b. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

2. Pipe: Install insulation continuously through floor penetrations.

3.5 PIPE INSULATION INSTALLATION – GENERAL

A. General: Requirements in this article apply to all insulation materials, unless more specific requirements are indicated for individual pipe insulation types.

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. Pipe Elbows: 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. Tee Fittings: 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. Valves: 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. Strainers: 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. Fittings and Unions: 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, 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, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated on Drawings. 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. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges

with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

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

3.6 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

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 MINERAL-FIBER INSULATION INSTALLATION

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 but 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.

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

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

    a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
    b. On duct sides with dimensions larger than 18 inches place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not over compress insulation during installation.
    e. Impale insulation over pins and attach speed washers.
    f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 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 Fat 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 2 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.

F. 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 over compress 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 1 edge and 1 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 Fat 18-footintervals. 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 2 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.

3.8 POLYISOCYANURATE INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3 o'clock and 9 o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

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, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of polyisocyanurate 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.

3.9 WEATHERPROOF DUCT INSULATION INSTALLATION

A. Provide thickness of polyisocyanurate insulation as indicated in the Schedule at the end of PART 3. Provide on the exterior of all supply, and return, ducts exposed to the weather.

B. Cover insulation with a field-applied jacket.

C. Top of duct insulation shall overlap the side of duct insulation. Side of duct insulation shall overlap the bottom of duct insulation. Provide corner angles at each corner.

D. Top of duct insulation shall be pitched for drainage. Pitch shall be a minimum of 1/2 inch per foot from the high point at the duct horizontal longitudinal centerline to the low points at the outsides of the duct. Insulation thickness at the low points shall be the minimum indicated in the Schedule at the end of PART 3. Duct pitch shall be achieved by either of the following:

1. Tapered insulation.
2. Insulation with tapered fesco board to achieve the pitch.

3. For ducts over 6 ft. wide, tapered continuous wood shims (1 in. wide) running laterally from the duct centerline high point to the low points at the outsides. Shims shall be located at 12 inches o.c. along the length of the duct.

E. Vapor retarder type mastic, or joint sealer, shall be applied on longitudinal and butt joints to prevent moisture and moisture vapor infiltration. Vapor retarder butt joints shall be sealed with 3 in. wide vapor retarder tape.

F. Apply insulation in a solid bed of waterproof adhesive.

G. Tightly wrap the insulation circumferentially with saran film. Overlap the seams by a minimum of 2 inches. Seal the overlapped seams with vapor retarder tape.

H. Secure the insulation with stainless steel bands on 12-inch centers.

I. Jacketing shall be secured with 1/2-inch wide stainless steel bands on 12 inch centers. Rivets, screws, staples, or any other fastener capable of penetrating the underlying vapor retarder shall not be used.

3.10 FIELD-APPLIED JACKET INSTALLATION

A. 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.

B. Where Stainless Steel, or Aluminum, 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.

3.11 LABELING AND IDENTIFYING INSTALLATION

A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.

1. Plastic markers with application systems. Install on pipe insulation segment where required for hot non-insulated pipes.

a. Fasten markers on pipes smaller than 6-inch diameter by one of following methods:

1) Snap-on application of pre-tensioned semi-rigid plastic pipe marker.
2) Adhesive lap joint in pipe marker overlap.
3) Laminated or bonded application of pipe marker to pipe (or insulation).
4) Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 3/4-inch wide, lapped 1-1/2 inches minimum at both ends of pipe marker, and covering full circumference of pipe.

b. Fasten markers on pipes 6-inch and larger diameter by one of following methods:

1) Laminated or bonded application of pipe marker to pipe (or insulation).
2) Taped to pipe (or insulation) with color-coded plastic adhesive tape, not less than 1-1/2-inches wide, lapped 3 inches minimum at both ends of pipe marker, and covering full circumference of pipe.
3) Strapped to pipe (or insulation) with manufacturer's standard stainless steel bands.

2. Locate pipe markers and color bands as follows wherever piping is exposed in finished spaces, machine rooms, accessible maintenance spaces (shafts, tunnels, plenums) and exterior non-concealed locations.

    a. Near each valve and control device.
    b. Near each branch connection, excluding short take-offs for fixtures and terminal units. Mark each pipe at branch, where flow pattern is not obvious.
    c. Near penetrations through walls, floors, ceilings, or enter non-accessible enclosures.
    d. At access doors, manholes, and similar access points that permit view of concealed piping.
    e. Near major equipment items and other points of origination and termination.
    f. Spaced at a maximum of 50-feet o.c. along each run. Reduce intervals to 25 feet in congested areas of piping and equipment.
    g. On piping above removable acoustical ceilings, except omit intermediately spaced markers.

3.12 FIELD QUALITY CONTROL

A. Testing Agency: Contractor shall engage a qualified testing agency to 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 for each duct system defined in the Article "Duct Insulation Schedule, General".
2. 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 for each type of equipment requiring insulation for this project. For large equipment, remove only a portion adequate to determine compliance.
3. 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 Article "Piping Insulation Schedule, General".

C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements. Architect may reject all work if sample work is found to be defective.

3.13 DUCT INSULATION PERFORMANCE , GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, supply and outdoor air.
2. Indoor, concealed return located in non-conditioned space.
3. Indoor, return located in non-conditioned space.
4. Indoor, exhaust between isolation damper and penetration of building exterior.
5. Outdoor, supply, return and outdoor air.

B. Items Not Insulated:

1. Factory-insulated flexible ducts.
2. Factory-insulated plenums and casings.
3. Flexible connectors.
4. Vibration-control devices.
5. Factory-insulated access panels and doors.

3.14 DUCT AND PLENUM INSULATION SCHEDULE

A. INSULATION APPLICATION SCHEDULE

1. General: Abbreviations used in the following schedules include:

a. Field-Applied Jackets: P - PVC, K - Foil and Paper, A - Aluminum, SS - Stainless Steel.

B. Indoor, Concealed duct insulation shall be mineral fiber blanket unless indicated otherwise.

C. DUCT SYSTEMS INSULATION SCHEDULE

DUCT LOCATION	OUTSIDE AIR, SUPPLY AIR, EXHAUST AIR (DOWNSTREAM OF DAMPER) INSULATION INSTALLED R-VALUE ($H \cdot Ft^2 \cdot deg$ F/BTU)	RETURN AIR INSULATION INSTALLED R-VALUE ($H \cdot Ft^2 \cdot deg$ F/BTU)
Exterior of Building (Notes 5, 6, 8)	12.0	12.0
Unconditioned Spaces (Notes 2, 5, 6, 7)	6.0	6.0
Indirectly Conditioned Space (Notes 3, 7)	4.0	N/A
Ceiling Cavity / Shafts / Soffits / Mechanical Spaces and Rooms (Notes 4, 5, 6, 7)	6.0	6.0
Exposed Locations within Conditioned Space (Notes 5, 6, 7,9)	N/A	N/A

NOTE 1: INSULATION R-VALUES, MEASURED IN (H X FT^2 X F)/BTU, ARE FOR THE INSULATION AS INSTALLED AND DO NOT INCLUDE FILM RESISTANCE. WHERE EXTERIOR WALLS ARE USED AS PLENUM WALLS, WALL INSULATION SHALL BE AS REQUIRED BY THE MOST RESTRICTIVE CONDITION OF ASHRAE 90.1-2004 SECTION 5 OR 6.4.4.2. INSULATION RESISTANCE MEASURED ON A HORIZONTAL PLANE IN ACCORDANCE WITH ASTM C518 AT A MEAN TEMPERATURE OF 75F AT THE INSTALLED THICKNESS.
NOTE 2: INCLUDING CRAWL SPACES (BOTH VENTILATED/NON-VENTILATED), FRAMED CAVITIES IN WALLS, FLOOR AND CEILING ASSEMBLIES WHICH (A) SEPARATE CONDITIONED SPACE FROM UNCONDITIONED SPACE OR OUTSIDE AIR, AND (B) ARE UNINSULATED ON THE SIDE FACING AWAY FROM CONDITIONED SPACE.
NOTE 3: RETURN AIR PLENUMS WITH OR WITHOUT EXPOSED ROOFS ABOVE.
NOTE 4: CAVITY CONTAINED WITHIN THE INSULATED BUILDING ENVELOPE.
NOTE 5: VAPOR BARRIER REQUIRED.
NOTE 6: FIELD APPLIED JACKET (STAINLESS STEEL, OR ALUMINUM, FOR EXTERIOR APPLICATIONS, PVC FOR INTERIOR EXPOSED LOCATIONS).
NOTE 7: PROVIDE MINERAL FIBER BOARD WITH FIELD APPLIED JACKET (SS, OR A, EXTERIOR, ALL SERVICE INTERIOR) IN EXPOSED LOCATIONS IN LIEU OF MINERAL FIBER BLANKET.
NOTE 8: PROVIDE POLYISOCYANURATE BOARD INSULATION FOR OUTDOOR DUCTWORK
NOTE 9: DO NOT INSULATE DUCTWORK LINED IN ACCORDNACE WITH SECTION 23 31 13.

3.15 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.

3.16 PIPING INSULATION SCHEDULE

A. Abbreviations used in the following schedule include:

1. Field-Applied Jackets: P - PVC, K - Foil and Paper, A - Aluminum, SS - Stainless Steel.
2. Pipe Sizes: NPS - Nominal Pipe Size.

B. Minimum HVAC Pipe Insulation Thickness Table (Non-LEED Projects):

HEATING SYSTEMS (Steam and Hot Water) (Note 1)	FLUID TEMPERATURE RANGE (deg F)	INSULATION TYPE / FIELD-APPLIED JACKET / IDENTIFICATION			PIPE SIZE AND INSULATION THICKNESS (INCHES) (Note 5, 6)				
		Glass Fiber	Polyiso-cyanurate	Flexible Elasto-meric	<1" (Note 4)	1" to <1-1/2"	1-1/2" to <4"	4" to 6"	8" and Larger
COOLING SYSTEMS									
Refrigerant, and Brine	40 – 60	X (Note 2, 7)	X (Note 2, 3, 7)	X (Note 7)	1/2	3/4	1	1	1
	Below 40	X (Note 2, 7)	X (Note 2, 3, 7)	X (Note 7)	1	1-1/2	1-1/2	1-1/2	1-1/2
Indoor Air-Conditioning Condensate Drains	40 – 60	X		X	1/2	3/4	1	1	1

NOTE 1: GLASS-FIBER INSULATION ONLY FOR HYDRONIC PIPING.
NOTE 2: (P), (A), OR (SS) FIELD-APPLIED JACKET ON OUTDOOR INSTALLATIONS, EXPOSED AND CONCEALED.
NOTE 3: FOR OUTDOOR USE ONLY.
NOTE 4: PIPING INSULATION IS NOT REQUIRED BETWEEN THE CONTROL VALVE AND COIL ON RUNOUTS, WHEN THE CONTROL VALVE IS WITHIN 4-FEET OF THE COIL AND THE PIPE SIZE IS 1-INCH OR LESS.
NOTE 5: FOR PIPING EXPOSED TO OUTDOOR AIR, INCREASE INSULATION THICKNESS BY 1-INCH.
NOTE 6: INSULATION THICKNESS IS BASED ON INSULATION HAVING A THERMAL CONDUCTIVITY OF 0.22 – 0.25 BTU·INCH/(H·FT^2·deg F)
NOTE 7: VAPOR BARRIER REQUIRED.
NOTE 8: INDOOR CONDENSER WATER PIPING SHALL NOT BE INSULATED. (SS) FIELD-APPLIED JACKET ON OUTDOOR INSTALLATIONS.

3.17 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material for all piping below 8 ft. height. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. Provide identification for all piping.

C. Piping, Exposed:

1. PVC, White – below 8 ft. height: 20 mils thick.

3.18 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

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

B. Ducts and Plenums, Exposed, up to 48 Inches in Diameter or with Flat Surfaces up to 72 Inches

1. Stainless Steel, Type 304, Smooth 2B Finish: 0.020 inch thick.
2. Aluminum, Alloy 3003, Temper H-14, Smooth Finish: 0.020 inch thick.

C. Ducts and Plenums, Exposed, Larger Than 48 Inches in Diameter or with Flat Surfaces Larger Than 72 Inches:

1. Stainless Steel, Type 304, Smooth Finish: 0.020 inch thick.
2. Aluminum, Alloy 3003, Temper H-14, Smooth Finish: 0.020 inch thick.

D. Piping, Exposed

1. Stainless Steel, Type 304 Smooth 2B Finish 0.016 inch thick.

END OF SECTION

SECTION 230800

COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Work Includes:

1. General Contractor shall coordinate Work of employees and each relevant subcontractor to facilitate the complete commissioning of Heating, Ventilating, and Air Conditioning (HVAC) Systems, as organized and guided by the CDB-hired Commissioning Provider.
2. Subject to the specific contractor participation roles outlined herein and in Section 01 91 13, *General Commissioning Requirements*, General contractor shall provide all labor, materials, equipment, and services necessary or incidental to the completion of Work in this section.

a. Section Includes:
1) Commissioning process requirements for electrical systems, assemblies, and equipment.

3. Requirements for documentation, testing, and training of electrical systems.

B. Related Work: The following items are not included in this Section and are specified under the designated Sections:

1. Division 23 Sections related to Testing, Adjusting, and Balancing (TAB).

1.3 ACTION SUBMITTALS

A. Submit procedural documentation and formal test reports associated with the Work described in this section, for all testing contracted by the General Contractor or any of its subcontractors.

1.4 COMMISSIONING

A. This section governs the commissioning of HVAC Systems.

B. The following systems and equipment shall be commissioned:

1. Split System Air Conditioning.
2. VRF Units.
3. Rooftop Units.
4. Dedicated Outdoor Air Units (DOAS).
5. Variable Air Volume Terminal Units (VAV).

6. Exhaust Fans
7. Building Automation System (BAS)

PART 2 - PRODUCTS: NOT USED

PART 3 - EXECUTION:

3.1 Provide training of the Owner's operation and maintenance personnel. Coordinate scheduling with the Commissioning Provider.

3.2 Work with the Commissioning Provider at all times, and in cooperation with other members of the Commissioning Team, to ensure compliance and completion of the commissioningprocess.

END OF SECTION

SECTION 230920 - BUILDING AUTOMATION SYSTEM (BAS) - GENERAL

PART 1 - GENERAL

1.1 **SUMMARY**

A. Section includes the installation of a building automation system (BAS) for control and monitoring of mechanical systems as indicated.

B. Building Systems Commissioning

1. An independent third party Commissioning Agent shall document completion of the Plumbing, HVAC, and Electrical Systems for the project. The Construction Manager, Division Contractors, and Building Automation System Contractor are members of the Commissioning Team and shall facilitate completion of the Commissioning process. Refer to section 019113 Building Systems Commissioning for the project Commissioning requirements and roles and responsibilities of each member of the Commissioning Team.

C. Sustainability Design Reporting

1. An independent third party Sustainability Agent shall document completion of the Plumbing, HVAC, and Electrical Systems for the project. The Construction Manager, Division Contractors, and Building Automation System Contractor are members of the Sustainability Team and shall facilitate completion of the Sustainability Design process. Refer to section 013329 Sustainability Design Reporting for the project requirements and roles and responsibilities of each team member.

1.2 **SYSTEM DESCRIPTION**

A. The distributed digital control (DDC) and building automation system (BAS) defined herein shall provide a complete Building Automation System (BAS) for all mechanical systems and other facility systems as included in the project documents. The contractor shall provide a complete and operational system to perform all sequences of operations stated in the Article "Sequence of Operation" or as shown on the control drawings.

B. The BAS shall utilize electronic sensing, microprocessor-based digital control, and electronic actuation of dampers and valves to perform the control sequences and functions specified. The BAS for this project shall consist of monitoring and control of the systems indicated.

C. The BAS system shall include the following:

1. One (1) Webserver (control system server CSS)

2. One (1) Desktop operator workstation (OWS)

3. All the software tools required to configure and maintain the server, OWS, and any local devices.

D. All interlock wiring for mechanical system equipment shall be by this contractor unless specifically stated otherwise. This shall include, but not be limited to, items such as thermostats for unit heaters, interlock wiring to central boiler control panels, chiller flow switches, and duct smoke detectors.

1.3 **APPLICATION OF OPEN SYSTEM (PROTOCOL AND LICENSING)**

A. Subject to the detailed requirements provided throughout the specification and contract documents, the BAS and digital control and communications components installed, as work of this contract shall be an integrated distributed processing system utilizing one of the following standards:

1. BACnet: System components shall communicate using native BACnet in accordance with ASHRAE Standard 135 and current addenda and annexes, including:

a. All workstations
b. All BACnet Building Controllers (B-BC)
c. All Advanced Application Controllers (B-AAC)
d. All Application Specific Controllers (B-ASC).

e. Gateways from other communication protocols are not acceptable.
f. All controllers must be BACnet Testing Labs listed for their required profile (B-BC, B-AAC or B-ASC).

B. Software Licensing:

1. Include open/non-proprietary licensing for all software packages at all required Operator Interface as listed in Division 23 Section "Building Automation System – Operator Interfaces".

2. All operator interface, programming environment, networking, database management and any other software used by the Contractor to install the system or needed to operate the system to its full capabilities shall be included, licensed, and provided to the Owner.

3. Open/non-proprietary licensing shall allow access to all aspects of the system including system access, thin-client workstations, points, programming, database management, graphics etc. No restrictions shall be placed on the licensing.

4. Hardware and software keys to provide all rights shall be fully provided and installed on all operator interface(s). At least 2 sets of CDs/USB drivers shall be provided with backup software for all software provided, so that the Owner may reinstall any software as necessary. Include all licensing for workstation operating systems, and all required third-party software licenses. These backup disks shall include a backup of all program data files, graphics etc. and shall allow the owner to completely restore the system in the case of a computer malfunction.

C. Throughout these specifications, there are parallel requirements for BACnet or VRF-Protocol systems. Such requirements shall be interpreted in light of whether the contractor is installing a BACnet, VRF-Protocol, or a hybrid system.

1.4 **ACCEPTABLE MANUFACTURERS:**

A. Qualifications: The following manufacturers are pre-approved to install a web-based BAS system:

Manufacturer/Contractor

1. Delta enteliWEB

2. Johnson Facility Explorer Controls with Tridium-N4

3. Honeywell Spyder Controls with Tridium-N4

4. Reliable MACH Controls

5. Vykon with Tridium-N4

6. KMC with Tridium-N4

7. Substitution require EOR approval.

B. This listing is a pre-approval only and shall not relieve the Contractor of compliance with any Contract Document requirements.

C. Any and all work that may be required to accommodate any items or equipment of the other acceptable manufacturers listed in the Contract Documents is, without limitation, subject to the review of the EOR.

1.5 **QUALITY ASSURANCE**

A. Contractor Experience

1. The BAS as defined in the Contract Documents is considered to be a highly specialized system. The Contractor shall be a building automation system specialist regularly engaged in the

engineering, programming, installation, and service of building automation systems of similar size and complexity. As a building automation system specialist, the Contractor is expected to demonstrate an understanding of the systems and equipment to be placed under control, including knowledge of acceptable engineering, programming, installation, and wiring interface methods. The Contractor shall submit in writing at the time of subcontractor approval the following information for review by the EOR:

a. Documentation to have a substantial experience with the complete, turn-key installation of building automation systems of similar scope and size as this project. Document this business experience.

b. Documentation to have a local service facility within a 50 mile radius of the job site.

c. Documentation to have a service department staff, fully capable of providing instructions as well as routine and emergency maintenance service on all system components.

d. Documentation to have emergency services, available on a 24 hour, 7 day a week basis. Describe this local service capability.

e. The Contractor shall employ specialists in the field of building automation systems including: project management, engineering, programming, field supervision installation, and start-up. Provide a project specific organizational chart with complete contact information. Provide technical resumes for each member of the project team proposed for this project.

f. The Contractor shall be an authorized and factory trained installer for the BAS proposed for this project. The BAS manufacturer shall provide written authorization of Contractor. Document this authorization.

g. The Contractor shall not be an exclusive installer for the BAS product line proposed. The BAS manufacturer shall provide written statement of multiple specialized installer in the 50-mile radius area. Document this condition.

h. Documentation to have three (3) reference projects where past BAS projects were on-line and functional such that the EOR can observe the BAS in full operation at the time of the project check-out. References shall include contact name and phone number.

i. Documentation to have direct installation experience with ASHRAE/ANSI BACnet 135-1995. Project reference shall include contact name and phone number.

j. The Contractor shall provide a building automation system that meets contract documents. Provide a riser diagram of the proposed BAS including the manufacturer's part numbers of individual DDC controllers. Submit product data information sheets for each model of DDC controller identified on the BAS riser diagram.

k. Provide a project schedule for this BAS installation including significant tasks and milestones.

l. The Contractor shall use certified electricians to install the BAS and pipefitters to install the pneumatic control components. Document the experience of these skilled trades and any Contractor employee to be used for this portion of the work.

B. BAS Manufacturer Experience

1. The Contractor shall provide building automation system products from manufacturers regularly engaged in the production of specialized building automation systems for the HVAC industry. The Contractor shall submit in writing the years of experience they have with the pre-approved manufacturer’s product line for review by the EOR.

C. Products

1. Building automation system DDC controllers shall be the products of manufacturers regularly engaged in the production of specialized building automation control systems for the HVAC

industry. Building automation system products shall be the manufacturer's latest standard design that complies with the contract document requirements. DDC controllers and system components shall be current production products at time of submittal; Prototypes, Beta or other non-current product offerings shall not be accepted.

2. All other project materials and equipment shall be the products of manufacturers regularly engaged in production of materials or equipment for building automation systems. The products shall be the manufacturer's latest standard design that complies with the contract document requirements. Where two or more units of the same equipment are required, these units shall be products of a single manufacturer; however, the component parts of the system need not be the products of a single manufacturer. Each component product shall have the manufacturer's name, city, model and serial number permanently attached on the product.

3. Upon additional Owner/EOR request, the DDC control manufacturing corporation shall provide a letter prior to the submittal phase stating that the installing contractor is an authorized dealer. In addition, the letter shall clearly identify that there are at a minimum of three (3) certified BMS contractors – within 50 miles of the site that are also authorized dealers of said manufacturer. Thus allowing continuous competitive bidding for future expansions and/or service contracts. Failure of compliance shall result to advancing to the next qualified BAS bidding contractor at no additional cost to the owner or design team.

D. Quality Assurance Program

1. The Contractor shall implement a pro-active Quality Assurance Program. This program shall consist of the following minimum requirements. The Contractor shall be fully responsible for compliance with the installation standards and system requirements as defined herein.

   a. The Contractor shall assign a single individual, the Quality Assurance Manager, to be responsible for the management of the Quality Assurance Program.

   b. The Quality Assurance Manager shall submit to the EOR documentation of:

      1) Training for employees, both office and field, and subcontractors, on the Quality Assurance Program.

      2) Written verification that each worker on the project has read the contract document sections outlining the project requirements for their area of specialty. No work shall be performed by any individual or company until this requirement has been met.

      3) A detailed audit trail for all Quality Assurance issues including: problem ID number, date of original problem report, name of individual initiating report, individual assigned responsibility for resolving the problem, all correspondence related to the problem, and final problem resolution shall be submitted to the EOR by the Quality Assurance Manager.

   c. Each individual team member shall be responsible for identifying and reporting Quality Assurance problems and for assisting, as requested by the Quality Assurance Manager, in the resolution thereof.

   d. Resolution of all Quality Assurance issues shall be at the Contractor’s expense.

   e. The Quality Assurance Manager shall submit copies of all Quality Assurance Audit Record entries to the EOR. All Quality Assurance related correspondence shall include the problem ID number.

2. The EOR shall have full audit authority over the Contractor’s Quality Assurance Program. The Contractor shall retrain or remove from the project any individual identified by the EOR whose workmanship is below acceptable quality standards. All quality control decisions by the EOR are final.

1.6 **CODES AND STANDARDS**

A. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Standards:

1. 90.1: Energy Standard for Buildings except Low-Rise Residential Buildings.
2. 62.1: Ventilation for Acceptable Indoor Air Quality.
3. 135: BACnet - A Data Communication Protocol for Building Automation and Control Networks, current version including all annexes and addenda.
4. 55: Thermal Environmental Conditions for Human Occupancy.

B. Electronics Industries Alliance:

1. EIA-709.1-A-99: Control Network Protocol Specification.
2. EIA-709.3-99: Free-Topology Twisted-Pair Channel Specification.
3. EIA-232: Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
4. EIA-458: Standard Optical Fiber Material Classes and Preferred Sizes.
5. EIA-485: Standard for Electrical Characteristics of Generator and Receivers for use in Balanced Digital Multipoint Systems.
6. EIA-472: General and Sectional Specifications for Fiber Optic Cable.
7. EIA-475: Generic and Sectional Specifications for Fiber Optic Connectors and all Sectional Specifications.
8. EIA-573: Generic and Sectional Specifications for Field Portable Polishing Device for Preparation Optical Fiber and all Sectional Specifications.
9. EIA-590: Standard for Physical Location and Protection of Below-Ground Fiber Optic Cable Plant and all Sectional Specifications.
10. EIA-852: Tunneling of Component Network Data over IP Channels.

C. Federal Communications Commission (FCC), FCC Part 15 - Rules

D. Underwriters Laboratories

1. UL 916: Energy Management Systems.

E. NEMA Compliance

1. NEMA 250: Enclosure for Electrical Equipment.
2. NEMA ICS 1: General Standards for Industrial Controls.

F. NFPA Compliance

1. NFPA 90A: "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to controls and control sequences.
2. NFPA 70: National Electrical Code (NEC).

G. Institute of Electrical and Electronics Engineers (IEEE)

1. IEEE 142: Recommended Practice for Grounding of Industrial and Commercial Power Systems.
2. IEEE 1428: Guide for Installation Methods for Fiber Optic Cables
3. IEEE 802.3: CSMA/CD (Ethernet – Based) LAN.
4. IEEE 802.4: Token Bus Working Group (ARCNET – Based) LAN.

1.7 **DEFINITIONS**

A. The following serves as a general guide of definitions:

1. Adjustable (ADJ) or (A): A characteristic of a control logic parameter such that it can be varied by the operator without downloading the program.
2. Field Adjustable (FA): A characteristic of a control logic parameter such that it can be varied by a high level/senior programmer only.
3. Advanced Application Controller (AAC): A device with limited resources relative to the Building Controller (BC). It may support a level of programming and may also be intended for application specific applications. A fully programmable control module. This control module shall be capable of certain advanced features found in Building Controllers (e.g. storing trends, and initiating read and write requests) but it shall not serve as a master controller. Advanced Application Controllers may reside on either the Ethernet/IP backbone or on a subnet. A BACnet device to be used as an AAC will meet the requirements of ASHRAE 135, Annex L and will be listed as an AAC by BACnet Testing Labs. A BTL listed device will carry the BTL Mark.
4. Application Specific Controller (ASC): A device with limited resources relative to the Advanced Application Controller (AAC). A pre-programmed control module, intended for use in a specific application. ASCs shall have limited configurability, allowing the user to select various pre-programmed options, but it shall not be fully customizable. A BACnet device used as an ASC will meet the requirements of ASHRAE 135, Annex L and will be listed as an ASC by BACnet Testing Labs. A BTL listed device will carry the BTL Mark.
5. BACnet/BACnet Standard: BACnet communication requirements, as defined by ASHRAE/ANSI 135, current version including all annexes and addenda.
6. Building Controller (BC): A fully programmable control module capable of storing trends and schedules, serving as a router to devices on a subnet, and initiating read and write requests to other controllers. Typically this controller is located on the Ethernet/IP backbone of the BAS. A BACnet device to be used as a BC shall meet the requirements of ASHRAE 135, Annex L and will be listed as a BC by BACnet Testing Labs. A BTL listed device will carry the BTL Mark.
7. Control System Server (CSS), Web Server (WS): Provides access to the control system. This device will allow access to the control system with a web browser over the Owner's network. As the BAS network devices are stand-alone, the CSS is not required for communications to occur. The webserver will have two NIC cards so that is functions as the bridge between the local supervisory LAN and the Owner.
8. Direct Digital Control (DDC): Microprocessor-based control including Analog/Digital conversion and program logic
9. Stand-Alone Controller: A stand-alone controller has provisions for all of the physical inputs and physical outputs associated with a single mechanical component such as a terminal unit, air handling unit, chiller or boiler. The controller shall also have embedded in it all of the control logic that associated the physical inputs to the physical outputs. A stand-alone controller may rely on other networked devices for time schedule inputs and trend data storage.
10. Supervisory Logic: The concept of gathering performance data from multiple terminal units to determine if a specific condition exists within the family of terminal devices.

B. See also 23 09 25 – BAS_GENERAL SEQUENCE" for additional definitions.

1.8 **FUNCTIONAL INTENT**

A. Where detailed functional or performance requirements are specified, products intended for the Project, conforming to the specified requirements, must be submitted to, and approved by, Owner prior to shipment to the Project site.

1.9 **SUBMITTALS**

A. Electronic Submittals: While all requirements for hard copy submittal apply, control submittals and O&M information shall also be provided in electronic format as follows.

1. Drawings and Diagrams: Shop drawings shall be provided on electronic media as an AutoCAD drawing file and/or Adobe Portable Document Format (PDF) file. All 'X-Reference' and font files must be provided with AutoCAD files.

2. Other Submittals: All other submittals shall be provided in Adobe PDF. Provide documents, such as Cheat Sheets and Trouble Shooting Guide, in rich text format (RTF) or Microsoft Word format as required.

3. A statement of BACnet compliancy shall be provided in the O&M documentation.

4. BIM modeling for temperature controls shall be furnished by the BAS Contractor. All control panels and raceways (at ¾" or greater) shall be modeled for clash-detection efforts with the prime contractor.

5. The naming convention for all physical control points and software objects shall be reviewed in a meeting with the Owner's Representative, Commissioning Agent, and Engineer before generation of control drawings and sequences of operation.

6. Where applicable, any deviations against the design intent shall be summarized with associated description of said deviation and itemized with an associated credit for final approval. Deviation(s) not listed and submitted may warrant an automatic rejection.

7. All sequences shall be reviewed with thought and care with respect to programming needs for the specific project's design. Insufficient or generic sequence details may warrant an automatic rejection.

8. Generic, non-compliant submittals shall not be reviewed, and shall be returned for resubmittal.

9. BAS Contractor shall not order material, begin fabrication or field installation until receiving authorization to proceed in the form of an approved submittal. BAS Contractor shall be solely responsible for the removal and replacement of any item not approved by submittal at no cost to the Owner.

10. It is the contractors' responsibility to coordinate and allow adequate time for an approval process. Where an expedited submittal review is required, the contractor(s) shall still be responsible for any associated project delays and pay all additional services incurred by the design engineer, at the design engineer's current standard rate.

11. The design engineer shall perform no more than two reviews of each submittal item. Should the submittals not be acceptable after the second review, the Contractor shall pay all additional expenses incurred by the design engineer in reviewing additional submittals at the design engineer's current standard rate.

12. At the time of the 23 09 00 series submittal, the BAS Contractor shall submit a copy of the following sections directly with a response of "comply" or "non-comply" for every bullet point for:

    a. 23 09 20, Section 1.9 "SUBMITTALS"

    b. Entirety of the 23 09 00 series and sub-sections, upon further request

B. Shop Drawings: Submit shop drawings for each control system, including a complete drawing for each major air distribution equipment, central hydronic system, device, etc. with all point descriptors, addresses and point names indicated. Each shop drawing shall contain the following information:

1. System Architecture and System Layout:

    a. One-line diagram indicating schematic locations of all control units, workstations, LAN interface devices, gateways, etc. Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each control unit. Indicate media, protocol, baud rate, and type of each LAN. All optical isolators, repeaters, end-of-line resistors, junctions, terminators, ground locations etc. shall be located on the diagram.

b. Provide floor plans locating all control panels, workstations, servers, LAN interface devices, gateways, repeaters, etc. Include all WAN and LAN communication wiring routing, power wiring, power originating sources, and low voltage power wiring. Indicate network number, device ID, address, device instance, MAC address, drawing reference number, and controller type for each control unit. All optical isolators, repeaters, end-of-line resistors, junctions, ground locations etc. shall be located on the floor plans. Wiring routing as-built conditions shall be maintained accurately throughout the construction period and the drawing shall be updated to accurately reflect accurate, actual installed conditions.

2. Schematic Flow Diagram of each air and water system showing fans, coils, dampers, valves, pumps, heat exchange equipment and control devices. Include contractor written description of sequence of operation per Schematic Flow Diagram.

3. All physical points on the schematic flow diagram shall be indicated with names, descriptors, and point addresses identified as listed in the point summary table per Schematic Flow Diagram.

4. Provide dedicated shop drawings of all space sensors/thermostats, OA sensors, meters (ie. All AFMS and utility meters), hydronic/duct/building static pressure sensors, and workstation for final EOR and AOR review.

5. With each schematic, provide a point summary table listing building number and abbreviation, system type, equipment type, full point name, point description, Ethernet backbone network number, network number, device ID, object ID (object type, instance number). See Division 23 Section "Building Automation System (BAS) - Software and Programming" PART 3 for additional requirements.

6. Label each control device with initial setting.

7. Label each input and output with the appropriate range.

8. Provide a Bill of Materials with each schematic for each equipment or system. Indicate each device in a spreadsheet with the following information:

   a. Unique device identification to match schematic and actual field labeling

   b. Quantity

   c. Part number

   d. Manufacturer

   e. Description

   f. Voltage Range (as applicable)

   g. Pressure Range (as applicable)

   h. Temperature Range (as applicable)

9. Control Valve Schedules: Provide a valve and the associated actuator information in a spreadsheet schedule. The schedule shall include a separate line for each valve and a column for each of the following valve attributes in the order presented here (no omissions):

   a. Valve Tag

   b. System (e.g.: HW Plant, Steam Plant, AHU-X)

   c. Service (e.g.: CHW, HW, Bypass, Isolation)

   d. Piping System Pressure Rating

   e. Design Body Pattern (e.g.: straight thru, mixing, diverting)

   f. Design Pipe Size

g. Design Valve Flow Rate (GPM or lbs/hr)

h. Design Valve Pressure Drop (PSI)

i. Design Valve Cv

j. Adjusted Pipe Size (actual from submittals/shop drawings)

k. Adjusted Valve Flow Rate (GPM or lbs/hr) (actual from submittals)

l. Adjusted Valve Pressure Drop (PSI) (actual from submittals)

m. Adjusted Calculated Valve Cv (provide formula and coefficient values)

n. Selected Valve Cv

o. Selected Valve actual Pressure Drop (in PSI),

p. Selected Manufacturer

q. Selected Part Number

r. Body Style (e.g. globe, butterfly, ball, eccentric, high-performance, pressure independent)

s. Selected Size (in inches)

t. Pipe Connections (sweat, screwed, flanged)

u. Actuator Fail Position Flow Pattern (de-energized) (e.g.: open, closed, last position)

v. Actuator Model Number

w. Actuator Working Range (e.g.: Volts, mA or PSI)

x. Actuator Close-Off Pressure (against system)

y. Coordination sign-off sheet with a list of the referenced equipment submittal and/or shop drawing. Reference shall include equipment tag and date of utilized equipment submittal.

z. Comments.

10. Control Damper Schedules: Provide a damper and its associated actuator information in a spreadsheet type schedule. The schedule shall include a separate line for each damper and a column for each of the following damper attributes in the order presented here (no omissions);

a. Damper Tag

b. System (e.g.: AHU, Electrical Room, Combustion)

c. Service (e.g.: Min_OA, OA, CAI, Intake, Exhaust, Isolation, Sub Zone)

d. Opening Size (W x H)

e. Design Flow Rate (CFM)

f. Design Velocity (FPM)

g. Selected Damper Size (W x H)

h. Section Labels & Sizes (W x H)

i. Manufacturer

j. Part Number

k. Blade Pattern (parallel, opposed, single)

l. Blade Type (e.g. air foil, two piece)

m. Bearing Type

n. Fail Position (de-energized)

o. Actuator Model Number

p. Actuator Quantity

q. Actuator Working Range (Volts, mA or PSI)

r. Actuator Mounting Location (electronic; shaft, sleeve-out collar, channel support

s. Damper Closing Torque

t. Actuator Rated Torque

u. Damper Close-Off Pressure (against system)

v. Leakage and flow characteristics charts shall be submitted for review.

w. Submit diagram for each damper of three or more sections wide showing the position of each section and associated actuator mountings.

x. Coordination sign-off sheet with a list of the referenced equipment submittal and/or shop drawing. Reference shall include equipment tag and date of utilized equipment submittal.

y. Comments

11. Air Flow Measuring Station Schedules: Spreadsheet type schedule shall include a separate line for each flow station and a column for each the following station attributes in the order presented here (no omissions);

    a. Station Tag

    b. System

    c. Service

    d. Opening Size (W x H)

    e. Design Flow Rate (CFM)

    f. Design Velocity (FPM)

    g. Selected Station Size (W x H)

    h. Section Labels & Sizes (W x H)

    i. Station Manufacturer

    j. Station Part Number

    k. Velocity Pressure Sensor Range

    l. Velocity Pressure Sensor Manufacturer

    m. Velocity Pressure Sensor Part Number

    n. Coordination sign-off sheet with a list of the referenced equipment submittal and/or shop drawing. Reference shall include equipment tag and date of utilized equipment submittal.

    o. Comments

12. Indicate all required electrical wiring; include ladder logic type diagram (for motor starters, boiler, chiller, RTU, control, and safety circuits). Ladder diagrams shall appear on system schematic.

13. Indicate all required electrical wiring; include detailed factory digital point termination diagrams with all wire numbers and terminal block numbers identified. Panel termination drawings shall appear on separate drawings. Clearly differentiate between portions of wiring, which are existing or factory-installed versus field-installed points.

14. For all devices with safety circuits (e.g. burners and chillers), field wiring shall be labeled and all added devices shall be properly mounted. Any internal wiring changes shall be approved by the manufacturer in writing. If for example, a gas booster needs to be tied into the burner circuit the manufacturer shall identify the terminal points and provide an updated control diagram.

15. Details of control panels, including controls, instruments, and labeling shown in plan or elevation indicating the installed locations.

16. Sheets shall be consecutively numbered.

17. Each sheet shall have a title indicating the type of information included and the HVAC system controlled.

18. Table of Contents listing sheet titles and sheet numbers.

19. Legend and list of abbreviations.

20. Provide an operating schedule for review. The schedule shall have a schedule for each major equipment and their associated equipment.

21. Terminal units serving private zones shall have a separate schedule from public areas.

22. Initial Graphical User Interface screens for each unique type of system shall be included as an appendix. Include display screen to be provided, data to be displayed, and links to other screens. Outline level hierarchy shall be:

    a. Site

    b. Building

    c. Floor

    d. System

    e. Parameters

    f. Schedules

    g. Histories

    h. Etc.

23. Final Graphical User Interface screens for each unique type of system shall be received 60 days prior to system startup.

C. Product Data:

D. Product Data: manufacturer technical information shall be provided after the BAS shop drawings. BAS contractor shall present the technical information in a user-friendly manner and organization.

1. Provide a summary index of all catalog cut sheets included. Index shall precede cut sheets and list the order of the cut sheets.

2. Include, but is not limited to DDC panels, OWS, portable operator terminals, sensors, actuators, dampers, valves, control air system components, etc. Provide range and scale information for all transmitters and sensors.

3. For each control device, panel, and accessory indicated or furnished. Include dimensions, capacities, performance limits, electrical characteristics, and material finishes.

4. Include installation and start-up instructions.

5. When manufacturer's cutsheets apply to a product series rather than a specific product, clearly indicate via highlighter, rectangle or circle on each sheet the specific device selected and applicable options. Non-compliance shall warrant an automatic rejection.

6. General catalogs shall not be accepted as cutsheets to fulfill submittal requirements.

E. Product Line Demonstrated History: The product line being proposed for the project must have an installed history of demonstrated satisfactory operation for a length of one (1) year since date of final completion in at least ten (10) installations of comparative size and complexity. Submittals shall document this requirement with references.

F. Testing Plan:

1. Submit a plan for executing all phases of testing and completion of checkout forms. This includes the following: manufacturers' normal testing, point-to-point testing, pre-functional testing, and functional performance testing. The testing plan shall show the overall milestones of the controls work and testing of the controls system.

2. Provide the schedule for completing each phase of testing for each system or set of equipment including, but not limited to, air handlers, chillers, boilers, unit-vents, VAV boxes, network wiring, and operator workstations. Schedules shall show the time frame needed to complete the tasks.

3. The testing plan shall identify other trade milestones that impact the successful completion of during each phase of testing.

4. This plan is not meant to take precedence over any other plan but is intended to provide coordination assistance to all trades as the project is scheduled.

G. Checkout and Testing Forms: Submit a blank copy of the forms that shall be used during Point-to-Point Checkout, Prefunctional Checkout, and Functional Performance Testing as outlined in Division 23 Section" Building Automation System (BAS) - Commissioning." Those forms should be structured to capture the following information at a minimum during each particular testing phase.

1. Point-to-Point Checkout Form containing the following information:

   a. Each point is addressed, labeled and that proper communication exists between the controller and the field device.

   b. Documents that installed condition match the control drawings and that any changes or differences are noted on the drawings.

2. Prefunctional Checkout Forms containing the following information:

   a. Documents correct voltage and or current present as well as verifying circuits are free from grounds or faults for each control device.

   b. Obtain and Record Test and Balance settings and incorporate into the BAS. Information from the TAB contractor shall include:

      1) Water and air system differential pressure and flow settings.

      2) AHU minimum outside air control point or damper setting.

   c. Calibration data for all sensing and actuating devices recording final measured and displayed value. Record the type and model of the meter(s) that determined the measured value for analog inputs.

   d. For analog outputs record both the displayed output as well state of the receiving device.

   e. For digital input/outputs record the signal at the controller and the state of the sensing/control device.

   f. For actuators:

      1) Check to ensure that actuated device moves smoothly and results are repeatable thru full range and seals tightly when the appropriate signal is applied to the operator.

      2) Check for appropriate fail position, and that the stroke and range is as required.

3) For sequenced electronic actuators, calibrate in accordance with manufacturer's instructions to required ranges. Record final settings.

g. For all valves and actuators, verify the actual position against the Operator Interface readout. Set pumps to normal operating mode. With command valve closed, verify that valve is closed, and adjust output zero signal as required. With command valve open, verify position is full open and adjust output signal as required. Command the valve to not less than three (3) intermediate positions. If actual valve position doesn't correspond correctly, replace actuator.

h. Valve leak check: Verify proper close-off of the valves. Ensure the valve seats properly by simulating the maximum anticipated pressure difference across the circuit.

i. For air and water flow measuring stations the data recorded shall include the independent flow measurement, area, and the independently measured output of the flow station. The BAS input from the flow station and any factors used to calculate the flow including area and any constants used in the calculation of flow. Two sets of data shall be collected. The first at design flow and the second at 50% of design flow. It is not acceptable to simply add a correction factor to address differences between the flow station and the independent reading.

j. For Operator Interfaces and Web accessible display:

1) Verify that all elements on the graphics are functional and are properly bound to physical devices and/or virtual points, and that hot links or page jumps are functional and logical.

2) Output all specified BAS reports for review and approval.

3) Verify that the alarm pop ups, printing, and logging are functional and in accordance with requirements.

4) Verify that all points are trended and are archiving to disk. Provide a sample to the Commissioning Authority and owner for review.

5) Verify that paging/dial-out alarm annunciation is functional.

6) Verify the functionality of remote Operator Interfaces and that a robust connection can be established consistently.

7) Verify that required third party software applications required with the bid are installed and are functional.

k. For all actuating devices record final settings for device.

l. Document verification of point to graphics binding for all points displayed on the OWS and that webserver display have been mapped correctly, and display the correct information.

m. Document that the webserver is on LAN and can be viewed from off site, that the modem is connected, and that the BAS is accessible via modem by the contractor.

3. Functional Performance Forms shall contain:

a. List of all sequences, modes of operation and setpoint that initiates each sequence and/or mode. For each confirm that proper sequence of operation. Document any variance between designed sequence and actual condition.

b. Record tuning parameters and response time for each control loop.

c. Document all alarm and safeties test and final results.

d. Results of trends including controlled points, setpoints, actual readings, and other point defined by the Boards Authorized Representative.

H. Open Protocol Information:

1. General: Provide all information necessary for review of the proposed system, including information required by the authority maintaining the protocol standard to determine if the product selected for implementation complies with the protocol standards specified.

2. BACnet Systems:

    a. BACnet object description, object ID, and device ID, for each I/O point.

    b. Documentation for any non-standard BACnet objects, properties, or enumerations used detailing their structure, data types, and any associated lists of enumerated values.

    c. Documentation of all explicit messaging.

    d. Submit PICS indicating the standardized BACnet device profile, functionality and configuration of each controller along with proof of BTL listing.

I. Framed Control Drawings: After completion of installation and check out, but prior to training, laminated control drawings including system control schematics, sequences of operation, and panel termination drawings, shall be provided in panels for major pieces of equipment. Terminal unit drawings shall be located in the central plant equipment panel or mechanical room panel.

J. Control Logic Documentation:

1. Documents are to be submitted, received, and approved prior to training.

2. Submit control logic program listings (for graphical programming) and logic flow charts illustrating (for line type programs) to document the control software of all control units.

3. Control logic shall be annotated to describe how it accomplishes the sequence of operation. Annotations shall be sufficient to allow an operator to relate each program component (block or line) to corresponding portions of the specified Sequence of Operation.

4. Include written description of each control sequence.

5. Include control response, settings, setpoints, throttling ranges, gains, reset schedules, adjustable parameters, and limits.

6. Sheets shall be consecutively numbered.

7. Each sheet shall have a title indicating the controller designations and the HVAC system controlled.

8. Include Table of Contents listing sheet titles and sheet numbers

9. Submit one complete set of programming and operating manuals for all digital controllers concurrently with control logic documentation. This set shall count toward the required number of Operation and Maintenance materials specified below.

K. Training Plan:

1. Documents are to be submitted, received, and approved prior to training.

2. Training shall be provided for a total of (16) hours.

3. A training plan is required for opposite season or refresher training.

4. The material to be covered shall be further sub-divided into descriptions of the material to be covered in every 15 minutes. See Division 23 Section "BAS – Commissioning," for specific items to be addressed.

5. The descriptions shall include not only the material to be covered but also its location in the Operation and Maintenance Manual or the Training Manual including Section and page number.

6. Opposite Season or Refresher Training:

a. The third training session shall be conducted on-site at a date specified by the Owner within twelve months of Preliminary Acceptance or Substantial Completion and shall consist of four, four-hour sessions of training. The session shall be structured to address specific topics that trainees need to discuss and to answer questions concerning operation of the system.

L. As Built Documentation:

1. The Contractor shall submit as-built documentation in accordance with Contract Documents.

2. Integrate with flow diagrams, show outlines of HVAC equipment with control devices, schematic one-line control piping and wiring, and reduced floor plan drawings showing installation routing of all DDC system network LANs, control panels, and power supply panels.

3. DDC wire sheets, a graphical display of DDC logic, shall be provide for every major equipment and system.

4. Equipment numbers shall correspond to those shown on the Contract Drawings. Provide As-Built drawings as follows:

a. One set of reproducible drawings

b. One set of applicable drawings placed in the plan pocket of each local control panel. System flow diagram, panel wiring diagram and points list shall be provided inside each panel housing a digital controller, except terminal units

c. Two complete flash-drive backup of the OWS.

d. Two complete flash-drive backup of all controller programs, controller software source code, database files, and configuration files.

e. Two copies of all training lecture video tapes

M. Operation and Maintenance Manual:

1. Digital documents are to be submitted, recieved, and approved prior to training.

2. Submit three (3) sets of each manual to the owner's operating staff.

3. Hardware Manual: Include the following documentation:

a. Complete set of approved as-built submittals reflecting all updates during construction.

b. As-Built Bill-of-Materials

c. As-Built cut sheets for all components

d. As-built detailed wiring, installation, and calibration procedures for each field and panel device

e. Complete trouble-shooting procedures and guidelines

f. Complete operating instructions for all systems

g. Maintenance Instructions: Document all maintenance and repair/replacement procedures. Provide ordering number for each system component, and source of supply. Provide a list of recommended spare parts needed to minimize downtime.

4. Software Manual: Include the following documentation:

a. Table of Contents

b. Program Function Index

c. Program Listing of Software Source Code or Flow Chart Diagrams of Programming Objects. For control systems using either compiled program code or interpreted code provide source code of all programs and function libraries to be installed. For systems using a

graphical object orientated programming environment, provide a computer plotted flow chart showing the interconnection of the programming objects and all associated parameters. A copy of the flow chart shall be provided on disk or CD-ROM and in hard copy format.

d. Printed listing of controller and OWS database files

e. Submit BAS advanced Programming Manuals for each controller type and for all OWS software.

f. Appendix A: Alphabetical Software Point Name Abbreviation List. Include Name, Description, Controller Where Located, Point Type and Point ID

g. Appendix B: Alphabetical I/O Point List. Include Point Name, Controller Location, Point Number, Control Device, Range and Span

h. Appendix C: Sample printouts of all; Reports, Group Listings and Alarm Messages

i. Alphabetical Index of all DDC point names with documentation manual page number references

5. Provide three (3) copies of all manufacturers manuals covering the installed system. This shall include, as a minimum:

a. System Engineering Manual

b. System Installation Manual

c. Programming Manual

d. Engineering and Troubleshooting Bulletins

e. Operator Workstation Software Manual

f. All other pertinent manuals published by the control system manufacturer

g. All manuals shall be provided in hard copy format and as part of an On-Line documentation system through the OWS.

6. Comply in accordance with requirements of Division 01 Sections.

N. Training Manual: Submit training manual electronically for review. Once accepted, provide three hard copies and one electronic copy of the training manual at the start of training. Include the following:

1. Cheat Sheets or quick reference section with step-by-step guidance with a level of detail that shall allow someone with no experience with the control system to follow the instructions. The quick reference guidance can be provided one of two ways: screen prints with bubbled text describing the navigation required or written description of the steps to be taken with screen prints provided to facilitate the written explanation. The required cheat sheets shall include:

a. Logins and logoffs.

b. Adjust and restore setpoints.

c. Overrides and releasing overrides. Include instructions for running a report to list all points currently overridden.

d. Start, group, plot and export Trends.

e. Adjust schedules and add holidays.

f. Processing of alarms including acknowledgement, review of alarm report, and clearing of alarm history.

g. Backup and restoration of system data.

h. Demonstrate how to clear/reset all field devices that may require manual intervention.

i. Demonstrate how to reset motor starter and the significance of Hand-Off-Auto switch position on motor starters.

j. Demonstration of each input and output device. Provide a picture of each input or output device with a brief narrative on its operation.

k. Demonstrate how to place the boiler or chiller system into manual control and boiler control, and how to restore the system to BAS control.

2. Operating instructions including system startup and shutdown, seasonal and emergency instruction.

3. Trouble Shooting Guide. Include actions to be taken to trouble shoot problems with the OWS, PCU's CSS, and local control devices.

4. Setpoint Table.

5. Preventative maintenance instructions.

6. Color print of each unique screen.

7. Final Sequence of Operations. This document shall be printed but shall also be provided electronically in rich text format (rtf). The sequence shall provide not only the original design sequence from the contract documents and drawings but also the any changes to the sequence.

8. Complete set of the design control drawings (provided by the Architect on 11"x17" sheets). The manual shall have a TAB for these drawings. The printed drawings shall come from the Architect or Engineer.

9. List of all alarm points and alarm priority.

O. Video Training: The following training shall be recorded on a CD using screen capture software. Any files required to run the CD shall be provided. The cadence of the video training shall be such that an inexperienced person can listen to the narrative and execute those steps on controls system while watching the CD. Include a screen view recording the actual video feed to the monitor for the workstation penetration while narrating the associated steps.

1. Quick reference procedures. The taping of these procedures must include both a screen view preferably recording the actual video feed to the monitor while narrating the associated steps.

a. Login and logoff to control system as well as Microsoft XP login;

b. Adjust and restore setpoints.

c. Overrides and releasing overrides, as well as running a report to list all points currently overridden.

d. Start, group, plot and export Trends.

e. Adjust schedules and add holidays.

f. Processing of alarms including acknowledgement, review of alarm report and clearing of alarm history.

g. Backup and restoration of system data.

h. Demonstrate workstation menu penetration and broad overview of the various workstation features.

i. Demonstrate all operations and functions that can be performed at the supervisory or local controllers as well as system display artifacts such as the indication that a point has failed or lost communication.

P. Demonstration of portable operator interface device display capabilities.

Q. Manufacturers Certificates: For all listed and/or labeled products, provide certificate of conformance.

R. Refer to specification 23 09 20, section 1.13 for Warranty requirements.

1.10 **PROJECT RECORD DOCUMENTS**

A. The Project Record documents that have not already been submitted as part of the Operating and Maintenance Manual or Training Manual are to be submitted with the Record Documents. Any documents in the Operating and Maintenance Manual or Training Manual that have changed since they were submitted shall need to be re-submitted as part of the Project record documents. All these documents maybe submitted electronically.

B. Record copies of product data and control shop drawings updated to reflect the final installed condition.

C. Record copies of approved control logic programming and database on tagged CDs or USB flash drives. The CDs or USB flash drives shall contain all information required to reinstall the control system program. It shall include actual final setpoints and settings of controls, final sequence of operation, including changes to programs made after submission and approval of shop drawings and including changes to programs made during specified testing. One set of CDs or USB flash drives shall be stored at the building in the main control panel and the second set shall be provided to Owner's facilities department.

D. Graphic Software: Record copies of approved project specific graphic software on flash drive.

E. For BACnet systems provide as-built network architecture drawings showing all BACnet nodes including a description field with specific controller identification, description and location information.

F. DDC wire sheets, a graphical display of DDC logic, shall be provide for every major equipment and system.

G. Include individual floor plans with controller locations with all interconnecting wiring routing including space sensors, LAN wiring, power wiring, low voltage power wiring. Indicate device instance, MAC address and drawing reference number.

H. Provide record riser diagram showing the location of all controllers.

I. Refer to specification 23 09 20, section 1.13 for Warranty requirements.

1.11 **OPERATOR INTERFACE**

A. The Operator Interface (OI) shall provide for overall system supervision, graphical user interface, management report generation, alarm annunciation, remote monitoring, and trend reporting. Refer to Division 23 Section" Building Automation System (BAS) - Operator Interfaces."

1.12 **SYSTEM ARCHITECTURE**

A. Application of Open Protocols:

1. Subject to the detailed requirements provided throughout the contract documents, the BAS and digital control and communications components installed, as work of this contract shall be an integrated distributed processing system utilizing the following standards:

a. BACnet or Hybrid System: The system architecture shall consist of a BACnet IP Router, a single Local Area Network (LAN) or two-level LANs that support BCs, AACs, ASCs, OWS, Smart Devices (SD), and Remote Communication Devices (RCDs) as applicable. In no event shall there be more than two levels of LAN topology within the system, excluding wiring to sensors with no control intelligence.

B. The system provided shall incorporate hardware resources sufficient to meet the functional requirements specified. The Contractor shall include all items not specifically itemized in the contract documents that are necessary to implement, maintain, and operate the system in compliance with the functional intent of the contract documents.

C. The system shall be configured as a distributed processing network(s) capable of expansion as specified below. Refer to the network architecture on the BAS drawings for other requirements and details.

D. The system architecture shall consist of an Ethernet-based, wide area network (WAN), a single Local Area Network (LAN) or multi-leveled LANs that support PCUs, Operator Workstations (OWS), and Remote Communication Devices (RCDs) as applicable. The following indicates a functional description of the BAS structure.

1. Owner WAN: Intranet-based network connecting multiple facilities with a central data warehouse and server, accessible via standard web-browser. This is an existing infrastructure and contractor is not required to configure any components of this WAN.

2. Local BAS Supervisory LAN: The Local BAS Supervisory LAN shall be an Ethernet-based, 100 Mbps LAN connecting Primary Control LANs and OWSs. The LAN serves as the inter-PCU gateway and OWS-to-PCU gateway and communications path and as the connection point for the Owner WAN. LAN shall be IEEE 802.3 Ethernet over Fiber or Category 5 cable with switches and routers that support 100 Mbps throughput. Power-line carrier communication shall not be acceptable for communications. The higher level layers of this network shall be BACnet/IP as defined in Addendum A (Annex J) of the BACnet standard, and shall share a common network number for the Ethernet backbone, as defined in BACnet.

   Primary Controller LAN ('Primary LAN'): High-speed, peer-to-peer communicating LAN used to connect and Primary Control (PCUs) and communicate exclusively control information. A BACnet network shall be used to connect AACs, ASCs or SDs. These can be Master Slave/ Token Passing or polling, or ARCnet in accordance with IEEE 802.4, in addition to those allowed for Primary Controller LANs. Network speed vs. the number of controllers on the LAN shall be dictated by the response time and trending requirements. The primary network shall communicate at a minimum of 38 kbps. Each secondary network may support up to 32 communicating devices without segmentation or repeaters subject to the requirements for response time, trending and bandwidth utilization.

E. Dynamic Data Access: Any data throughout any level of the network shall be available to and accessible by all other devices, Controllers and OWS, whether directly connected or connected remotely.

F. Remote Data Access: The system shall support the following methods of remote access to the building data.

1. Browser-based access: A remote user, connecting via the Owner WAN and using a standard browser shall be able access all control system facilities and graphics with proper password. The remote access user shall not need to load applications to view the web pages.

G. Network Performance: The communication speed between the controllers, control LAN interface devices, and operator interface devices shall be sufficient to ensure fast system response time under any loading condition. Contractor shall submit guaranteed response times with shop drawings including calculations to support the guarantee. In no case shall delay times between an event, request, or command initiation and its completion be greater than those listed herein. Contractor shall reconfigure LAN as necessary to accomplish these performance requirements. The performance shall also include the trending of all AI, AO and DI points at 15-minute intervals. Generally requirements do not apply when a remote connection must be established via modem:

1. 5 seconds between a Level 1 (critical) alarm occurrence and annunciation at the OWS.

2. 10 seconds between a Level 2 alarm occurrence and annunciation at the OWS.

3. 20 seconds between and a Level 3-5 alarm occurrence and annunciation at the OWS.

4. 10 seconds between an operator command via the operator interface to change a setpoint and the subsequent change in the controller.

5. 5 seconds between an operator command via the operator interface to start/stop a device and the subsequent command to be received at the controller.

6. 10 seconds between a change of value or state of an input and it being updated on the operator interface.

7. Graphic Display, 10 seconds between an operator selection of a graphic and it completely painting the screen and updating all points.

8. Graphic Refresh, every 15 seconds the graphic shall automatically refresh all graphic data.

H. Control Systems Server (CSS) and Operator Work Station (OWS):

1. These are two separate computers that maintain the systems configuration and programming database and is the operating platform for the operator interface (OI).

2. It shall hold the backup files of the information downloaded into the individual controllers and as such support uploading and downloading that information directly to/from the controllers.

3. It shall be located within each facility.

4. It shall also act as a control information server to non-control system based programs.

5. It shall allow secure multiple-access to the control information.

6. Refer to Division 23 Section" Building Automation System (BAS) - Operator Interfaces," for requirements.

I. The PCUs shall monitor, control, and provide the field interface for all points specified. Each PCU shall be capable of performing all specified energy management functions, and all DDC functions, independent of other PCUs and operator interface devices as more fully specified in Division 23 Section" Building Automation System (BAS) - Field Panels."

J. Systems Configuration Database: The system architecture shall support maintaining the systems configuration database on a server or OWS on the Local Supervisory LAN. User tools provided to Owner shall allow configuring, updating, and maintaining current configurations and settings whether they are initiated at the server or the end device.

1. Database Schema shall be published and provided to Owner to facilitate easy access to the data.

2. Database shall be ODBC compliant or a data access driver shall be provided to act as an ODBC or OLE DB data provider.

K. Interruptions or fault at any point on any Primary Controller LAN shall not interrupt communications between other nodes on the network. If a LAN is severed, two separate networks shall be formed and communications within each network shall continue uninterrupted.

L. All line drivers, repeaters, terminators, signal boosters, and signal conditioners shall be provided as necessary for proper data communication.

M. Anytime any controller’s database or program is changed in the field, the controller shall be capable of automatically uploading the new data to the OWS and CSS.

1.13 **WARRANTY PERIOD**

A. Contractor shall warrant all hardware and labor for a period of one (1) year after Final Acceptance.

B. Contractor shall warrant all meters for a period of two (2) year after Final Acceptance.

C. Contractor shall warrant automatic software update for a period of five (5) year after Final Acceptance.

D. If a product that was installed does not comply with the listed pre-approved product, manufacturer or contractor, all related product and labor shall automatically escalate to a 5-year warranty at no cost to the owner, architects, or design team.

E. After completion of the installation, the Contractor shall adjust all control equipment and software provided under this Section. If within the warranty period any of the control equipment and software is defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted, at no cost to the Owner.

F. The Owner reserves the right to make changes to the BAS during the warranty period. Such changes shall not constitute a waiver of warranty. The Contractor shall warrant parts and installation work

regardless of any such changes made by owner, unless the Contractor provides clear and convincing evidence that a specific problem is the result of such changes to the BAS.

G. At no cost to the Owner during the warranty period, the Contractor shall provide maintenance services for software and hardware components as specified below:

1. Preventative Maintenance services shall be provided for all devices and hardware specified in Division 23 Section" Building Automation System (BAS)" Sections. Service all equipment per the manufacturer's recommendations. All devices shall be calibrated within the last month of the warranty period.

2. Normal Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would not result in property damage or loss of comfort control shall be corrected and repaired following telephonic notification by Owner to the Contractor.

   a. Response by telephone to any request for service shall be provided within eight (8) working hours (contractor specified 40 hr/week normal working period) of the initial telephone request for service.

   b. In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the site within three (3) working days of the initial telephone request for such services, as specified.

3. Emergency Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would result in property damage or loss of comfort control shall be corrected and repaired following telephonic notification by Owner to the Contractor.

   a. Response by telephone to any request for service shall be provided within two (2) hours of the initial telephone request for service.

   b. In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the site within eight (8) hours of the initial telephone request for such services, as specified.

   c. Emergency service shall be available on a 24-hour, 7-day-a-week basis.

4. Telephonic Support: Contractor shall provide up to three telephone numbers for Owner to call in the event of a need for service. At least one of the lines shall be attended 24 hours a day, 7 days a week. Alternatively, emails can be used for technicians trained in system to be serviced. A technician shall respond to every call within 15 minutes.

H. Product Warranty Certificates: Submit product manufacturers and/or representative's warranty certificates covering the hardware provided.

I. Project Record Documentation: Maintain project record documents throughout the warranty period and submit final documents at the end of the warranty period.

1.14 **DELIVERY, STORAGE, AND HANDLING**

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons during shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protect from weather.

1.15 **LISTING AND LABELING**

A. The BAS and components shall be listed by Underwriters Laboratories (UL 916) as an Energy Management System.

B. BACnet controllers, B-BC, B-AAC, B-ASC, etc. shall carry the BTL Mark for their device profile.

PART 2 - PRODUCTS

2.1 **MATERIALS AND EQUIPMENT**

A. Materials shall be new, the best of their respective kinds without imperfections or blemishes, and not be damaged in any way. Used equipment shall not be used in any way for the permanent installation except where drawings or specs specifically allow existing materials to remain in place.

B. Instrumentation required to verify readings and test the system and equipment performance shall be provided by the Contractor. All equipment used for testing and calibration shall be NIST/NBS traceable and calibrated within the preceding 6-month period. Certificates of calibration shall be submitted.

C. Refer 23 09 00 series sub-section “BAS – Control Materials” for requirements.

2.2 **UNIFORMITY**

A. To the extent practical, all equipment of the same type serving the same function shall be identical and from the same manufacturer.

PART 3 - EXECUTION

3.1 **INSPECTION**

A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.2 **INSTALLATION OF CONTROL SYSTEMS**

A. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings.

B. Factory/Owner Acceptance Test: a test shall be conducted by this contractor with the owner and designer with a minimum of three months prior to onsite installation. The intent of this verification/approval is to determine that all custom built panels, programs, graphical user interface screens, PID loops for hydronic and airside controls comply with contract documents and construction codes. Approval by Owner and EOR are required prior to installation. All delays incurred due to non-compliance shall be at the cost of this contractor.

C. If any material were procured or installation was started prior to an approved BAS submittal by the designer and owner, any corrections shall be resolved at no cost to the design team or owner. All implicated delays incurred due to non-compliance shall be at the cost of this contractor.

D. If the work fails to be demonstrated to conform to Contract documents, so as to require scheduling of additional site visits by the EOR and/or owner for re-demonstration, Contractor shall reimburse EOR and/or Owner for costs of subsequent site visits.

E. Where a discrepancy exist among details, schematic, construction documents, or sequence, the most stringent shall apply to complete a fully functional system.

3.3 **DIGITAL CONTROL STATIONS, CONTROLLER QUANTITY AND LOCATION**

A. Individual Digital Control Stations (DCS) are referenced to indicate allocation of points to each DCS and DCS location. Digital control stations shall consist of one or multiple controllers to meet requirements specified.

B. Where a DCS is referenced, Contractor shall provide at least one (1) enclosure, one (1) controller, and additional controllers as required and in sufficient quantity to meet the requirements of the contract documents. Restrictions in applying controllers are specified in 23 09 00 series sub-section "Building Automation System (BAS) - Field Panels”.

C. This Contractor shall extend power to the DCS from an acceptable power panel. If the contractor wishes to further distribute panels to other locations, contractor is responsible for extending power to that location also. Furthermore, contractor is responsible for ensuring adequate locations for the panels that

do not interfere with other requirements of the project and maintain adequate clearance for maintenance access.

D. Contractor shall locate DCSs as required. It is the Contractor's responsibility to provide enough controllers and enclosures to ensure a completely functioning system, according to the point list, trending requirements and sequence of operations. Contractor shall coordinate with other trades for

E. Contractor shall provide the following, as a minimum:

1. One DCS (enclosure & controller) in each hydronic plant's mechanical room.
2. One DCS (enclosure & controller) for each air handler (e.g. AHU, MUA, RTU).
3. One DCS (enclosure & controller) for each unitary equipment (e.g. ERV, UV, FCU, Manifolds).
4. One DCS (enclosure & controller) for each group of equipment within a 50-ft radius (e.g. EF, radiant manifolds, meters, miscellaneous monitoring).
5. One controller shall be provided for each terminal unit with factory enclosure.

3.4 SURGE PROTECTION

A. The Contractor shall furnish and install any power supply surge protection, filters, and other equipment as necessary for proper operation and protection of all PCUs, operator interfaces, printers, routers, gateways and other hardware and interface devices. All equipment shall be capable of handling voltage variations 10% above or below measured nominal value, with no affect on hardware, software, communications, and data storage.

3.5 **CONTROL POWER SOURCE AND SUPPLY**

A. Extend all power source wiring required for operation of all equipment and devices provided under Division 23 Building Automation System (BAS) Sections and Sequences of Operation.

1. Control panels shall not share a power circuit. Power supplied to the panels shall have dedicated circuits and the circuit location shall be documented in the panel.

3.6 **STARTUP, COMMISSIONING, AND TRAINING**

A. Refer to Division 23 Section "Building Automation System (BAS) - Commissioning."

B. At the direction of the engineer during construction, testing implementation, and/or after acceptance, allow time for application programming modifications to the sequence of operation to accommodate tuning of controlled system devices to match intended functional performance.

C. At the direction of the engineer (EOR and not Cx) after acceptance, allow for a minimum of 40 hours of modifications to the control system To meet intended functional performance.

3.7 **SEQUENCE OF OPERATION**

A. Refer to Division 23 Section "Building Automation System (BAS) - Sequences of Operation."

3.8 **IDENTIFICATION STANDARDS**

A. Controller Identification. All controllers shall be identified by a plastic engraved nameplate securely fastened to the outside of the controller enclosure.

B. Panel Identification. All local control panels shall be identified by a plastic engraved nameplate securely fastened to the outside of the controller enclosure.

C. Field Devices. All field devices shall be identified by a typed (not handwritten) securely attached tag label.

D. Panel Devices. All panel devices shall be identified by a typed label securely fastened to the backplane of the local control panel.

E. Raceway Identification. All the covers to junction and pull boxes of the control system raceways shall be painted blue or have identification labels stating "Control System Wiring" affixed to the covers. Labels shall be typed, not hand written.

F. Wire Identification. All low and line voltage control wiring shall be identified by a number, as referenced to the associated control diagram, at each end of the conductor or cable. Identification number shall be permanently secured to the conductor or cable and shall be typed

END OF SECTION

SECTION 230921 - BUILDING AUTOMATION SYSTEM (BAS) - BASIC MATERIALS, INTERFACE DEVICES, AND SENSORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:

1. Pneumatic Tubing.
2. Wiring.
3. Control Valves and Actuators.
4. Control Dampers and Actuators.
5. Field Panels.
6. Sensors.
7. Pneumatic Control Components (Gauges, switches, relays, etc.).
8. Electric Control Components (Switches, EP Valves, Thermostats, Relays, Smoke Detectors, etc.).
9. Transducers.
10. Specialty Gas Detection.
11. Measuring & Metering.
12. Current Switches.
13. Nameplates.
14. Testing Equipment.

1.2 DESCRIPTION OF WORK

A. Refer to Division 23 Section "Building Automation System (BAS)" for general requirements.

B. Refer to other Division 23 Sections for installation of instrument wells, valve bodies, and dampers in mechanical systems; not work of this Section.

C. Provide the following electrical work as work of this Section, complying with requirements of Division 26 Sections:

1. Control wiring between field-installed controls, indicating devices, and unit control panels.
2. Interlock wiring between electrically interlocked devices, sensors, and between a hand or auto position of motor starters as indicated for all mechanical and controls.
3. Wiring associated with indicating and alarm panels (remote alarm panels) and connections to their associated field devices.
4. All other necessary wiring for fully complete and functional control system as specified.
5. Power wiring from spare circuits in electrical panels to Digital Control System Field Panels.

D. Warranty Period: Refer to specification 23 09 20, section 1.13 for Warranty requirements.

1.3 COORDINATED WORK WITH OTHERS

A. BAS contractor shall provide written coordination on capacity, performance, and location on all devices that require installation by trade contractor during the 230920 submittal phase.

B. AFMS that may be factory-installed require written coordination with sign-off during the 230920 submittal phase.

C. Automated Control Valves shall be furnished under this Section and shall be installed under the applicable piping Section under the direction of the Digital Control System Contractor who shall be fully responsible for the proper operation of the valve.

D. Control Dampers furnished under this Section shall be installed under the applicable air distribution or air handling equipment Section under the direction of the Digital Control System Contractor who shall be fully responsible for the proper operation of the damper

E. Water Pressure Taps, Thermal Wells, Flow Switches, Flow Meters, etc. that will have wet surfaces, shall be installed under the applicable piping Section under the direction of the Digital Control System Contractor who shall be fully responsible for the proper installation and application.

F. Controlled Equipment Power Wiring shall be furnished and installed under Division 26. Where control involves 120V control devices controlling 120V equipment, Division 26 Contractor shall extend power wiring to the equipment. Building Automation System Contractor shall extend it from the equipment to the control device.

G. BAS Contractor shall provide adequate time to coordinate and work with Equipment Manufacturer where factory-controls are provided to achieve the design sequence of operations.

H. BAS Contractor shall provide adequate time to coordinate and work with Test and Balancing Contractor to achieve the design sequence of operations.

I. If coordination has been neglected or failed to occur, the BAS contractor shall provide the required design intent device and trade contractor shall install said device at no cost to the owner and designers.

PART 2 - PRODUCTS

2.1 GENERAL FIELD DEVICES

A. Provide field devices for input and output of digital (binary) and analog signals into BACnet controllers (BCs, AACs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers, and as required for proper operation in the system.

B. It shall be this contractor's responsibility to assure that all field devices are compatible with controller hardware and software.

C. Field devices specified herein are generally ‘two-wire’ type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, designed to work with ‘two-wire’ type transmitters, if field device is to serve as input to more than one controller, or where the length of wire to the controller will unacceptably affect the accuracy, the Contractor shall provide ‘four-wire’ type equal transmitter and necessary regulated DC power supply or 120 VAC power supply, as required.

D. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, Contractor shall furnish and install proper device, including 120V power as required. Such devices shall have accuracy equal to, or better than, the accuracy listed for respective field devices.

E. Accuracy: As stated in this Section, accuracy shall include combined effects of nonlinearity, non-repeatability and hysteresis.

F. Acceptable manufacturers: No exceptions shall be acceptable post bid without the EOR’s approval.

2.2 MATERIALS AND EQUIPMENT

A. General: Provide electronic control products in sizes and capacities indicated, consisting of valves, dampers, thermostats, clocks, controllers, sensors, and other components as required for complete installation. Except as otherwise indicated, provide manufacturer's standard materials and components as published in their product information; designed and constructed as recommended by manufacturer, and as required for application indicated.

B. Conduit: All wiring shall be in conduit and in accordance with the most stringent of National Electrical Codes, Local Electrical Codes, Division 23, and Division 26 of the contract documents.

C. Communication Wiring: All wiring shall be in accordance with National Electrical Codes and Division 26 of the contract documents.

1. Contractor shall supply all communication wiring between Building Controllers (BC), Routers, Gateways, Advanced Application Controllers (AAC), Application Specific Controllers (ASC) and local and remote peripherals (e.g., operator workstations, printers, and modems).
2. Local Supervisory LAN: For any portions of this network required under this Section of the specification, contractor shall use Fiber or Category 5 of standard TIA/EIA 68 (10BaseT).
3. Network shall be run with no splices and separate from any wiring over thirty (30) volts.
4. Primary and Secondary Controller LANs: Communication wiring shall be individually 100% shielded pairs per manufacturers recommendations for distances installed, with overall PVC cover, Class 2, plenum-rated run with no splices and separate from any wiring over thirty (30) volts. Shield shall be terminated and wiring shall be grounded as recommended by BC manufacturer.

D. Control Panels: Provide control panels with suitable brackets for wall mounting for each control system. It shall be the Contractor's responsibility for coordination with other trades for space clearance, elevation, and power requirements. Contractor shall provide and locate panels adjacent to systems served.

1. Fabricate panels of 16-gage furniture-grade steel, or 6063-T5 extruded aluminum alloy, totally enclosed on four sides, with hinged door and keyed lock, with manufacturer's standard shop-painted finish and color.
2. Provide UL-listed cabinets for use with line voltage devices.
3. All gauges and control components shall be identified by means of nameplates.
4. All control tubing and wiring shall be run neatly and orderly in open slot wiring duct with cover.
5. Complete wiring and tubing termination drawings shall be mounted in or adjacent to panel.
6. All panels shall be RoHS compliant.

E. Signal Wiring: Contractor shall run all signal wiring in accordance with National Electric Codes and Division 26 of the contract documents.

1. Signal wiring to all field devices, including, but not limited to, all sensors, transducers, transmitters, switches, etc. shall be twisted, 100% shielded pair, minimum 18-gauge wire, with PVC cover.
2. Signal wiring shall be run with no splices and separate from any wiring above thirty (30) volts.
3. Signal wiring shield shall be grounded at controller end only unless otherwise recommended by the controller manufacturer.

F. Low Voltage Analog Output Wiring: Contractor shall run all low voltage control wiring in accordance with National Electric Codes and Division 26 of the contract documents.

1. Low voltage control wiring shall be minimum 16-gauge, twisted pair, 100% shielded, with PVC cover, Class 2 plenum-rated.
2. Low voltage control wiring shall be run with no splices separate from any wiring above thirty (30) volts.

G. Instrument Pipe and Tube

1. Low Pressure Air Instrument Sensing Lines

a. Connections: Use suitable bulkhead type fitting and static sensing tip for static pressure connections. Adapt tubing to instrument connection.
b. Tubing: Virgin polyethylene non-metallic tubing type FR, ASTM D 2737, and with flame-retardant harness for multiple tubing.
c. Use compression or push-on brass fittings.

2.3 CONTROL VALVES

A. General: Provide factory fabricated control valves of type, body material and pressure class indicated. Where type or body material is not indicated, provide selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature in piping

system. Provide valve size in accordance with scheduled or specified maximum pressure drop across control valve. Control valves shall be equipped with heavy-duty actuators, and with proper close-off rating for each individual application. Minimum close-off rating shall be as scheduled and adequate for each application, and shall generally be considered at dead head rating of the pump.

B. Indicate normal (fail) positions of spring return valves. This is the valve position with no power to the actuator.

C. Acceptable Manufacturers for all non-pressure independent control valves:

1. Belimo
2. Bray Control Valves
3. Johnson Control Valves

D. Ball Type: Valve shall be sized for 50 to 100% of branch pressure drop.

1. Body: Brass; one-, two-, or three-piece design; threaded ends.
2. Seat: Reinforced Teflon
3. Ball: Stainless steel.
4. Port: Standard or 'V' style.
5. Stem: Stainless steel, blow-out proof design, extended to match thickness of insulation.
6. Cold Service Pressure: 600 psi WOG
7. Steam working Pressure: 150 psi
8. Actuator: Provide 0-10V/4-20mA modulating, spring-return, with control feedback motors. No exception.
9. Application: Modulating or 2-position control of water or steam lines.

E. Characterized Ball Type

1. Body: Carbon Steel (ASTM 216), one-piece design with wafer style ends.
2. Seat: Reinforced Teflon (PTFE).
3. Ball: Stainless steel ASTM A351
4. Port: Segmented design with equal-percentage characteristic.
5. Stem: Stainless steel.
6. Cold Service Pressure: 200 psi WOG
7. Cavitation Trim: Provide cavitation trim where indicated and/or required, designed to eliminate cavitation and noise while maintaining an equal percentage characteristic. Trim shall be a series of plates with orifices to break the pressure drop into multi-stages.
8. Actuator: Provide 0-10 V/4-20 mA modulating, spring-return, with control feedback motors. No exception.
9. Application: Modulating or 2-position control of water or steam lines.

F. Plug-Type Globe Pattern for Water Service:

1. Valve Sizing: Where not specifically indicated on the control drawings, modulating valves shall be sized for maximum full flow pressure drop between 50% and 100% of the branch circuit it is controlling unless scheduled otherwise. Two-position valves shall be same size as connecting piping.
2. Single Seated (Two-way) Valves: Valves shall have equal-percentage characteristic for typical heat exchanger service and linear characteristic for building loop connections to campus systems unless otherwise scheduled on the drawings. Valves shall have cage-type trim, providing seating and guiding surfaces for plug on 'top-and-bottom' guided plugs.
3. Double Seated (Three-way) Valves: Valves shall have linear characteristic. Valves shall be balanced-plug type, with cage-type trim providing seating and guiding surfaces on 'top-and-bottom' guided plugs.
4. Temperature Rating: 25°F minimum, 250°F maximum

5. Body: Bronze, screwed, 250 psi maximum working pressure for 1/2" to 2"; Cast Iron, flanged, 125 psi maximum working pressure for 2-1/2" and larger.
6. Valve Trim: Bronze; Stem: Polished stainless steel.
7. Packing: Spring Loaded Teflon or Synthetic Elastomer U-cups, self-adjusting.
8. Plug: Stainless steel, Seat: Brass
9. Disc: Stainless Steel Filled PTFE.
10. Ambient Operating Temperature Limits: -10 to 150°F
11. Actuator: Provide 0-10 V/4-20 mA modulating, spring-return, with control feedback motors. No exception.
12. Application: Modulating or 2-position control of water or steam lines

G. Butterfly Type: Valve shall be sized for 50 to 100% of branch pressure drop. For valves sized at 3way less than 90 degree position for pressure drop are to have the linkage for full closed when the open port is at the design point.

1. Body: Extended neck epoxy coated cast or ductile iron with full lug pattern, ANSI Class 125 or 250 bolt pattern to match specified flanges.
2. Seat: EPDM, except in loop bypass applications where seat shall be metal to metal
3. Disc: Bronze or stainless steel, pinned or mechanically locked to shaft
4. Bearings: Stainless steel
5. Shaft: 416 stainless steel
6. Cold Service Pressure: 175 psi
7. Close Off: Bubble-tight shutoff to 150 psi
8. Operation: Valve and actuator operation shall be smooth both seating and unseating. Should more that 2 psi deadband be required to seat/unseat the valve, valve shall be replaced at no cost to the owner.
9. Actuator: Provide 0-10 V/4-20 mA modulating, spring-return, with control feedback motors. No exception.
10. Application: 2-position control of water lines. Modulating applications require EOR approval.

H. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:

I. Pressure Independent Control Valves (PICV)

1. PI valves is a control valve with a regulator valve which maintains the differential pressure across a flow control valve.
2. PI valves shall accurately control the flow from 0-100% full rated flow regardless of changes in the piping pressure.
3. PI valves shall not vary the flow more than ±5% at any given flow control valve position when the PIV differential pressure lies between the manufacturer's stated minimum and maximum.
4. The rated minimum differential pressure for steady flow must not exceed 5 psid across the PIV.
5. Provide either globe or ball type valves meeting the indicated requirements for globe and ball valves.
6. Provide valves with a flow tag listing full rated flow and minimum required pressure drop.
7. Provide valves with factory installed Pressure/Temperature ports ("Pete's Plugs") to measure the pressure drop to determine the valve flow rate.
8. Actuator: Provide 0-10 V/4-20 mA modulating, spring-return, with control feedback motors. No exception.
9. Application: Modulating control of water lines.

J. Acceptable Manufacturers for pressure independent control valves only:

1. Flow Control
2. Belimo
3. Bray Control Valves

4. DeltaP

K. General: Provide factory fabricated control valves of type, body material and pressure class indicated. Where type or body material is not indicated, provide selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature in piping system. Provide line size valves. Valves shall be equipped with heavy-duty actuators, and with proper close-off rating for each individual application. Minimum close-off rating shall be as scheduled and adequate for each application and shall generally be considered at dead head rating of the pump.

L. Indicate normal (fail) positions of spring return valves. This is the valve position with no power to the actuator.

M. Application: Modulating or 2-position control of potable water lines.

N. Acceptable Manufacturers for all solenoid valves:

1. ASCO
2. Danfoss
3. Or approved equal.

O. Solenoid Type: Valve shall be sized for 50 to 100% of branch pressure drop.

1. Body: Brass; one-, two-, or three-piece design; threaded ends.
2. Seat: PTFE or NBR
3. Spring: 302 Stainless steel.
4. Cold Service Pressure: 150 psi WOG
5. Actuator: 2-position, spring-return.
6. Potable Water requirement: SDWA 1417

2.4 CONTROL DAMPERS

A. General: Provide factory fabricated automatic control dampers of sizes, velocity and pressure classes as required for smooth, stable, and controllable air flow. Provide parallel or opposed blade dampers as recommended by manufacturers sizing techniques. Provide parallel blade dampers for dampers providing two-position control (for multi zone dampers a parallel blade application with lower torque requirements should be submitted as an alternate). For dampers located near fan outlets, provide dampers rated for fan outlet velocity and close-off pressure, and recommended by damper manufacturer for fan discharge damper service.

B. Indicate normal (fail) positions of spring return dampers. This is the damper position with no power to the actuator.

C. For zone dampers and other applications with duct or opening areas less than 5 square feet that do not provide isolation to outdoors and function in a general isolation and modulating control service in rectangular ducts at velocities not greater than 1500 fpm , differential pressure not greater than 2.5" w.c.:

1. Performance: Test in accordance with AMCA 500.
2. Frames: Galvanized steel, 16-gauge minimum thickness, welded or riveted with corner reinforcement.
3. Blades: Stainless steel in lab exhausts and galvanized steel elsewhere, maximum blade size 8 inches wide by 48 inches long, attached to minimum 1/2 inch shafts with set screws, 16 gauge minimum thickness.
4. Blade Seals: Synthetic elastomer, mechanically attached, field replaceable.
5. Jamb Seals: None.
6. Shaft Bearings: Oil impregnated sintered bronze, graphite impregnated nylon sleeve or other molded synthetic sleeve, with thrust washers at bearings.
7. Linkage: Concealed in frame if parallel.
8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.

9. Leakage: Less than one percent based on approach velocity of 1500 ft./min. and 1 inch wg.
10. Maximum Pressure Differential: 2.5 inches wg.
11. Temperature Limits: -40 to 200 °F.
12. Where two dampers are to be mechanically interlocked such as a face and bypass arrangement, the manufacturer shall provide required torque values for the combined damper assembly.
13. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:

    a. Tamco
    b. Johnson Controls D-1100
    c. Ruskin CD36
    d. Vent Products 5810

D. For applications with duct or opening areas greater than 5 square feet that do not provide isolation to outdoors and function in a general isolation and modulating control service in rectangular ducts at velocities exceeding 1500 fpm, differential pressure greater than 2.5" w.c.:

1. Performance: Test in accordance with AMCA 500.
2. Frames: Galvanized steel, 16-gauge minimum thickness, welded or riveted with corner reinforcement.
3. Blades: Galvanized steel or extruded aluminum hollow airfoil shape, maximum blade size 8 inches wide by 48 inches long, attached to minimum 1/2 inch shafts, 14 gauge minimum extrusion thickness.
4. Blade Seals: Synthetic elastomeric, mechanically attached, field replaceable.
5. Jamb Seals: Stainless steel.
6. Shaft Bearings: Oil impregnated sintered bronze sleeve, graphite impregnated nylon sleeve, molded synthetic sleeve, or stainless-steel sleeve, with thrust washers at bearings.
7. Linkage: Concealed in frame if parallel.
8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.
9. Leakage: Less than 0.1 percent based on approach velocity of 4000 ft./min. and 1 inch wg. .
10. Maximum Pressure Differential: 6 inches wg.
11. Temperature Limits: -40 to 200 °F.
12. Where opening size is larger than 48 inches wide, or 72 inches high, provide dampers in multiple sections, with appropriately intermediate frames, and jackshafts. For multiple dampers driven by a jackshaft the shaft shall rigid in torsion and driven by at least two actuators located at either end of the shaft.
13. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:

    a. TAMCO 1000
    b. Ruskin CD60
    c. CESCO Products AGA or AGB

E. For all outside air intake or exhaust control dampers that provide isolation to outdoors or otherwise need to provide thermal isolation:

1. Performance: Test in accordance with AMCA 500.
2. Frames: Galvanized steel, 16-gauge minimum thickness, welded or riveted with corner reinforcement.
3. Blades: Extruded aluminum hollow airfoil shape, maximum blade size 8 inches wide by 48 inches long, attached to minimum 1/2 inch shafts, 14 gauge minimum extrusion thickness.
4. Blade Seals: Synthetic elastomeric, mechanically attached, field replaceable.
5. Jamb Seals: Non-metallic seal.
6. Shaft Bearings: Oil impregnated sintered bronze sleeve, graphite impregnated nylon sleeve, molded synthetic sleeve, or stainless steel sleeve, with thrust washers at bearings.
7. Linkage: Concealed in frame if parallel.
8. Linkage Bearings: Oil impregnated sintered bronze or graphite impregnated nylon.

9. Leakage: Less than 0.1 percent based on approach velocity of 4000 ft./min and 1 inch wg.
10. Maximum Pressure Differential: 6 inches wg.
11. Temperature Limits: -40 to 200 °F.
12. Where opening size is larger than 48 inches wide, or 72 inches high, provide dampers in multiple sections, with appropriately intermediate frames, and jackshafts. For multiple dampers driven by a jackshaft the shaft shall rigid in torsion and driven by at least two actuators located at either end of the shaft.
13. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:

    a. Ruskin TED50
    b. TAMCO 9000

14. For general isolation and modulating control service in round ducts up to 40 inches in size at velocities not greater than 2500 fpm , differential pressure not greater than 4" w.c.:
15. Performance: Test in accordance with AMCA 500.
16. Frames: rolled 12 gauge steel strip for sizes 6 inch and smaller, rolled 14 gauge steel channel for larger sizes, galvanized or aluminum finish.
17. Blades: Steel construction, 12 gauge minimum thickness for dampers less than 18 inches in size, 10 gauge minimum thickness for larger dampers.
18. Blade Seals: Full circumference neoprene.
19. Shaft: ½ inch diameter zinc or cadmium plated steel.
20. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
21. Leakage: Less than 0.2 percent based on approach velocity of 4000-ft/min and 1 inch-wg differential pressure.
22. Maximum Pressure Differential: 4 inches wg.
23. Temperature Limits: -40 to 300 °F.

F. For general isolation and modulating control service in round ducts up to 60 inches in size at velocities not greater than 4000 fpm (20.3 m/s), differential pressure not greater than 6" w.c. (1492 Pa):

1. Performance: Test in accordance with AMCA 500.
2. Frames: rolled 10-gauge steel channel for sizes 48 inch and smaller, rolled 3/16 inch thick steel channel for larger sizes, galvanized or aluminum finish.
3. Blades: Steel construction, 10-gauge minimum thickness for dampers not greater than 48 inches in size, ¼ inch minimum thickness for larger dampers.
4. Blade stops: ½ inch x ¼ inch full circumference steel bar.
5. Blade Seals: Full circumference neoprene.
6. Shaft: zinc or cadmium plated steel, angle reinforcing as necessary.
7. Shaft Bearings: Oil impregnated sintered bronze or stainless steel, pressed into frame, with thrust washers at bearings.
8. Leakage: Less than 0.4 percent based on approach velocity of 4000 ft/min and 1 inch wg differential pressure.
9. Maximum Pressure Differential: 6 inches wg.
10. Temperature Limits: -40 to 250 °F.

2.5 ACTUATORS

A. General: Size actuators and linkages to operate their appropriate dampers or valves with sufficient reserve torque or force to provide smooth modulating action or 2-position action as specified. Select spring-return actuators with manual override to provide positive shut-off of devices as they are applied.

B. Damper Actuators:

1. Ambient Operating Temperature Limits: -10 to 122°F
2. Two Position Electric Actuators: Line voltage with spring return

3. Electronic Actuators: Provide actuators with spring return for two-position (24v), 0-5 Vdc, 0-10 Vdc, 2-10Vdc, 4-20 mA, as required. Actuators shall travel full stroke in less than 90 seconds, unless prior approval is obtained. Actuators shall be designed for a minimum of 60,000 full cycles at full torque and be UL 873 listed. Provide stroke indicator. Actuators shall have positive positioning circuit. Where two actuators are required in parallel, or in sequence, provide an auxiliary actuator driver. Actuators shall have current limiting motor protection. Actuators shall have manual override. Modulating actuators for valves shall have minimum rangeability of 40 to 1.

   a. Close-Off Pressure: Provide the minimum torque required, and spring return for fail positioning (unless otherwise specifically indicated) sized for required close-off pressure. Required close-off rating of air damper applications shall be shutoff pressure of associated fan, plus 10 percent. When shutoff does not apply the actuator shall be sized based on the manufactures required torque plus 30%.
   b. Acceptable Manufacturers: Subject to compliance with requirements approved manufacturers are as follows:

      1) Belimo
      2) Honeywell

C. Valve Actuators:

1. Electric

   a. Motor: Suitable for 120 or 240 Volt single-phase power supply. Insulation shall be NEMA Class F or better. Motor shall be rated for 100 percent duty cycle. Motors shall have inherent overload protection.
   b. Gear Train. Motor output shall be directed to a self-locking gear drive mechanism. Gears shall be rated for torque input exceeding motor locked rotor torque.
   c. Wiring: Power and control wiring shall be wired to a terminal strip in the actuator enclosure
   d. Failsafe Positioning: Actuators shall be spring-return type or battery-powered for failsafe positioning.
   e. Enclosure: Actuator enclosure shall be NEMA-4 rated, and shall have a minimum of two threaded conduit entries. Provide an enclosure heater for actuators located outside of buildings.
   f. Limit Switches: Travel limit switches shall be UL and CSA approved. Switches shall limit actuator in both open and closed positions.
   g. Mechanical Travel Stops: The actuator shall include mechanical travel stops of stainless steel construction to limit actuator to specific degrees of rotation.
   h. Manual Override: Actuators shall have manual actuator override to allow operation of the valve when power is off. For valves 4 inches and smaller the override may be a removable wrench or lever or geared hand-wheel type. For larger valves, the override shall be a fixed geared hand-wheel type. An automatic power cut-off switch shall be provided to disconnect power from the motor when the hand-wheel is engaged for manual operation.
   i. Valve Position Indicator: A valve position indicator with arrow and open and closed position marks shall be provided to indicate valve position.
   j. Torque Limit Switches: Provide torque limit switches to interrupt motor power when torque limit is exceeded in either direction of rotation.
   k. Position Controller: For valves used for modulating control, provide an electronic positioner capable of accepting 4-20 mA, 0-10 Vdc, 2-10 Vdc, and 135 Ohm potentiometer.
   l. Ambient Conditions: Actuator shall be designed for operation from –10 to 150 °F ambient temperature with 0 to 100 percent relative humidity.

2.6 GENERAL FIELD DEVICES

A. Provide field devices for input and output of digital (binary) and analog signals into controllers (BCs, AACs, ASCs). Provide signal conditioning for all field devices as recommended by field device manufacturers, and as required for proper operation in the system.

B. It shall be the Contractor's responsibility to assure that all field devices are compatible with controller hardware and software.

C. Field devices specified herein are generally 'two-wire' type transmitters, with power for the device to be supplied from the respective controller. If the controller provided is not equipped to provide this power, or is not designed to work with 'two-wire' type transmitters, or if field device is to serve as input to more than one controller, or where the length of wire to the controller shall unacceptably affect the accuracy, the Contractor shall provide 'four-wire' type equal transmitter and necessary regulated DC power supply or 120 VAC power supply, as required.

D. For field devices specified hereinafter that require signal conditioners, signal boosters, signal repeaters, or other devices for proper interface to controllers, Contractor shall furnish and install proper device, including 120V power as required. Such devices shall have accuracy equal to, or better than, the accuracy listed for respective field devices.

E. Accuracy: As stated in this Section, accuracy shall include combined effects of nonlinearity, non-repeatability and hysteresis.

2.7 TEMPERATURE SENSORS (TS)

A. Sensor range: When matched with A/D converter of BC, AAC/ASC, or Smart Sensor (SS), sensor range shall provide a resolution of no worse than 0.3°F (unless noted otherwise). Where thermistors are used, the stability shall be better than 0.25°F over 5 years.

B. Matched Sensors: The following applications shall require matched sensors:

1. Building Loop Connections: Provide matched loop and building supply sensors where control sequence requires controlling to a temperature rise (differential).
2. Hydronic Temperature Difference Calculations: Provide matched supply and return temperature sensors where the pair is used for calculating temperature difference for use in load calculations or sequencing such as across chillers and plants.
3. Air Handling Unit Sequencing: Provide matched pair for the cooling and heating coil leaving sensors where the sequence includes calculating an offset from the supply air setpoint to maintain a leaving heating coil temperature.

C. Room Temperature Sensor: Shall be a stainless steel wall plate sensor. An electronic thermostat with manual override shall be provided in the office areas and in select common areas as approved by Owner. Provide ¼" medical grade closed cell foam insulating material. The following sensing elements are acceptable:

1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.3°F accuracy at calibration point.

D. Single-Point Duct Temperature Sensor: Shall consist of sensing element, junction box for wiring connections and gasket to prevent air leakage or vibration noise. Temperature range as required for resolution indicated in paragraph A. Sensor probe shall be 316 stainless steel.

1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.3°F accuracy at calibration point

E. Averaging Duct Temperature Sensor: Shall consist of an averaging element, junction box for wiring connections and gasket to prevent air leakage. Provide sensor lengths and quantities to result in one lineal foot of sensing element for each three square feet of cooling coil/duct face area. Temperature range as required for resolution indicated in paragraph A.

1. Sensing element shall be platinum RTD, or thermistor, +/- 0.3°F accuracy at calibration point.

F. Liquid immersion temperature sensor shall include thermowell, sensor and connection head for wiring connections. Provide thermally conductive paste in well to ensure good contact with the well. Temperature range shall be as required for resolution of 0.15°F.

1. Sensing element (chilled water/glycol systems) shall be platinum RTD +/- 0.2°F accuracy at calibration point. Temperature range shall be as required for resolution of 0.15°F.
2. Sensing element (other systems) shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point. Temperature range shall be as required for resolution of 0.3°F.

G. Pipe Surface-Mount Temperature Sensor: Sensor are only for use in applications specifically identified on the drawings. Normally only used on condensate return piping for steam systems. Shall include metal junction box and clamps and shall be suitable for sensing pipe surface temperature and installation under insulation. Provide thermally conductive paste at pipe contact point. Temperature range shall be as required for resolution indicated in paragraph A.

1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point.

H. Outside air sensors shall consist of a sensor, an aspirated enclosure, utility box, and watertight gasket to prevent water seepage. Temperature range shall be as required for resolution indicated in Paragraph A

1. Sensing element shall be platinum RTD, thermistor, or integrated circuit, +/- 0.4°F accuracy at calibration point.
2. Acceptable Manufacturers: Kele A21 or equal

2.8 TEMPERATURE TRANSMITTERS

A. Where required by Controller, or where wiring runs are over 50 feet, sensors as specified above may be matched with transmitters outputting 4-20 mA linearly across the specified temperature range. Transmitters shall have zero and span adjustments, an accuracy of 0.1°F when applied to the sensor range.

2.9 HUMIDITY TRANSMITTERS

A. Units shall be suitable for duct, wall (room) or outdoor mounting. Unit shall be two-wire transmitter utilizing bulk polymer resistance change or thin film capacitance change humidity sensor. Unit shall produce linear continuous output of 4-20 mA for percent relative humidity (% RH). A combination temperature and humidity sensor may be used for zone level monitoring. Sensors shall have the following minimum performance and application criteria:

1. Input Range: 0 to 100% RH.
2. Accuracy (% RH): +/- 2% (when used for enthalpy calculation, dewpoint calculation or humidifier control) or +/- 3% (monitoring only) between 20-90% RH at 77°F, including hysteresis, linearity, and repeatability.
3. Sensor Operating Range: As required by application
4. Long Term Stability: Less than 1% drift per year.

B. Acceptable Manufacturers: Units shall be Vaisala HM Series, General Eastern, or Honeywell H7 Series.

2.10 PRESSURE AND DIFFERENTIAL PRESSURE TRANSMITTERS (DP)

A. General Purpose - Water: Two-wire transmitter, 4-20 mA output with zero and span adjustments. Plus or minus 0.5% overall accuracy, 450 psig maximum static pressure rating, 200 psid maximum overpressure rating for 6 through 60 psid range, 450 psid for 100 through 300 psid range.

1. Acceptable Manufacturers: Dwyer, Mamac, Setra, or equal.

B. Liquid, Steam and Gas:

1. General: Two-wire smart DP cell type transmitter, 4-20 mA or 1-5 Vdc user-selectable linear or square root output, adjustable span and zero, stainless steel wetted parts.
2. Environmental limits: –40 to 250 °F , 0 to 100% RH..
3. Accuracy: less than 0.1 percent of span.
4. Output Damping: Time constant user selectable from 0 to 36 seconds.
5. Vibration Effect: Less than ±0.1% of upper range limit from 15 to 2000 Hz in any axis relative to pipe mounted process conditions.
6. Electrical Enclosure: NEMA-4, -4X, -7, -9.
7. Approvals: FM, CSA.
8. Acceptable Manufacturers: Dwyer, Foxboro, Johnson-Yokogawa, Mamac, Setra, or Rosemount Inc.

C. General Purpose Low Pressure Air: Generally for use in static measurement of duct pressure or constant volume air velocity pressure measurement where the range is applicable.

1. General: Loop powered two-wire differential capacitance cell-type transmitter.
2. Output: two wire 4-20 mA output with zero adjustment.
3. Overall Accuracy: Plus or minus 1% of reading.
4. Minimum Range: 0.1 in. w.c.
5. Maximum Range: 10 inches w.c.
6. Housing: Polymer housing suitable for surface mounting.
7. Acceptable Manufacturers: Modus T30.
8. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.
9. Range: Select for specified setpoint to be between 25% and 75% full-scale.

D. General Purpose Low Pressure/Low Differential Air: Generally for use in static measurement of space pressure or constant volume air velocity pressure measurement where the range is applicable.

1. General: Loop powered, two-wire differential capacitance cell type transmitter.
2. Output: Two-wire 4-20 mA output with zero adjustment.
3. Overall Accuracy: Plus or minus 1% of reading.
4. Minimum Range: 0 in. w.c.
5. Maximum Range: 0.1, 0.25, or 0.5 inches w.c.
6. Housing: Polymer housing suitable for surface mounting.
7. Acceptable Manufacturers: Modus T30 or Setra.
8. Static Sensing Element: Pitot-type static pressure sensing tips similar to Dwyer model A-301 and connecting tubing.
9. Range: Select for specified setpoint to be between 25% and 75% full-scale.

E. Velocity Pressure: Generally for use in air velocity pressure measurement where the range is applicable.

1. General: Loop powered two-wire differential capacitance cell type transmitter.
2. Output: Two-wire, 4-20 mA output with zero adjustment.
3. Overall Accuracy: Plus or minus 0.25%
4. Minimum Range: 0 in. w.c.
5. Maximum Range: 1 inch w.c.
6. Housing: Polymer housing suitable for surface mounting.
7. Acceptable Manufacturers: Setra 264 with optional FS accuracy above or equal. .
8. Range: Select for minimum range that shall accept the maximum velocity pressure expected.

2.11 VALVE BYPASS FOR DIFFERENTIAL PRESSURE SENSORS

A. Provide a five valve bypass kit for protection of DP sensors where the static on the pipe can cause on over pressure when connected to one port with the other at atmospheric pressure. Kit shall include

high and low pressure isolation valves, high and low pressure vent valves, and a bypass valve contained in a NEMA-1 enclosure.

2.12 DIFFERENTIAL PRESSURE SWITCHES (DPS)

A. General Service - Air: Diaphragm with adjustable setpoint and differential and snap acting form C contacts rated for the application. Provide manufacturer's recommended static pressure sensing tips and connecting tubing

B. General Service - Water: Diaphragm with adjustable setpoint, 2 psig or adjustable differential, and snap-acting Form C contacts rated for the application. 60 psid minimum pressure differential range. 0°F to 160°F operating temperature range.

C. Acceptable Manufacturers: BAPI, Dwyer, Honeywell, and Johnson Controls.

2.13 PRESSURE SWITCHES (PS)

A. Diaphragm or bourdon tube with adjustable setpoint and differential and snap-acting Form C contacts rated for the application. Pressure switches shall be capable of withstanding 150% of rated pressure.

B. Acceptable Manufacturers: Square D, ITT Neo-Dyn, ASCO, Penn, Honeywell, and Johnson Controls.

2.14 LEAK DETECTORS

A. General: Single zone leak detection rope with controller and audible alarm.

1. Environmental limits: 32 to 160 °F , 5 to 95% RH..
2. Output: 2 Form C Alarm Relays.

B. Acceptable Manufacturers: RLE, FloodMaster, Liebert

2.15 TRANSDUCERS

A. Standard Capacity Electronic-to-Pneumatic (E-P) Transducers: E-P transducers shall be Voltage-to-Pneumatic (V-P) type, Current-to-Pneumatic (I-P) type,:

1. Electrical Power Supply: 24 Vac or 24 Vdc.
2. Pneumatic Air Supply: 25 psig (1.72 bar) maximum.
3. Air Capacity: 515 scim @ 20 psig (135 cm^3/sec @ 1.38 bar).
4. Air Consumption: Zero at steady state.
5. Output Span: 3-15 psig (.21-1.03 bar).
6. Input: 4-20 mA, 0-5 Vdc, 1-5 Vdc, 0-10 Vdc, 2-10 Vdc, 0-15 Vdc, or 3-15 Vdc input.
7. Enclosure: Polymer designed for surface or panel mount.
8. Air Connections: ¼" (6.35 mm) barbed.
9. Failure Mode on Power Loss: Non-failsafe transducers shall have no output air loss. Failsafe transducers shall exhaust output upon power loss.
10. Acceptable Manufacturers: Kele Model UCP-422.

B. Binary to Analog Transducers or Tri-State-to-Voltage or -Current:

1. Adjustable zero and span.
2. Failure Mode on Power Loss: Shall be provided with memory feature to allow the transducer to return to last value on power failure.
3. Accuracy: ± 1% of span
4. Output Span: 4-20 mA, 0-5 Vdc, 1-5 Vdc, 0-10Vdc, 2-10Vdc, 0-15Vdc, 3-15Vdc
5. Input: 4-20 mA, pulse width modulated or tri-state input.
6. Tri-state Input Time Base: Dip switch selectable.

7. Enclosure: Polymer designed for surface or panel mount.
8. Failure Mode on Power Loss: Non-failsafe transducers shall have no output air loss. Failsafe transducers shall exhaust output upon power loss.
9. Acceptable Manufacturers: Kele Model PWA Series.

C. Electronic-to Electronic (Voltage or Current to Current or Voltage):

1. Adjustable zero and span.
2. Failure Mode on Power Loss: Memory feature to allow the transducer to return to last value on power failure.
3. Accuracy: ± 1% of span.
4. Output Span: 4-20 mA, 0-5 Vdc, 1-5 Vdc, 0-10 Vdc, 2-10 Vdc, 0-15 Vdc, 3-15 Vdc.
5. Input: 0-20 Vdc, 0-20 ma, 0-10 kOhm.
6. Enclosure: Polymer enclosure designed for surface or panel mount.
7. Acceptable Manufacturers: Kele Model PWA Series.

2.16 CURRENT SWITCHES (CS)

A. Clamp-On or Solid-Core Design Current Operated Switch (for Constant Speed Motor Status Indication)

1. Range: 1.5 to 150 amps.
2. Trip Point: Adjustable.
3. Switch: Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage.
4. Lower Frequency Limit: 6 Hz.
5. Trip Indication: LED
6. Approvals: UL, CSA
7. Max. Cable Size: 350 MCM
8. Acceptable Manufacturers: Veris Industries H-708/908; Inc., Kele SCS1150A-LED.

B. Clamp-on or Solid-Core Wire Through Current Switch (CS/CR) (for Constant Speed Motors): Same as CS with 24v command relay rated at 5A @ 240 Vac resistive, 3A @ 240 Vac inductive, load control contact power shall be induced from monitored conductor (minimum conductor current required to energize relay 5A, max. rating of 135A). Acceptable Manufacturers shall be Veris Industries, Inc., Model # H938/735; or RE Technologies RCS 1150.

1. Where used for single-phase devices, provide the CS/CR in a self-contained unit in a housing similar with override switch to a RIBX.

C. Clamp-On Design Current Operated Switch for Variable Speed Motor Status Indication

1. Range: 1.5 to 135 Amps.
2. Trip Point: Self-calibrating based on VA memory associated with frequency to detect loss of belt with subsequent increase of control output to 60 Hz.
3. Switch: Solid state, normally open, 1 to 135 Vac or Vdc, 0.3 Amps. Zero off state leakage.
4. Frequency Range: 5-75 Hz
5. Trip Indication: LED
6. Approvals: UL, CSA
7. Max. Cable Size: 350 MCM
8. Acceptable Manufacturers: ACI, Functional Devices, or Veris.

D. Clamp-On Wire Through Current Switch (CS/CR) (for Variable Speed Motors): Same as CS with 24v command relay rated at 5A @ 240 Vac resistive, 3A @ 240 Vac inductive, load control contact power shall be induced from monitored conductor (minimum conductor current required to energize relay 5A, max. rating of 135A).

1. Acceptable Manufacturers: ACI, Functional Devices, or Veris.

E. Variable Speed Status: Where current switches are used to sense the status for variable speed devices, the CT shall include on-board VA/Hz memory to allow distinction between a belt break and subsequent

ramp up to 60 Hz, versus operation at low speed. The belt break scenario shall be indicated as a loss of status and the operation at low speed shall indicate normal status.

1. Acceptable Manufacturers: ACI, Functional Devices, or Veris.

2.17 CURRENT TRANSFORMERS (CT)

A. Clamp-On Design Current Transformer (for Motor Current Sensing)

1. Range: 1-10 amps minimum, 20-200 amps maximum
2. Trip Point: Adjustable
3. Output: 0-5 VDC.
4. Accuracy: ±0.2% from 20 to 100 Hz.
5. Acceptable Manufacturers: ACI, Functional Devices, or Veris.

2.18 OUTDOOR AIR STATIC PRESSURE SENSING TIP

A. Pressure sensor: Pressure sensing tip shall be designed to minimize the effects of wind and resulting velocity pressure up to 80 mph. Acceptable manufacturers shall be Dwyer A-306.

B. Low Air Pressure Surge Dampener: 30-second time constant.

C. Acceptable Manufacturers: ACI, Functional Devices, or Veris.

2.19 CONTINUOUS LEVEL TRANSMITTERS

A. Capacitance Type

1. Provide a loop powered, continuous capacitance type level transmitter with adjustable span and zero.
2. Output: 4-20 mA.
3. Probe: Fluoropolymer coated stainless steel rod or cable. Provide cable probe with end attachment hardware or weight.
4. Electrical Enclosure: NEMA-4, -7.
5. Approvals: UL or CSA.
6. Accuracy: ±1% of calibrated span.
7. Process Connection: MPT or ANSI Flange as required.
8. Acceptable Manufacturers: Drexelbrook, Endress & Hauser.

B. Hydrostatic Pressure

1. Two wire smart d/p cell type transmitter
2. 4-20 mA or 1 to 5 volt user selectable linear or square root output
3. Adjustable span and zero
4. Stainless steel wetted parts
5. Environmental limits: –40 to 250 °F (-40 to 121°C), 0 to 100% RH
6. Accuracy: less than 0.1 percent of span
7. Output Damping: time constant user selectable from 0 to 36 seconds
8. Vibration Effect: Less than ±0.1% of upper range limit from 15 to 2000 Hz in any axis relative to pipe mounted process conditions.
9. Electrical Enclosure: NEMA 4, 4X, 7, 9
10. Approvals: FM, CSA
11. Acceptable Manufacturers: Rosemount Inc. 3051 Series, Foxboro, and Johnson-Yokogawa.

2.20 AIRFLOW MEASURING STATIONS (AFMS)

A. Duct mounted airflow measuring stations utilizing thermal dispersion technology. Each sensing point shall measure both airflow and temperature using a pair of instrument grade, hermetically sealed, glass

encapsulated thermistors. Thermistors resistance/temperature characteristics shall be traceable to NIST calibration standards.

B. Each measurement location shall produce a single, linear isolated 4-20 ma analog output signal for airflow and/or temperature where indicated. The system shall have the ability to perform self-diagnostics and produce an alarm, which can identify the source of malfunction. In the event of a sensor failure, the system shall ignore failed sensor(s), average remaining sensors and shall continue to operate. The unit shall be equipped with a 16 character alpha-numeric LCD display.

C. Sensor shall have an accuracy of ±2.0% of reading with ± 0.25% repeatability. Sensors shall operate over a temperature range of -20 °F to 160 °F and a relative humidity range of 0% to 99% (non-condensing). Electronics shall operate over a temperature range of -20 °F to 120 °F

D. The number of independent sensing points shall be per manufacturer's recommendations for the specified application as shown on drawings. The probe body shall be constructed of extruded aluminum alloy. Provide airflow straightening devices as per manufacturer's recommendations if the required minimum diameters of straight duct upstream and downstream of the device cannot be achieved in the area where the device is to be installed as designated on drawings.

E. Where an airflow measurement is required and either a lack of straight duct run or is exposed to unfiltered outdoor air are present (e.g. minimum outside air application), standard pitot and thermal technologies will not overcome these conditions to obtain accurate or repeatable measurement. In such condition, a VOLU-Flo station shall be utilized.

F. Acceptable Manufacturers:

1. Ebtron: GTx116-P+ series.
2. Air Monitor Corporation: Model: VOLU-flo/OAM II station.

2.21 AIR VELOCITY PRESSURE SENSORS (INSERTION TYPE)

A. Single or Multi-Point Averaging (as indicated): Sensing tip shall be for insertion into duct with mounting flange and push on tube connections. Material shall be suitable to the application.

2.22 SPECIALTY GAS DETECTION

A. Carbon Dioxide (CO_2) Sensors/Transmitters

1. CO_2 sensors shall use silicon based, diffusion aspirated, infrared single beam, dual-wavelength sensor.
2. Range: 0-2000 ppm
3. Accuracy: ±36ppm at 800 ppm and 68°F.
4. Stability: 5% over 5 years.
5. Output: 4-20 mA, 0-10 Vdc or relay.
6. Mounting: Duct as indicated
7. Acceptable Manufacturer: Vaisala, Inc. GMD20 (duct) or GMW90 (wall), MSA, Inc, Amphenol sensors.

B. Carbon Monoxide (Co) Detectors

1. The carbon monoxide sensor shall be of maintenance free solid state construction and use a microprocessor based transmitter which calculates various calibration factors and transmits a linear 4 - 20 mA output proportional to carbon monoxide concentration.

2. Wall mounted installations shall be mounted in a NEMA 12 enclosure with field replaceable sensors.
3. Provide a calibration test kit complete with a calibration apparatus, carrying case and test gas cylinder.
4. Provide individual indicators and contactors for each level, initially calibrated for 0 ppm and 100 ppm.
5. Maximum response time to 100 ppm CO calibration gas: Two minutes.
6. Acceptable Manufacturers: MSA Instruments, Honeywell, Critical Environmental Technologies. No exceptions.

C. REFRIGERANT MONITOR

1. The unit shall meet or exceed all requirements of ANSI/ASHRAE 15 plus all local, state, and national codes.
2. The refrigerant monitor shall be housed in a NEMA-4 wall mount enclosure as assembled by manufacturer. Detection of refrigerant vapor concentration shall be refrigerant specific and include circulation of ambient air through a non-dispersing infrared energy cell. Electro- chemical sensing technology employing depletion sensors or short term life sensors, which deplete as a normal part of their operation or storage shelf life, shall not be acceptable.
3. Unit range of sensing shall be 0-100 parts per million (ppm) for refrigerant R-123 and/or 0-1000 ppm for all other refrigerants. Concentrations of refrigerant in the ambient air space will be displayed as PPM on the face of the monitor. The monitoring device shall indicate threshold violation via a status panel readout and remote alarm signaling.
4. Monitor shall include: Visual Strobe, Audible Horn, and Signage
5. Refrigerant leak detection system shall include an audible and visual alarm, located directly outside of each door to the machinery room
6. Visual alarm shall consist of a flashing yellow light placed directly over the machinery room doors with a sign that states:

    a. DANGER – DO NOT ENTER WHEN LIGHT IS FLASHING
    b. PELIGRO – NO ENTRAR CUANDO LA LUZ ESTE

7. Sequential sampling and multi-point monitoring shall be employed where airflow currents and/or room size prohibit a representative sample from one sensing point. The system shall have add-on sample point expansion modules available for present configuration and future expansion.
8. Unit to utilize three levels of dry contact alarms to afford the following:

    a. Level 1: 25 percent contamination (to energize local strobe light and audible alarm).
    b. Level 2: 50 percent contamination (to energize remote alarms and area ventilating process).
    c. Level 3: 100 percent contamination (to shut down all chillers in Chiller Room).

9. The monitor shall incorporate dry contact relays for each alarm level and a malfunction relay. An analog 4-20ma signal, and an RS-485 digital output shall also be standard equipment.
10. Preliminary acceptable manufacturer: Critical Environmental Technologies, MSA Instruments, Macurco. No exceptions.

2.23 ELECTRIC METER:

A. Power Quality or Over 600V

1. ION7550: revenue-class power and energy metering, event and min/max logging, historical logging (up to 800 channels), expandable memory, sag/swell monitoring, harmonics measurement, waveform capture at 256 samples/cycle, setpoints, digital and analogue I/O, and Internet-enabled multi-port communications
2. ION7650: adds symmetrical components measurement, fast transient detection, waveform capture at 1024 samples/cycle, and power quality compliance monitoring.
3. Characteristics:

    a. Panel-mount, large customizable LCD display, available without display
    b. Multilingual support for English, French, Spanish and Russian. User-configurable IEC or IEEE notations. 12/24 hour clock support in multiple date/time formats.
    c. 3-phase, 4-quadrant metering, class 0.2 accuracy (IEC, ANSI)
    d. Voltage, current, neutral and earth current, power, frequency, power factor, demand, energy, and time-of-use metering
    e. Instrument transformer correction, transformer/line loss compensation
    f. IEC 61000-4-30 class A ed. 2, IEEE 519/1159, EN50160, IEC 61000-4-7/4-15 power quality compliance monitoring
    g. 1024 samples/cycle waveform capture, transient capture (20 µs @ 50 Hz), sag/swell monitoring, harmonics measurement (up to 63rd), symmetrical components
    h. COMTRADE waveform format available directly from the meter
    i. Disturbance direction detection to indicate whether a disturbance originated upstream or downstream from the meter
    j. Setpoint learning to automatically learn what constitutes a sag, swell, transient or high and low setpoint
    k. Sequence-of-events, coincident minimum/maximum, historical trends, and high-speed snapshot recording, 1-ms resolution timestamping, GPS time synchronization
    l. 4 analogue inputs, 4 analogue outputs, 16 digital status/counter inputs, 7 digital control/pulse outputs
    m. 65 setpoints for alarms and control, 1/2 cycle response, multi-condition, call out on alarm
    n. 5 communication ports: Ethernet, modem, RS-232/485, RS-485, front panel optical
    o. 100-Base–TX and 100-Base–FX for faster Ethernet communication
    p. Protocols: Modbus RTU slave/master, Modbus TCP, DNP 3.0, MV-90, IEC 61850
    q. Ethernet and modem gateways to 31 devices on RS-485 port
    r. On-board web server, email for alarms and data, FTP server
    s. All meters shall be RoHS compliant.

4. BAS contractor shall provide written coordination on capacity, performance, and location with trade contractor during the 230920 submittal phase.
5. Preliminary acceptable manufacturer: Schneider Electric ION 7650 with Ethernet communications.

B. Electrical kWh only under 600V

1. Control Power, AC: 50/60 Hz; 5VA max.; 90V min.; UL Maximums: 600V L-L (347V L-N); CE Maximums: 300V L-N (520V L-L)
2. Control Power, DC: 3W max.; UL and CE: 125 to 300VDC (external DC current limiting required)
3. Voltage Input: UL: 90 V L-N to 600 V L-L ; CE: 90 V L-N to 300 V L-L
4. Current Input Scaling: 5 A to 32,000 A
5. Current Input Range: 0 to 0.333 V or 0 to 1 V (selectable)
6. Current Pulse Inputs: Two sets of contact inputs to pulse accumulators
7. Accuracy: Real Power and Energy 0.2% (ANSI C12.20, IEC 62053-22 Class 0.2S)
8. Outputs: Serial Communication: RS-485 2-wire BACnet MS/TP (9600 baud to 115.2 kbaud)
9. Mounting: DIN Rail or 3-point screw mount, NEMA 4 enclosure optional
10. Operating Temperature Range: -30° to 70 °C (-22° to 158 °F)

11. Storage Temperature Range: -40° to 85 °C (-40° to 185 °F)
12. Humidity Range: <95% Relative Humidity, noncondensing
13. Warranty: Refer to specification 23 09 20, section 1.13 for Warranty requirements.
14. Compliance: UL508, ANSI-C12.20, Cat III, pollution degree 2, RoHS
15. BAS contractor shall provide written coordination on capacity, performance, and location with trade contractor during the 230920 submittal phase.
16. Preliminary acceptable manufacturer: Veris E50 series, Schneider Electric (EM3500 series), or CCS WattNode.

2.24 ELECTRIC CONTROL COMPONENTS

A. Limit Switches (LS): Limit switches shall be UL listed, SPDT or DPDT type, with adjustable trim arm. Limit switches shall be as manufactured by Square D, Allen Bradley.

B. Electric Solenoid-Operated Pneumatic Valves (EP): EP valves shall be rated for a minimum of 1.5 times their maximum operating static and differential pressure. Valves shall be ported 2-way, 3-way, or 4-way and shall be normally closed or open as required by the application. EPs shall be sized for minimum pressure drop, and shall be UL and CSA listed. Furnish and install gauges on all inputs of EPs. Furnish an adjustable air pressure regulator on input side of solenoid valves serving actuators operating at greater than 30 psig.

1. Coil Enclosure: Indoors shall be NEMA-1, Outdoors and NEMA-3, 4, 7, 9.
2. Fluid Temperature Rating: Valves for compressed air and cold water service shall have 150°F (66°C) minimum rating. Valves for hot water or steam service shall have fluid temperature rating higher than the maximum expected fluid temperature.
3. Acceptable Manufacturers: EP valves shall be as manufactured by ASCO or Parker.
4. Coil Rating: EP valves shall have appropriate voltage coil rated for the application (i.e., 24 VAC, 120 VAC, 24 VDC, etc.).

C. Low Temperature Detector (‘Freezestat’) (FZ): Low temperature detector shall consist of a ‘cold spot’ element which responds only to the lowest temperature along any one foot of entire element, minimum bulb size of 1/8" x 20', junction box for wiring connections and gasket to prevent air leakage or vibration noise, DPST (4 wire, 2 circuit) with manual reset. Temperature range 15 to 55°F, factory set at 38°F.

D. High Temperature Detectors (‘Firestat’) (FS): High temperature detector shall consist of 3-pole contacts, a single point sensor, junction box for wiring connections and gasket to prevent air leakage of vibration noise, triple-pole, with manual reset. Temperature range 25 to 215°F.

E. Surface-Mounted Thermostat: Surface-mounted thermostat shall consist of SPDT contacts, operating temperature range of 50 to 150°F, and a minimum 10°F fixed setpoint differential.

F. Low Voltage Wall Thermostat: Wall-mounted thermostat shall consist of SPDT sealed mercury contacts, operating temperature range of 50 to 90°F, switch rating of 24 Vac (30 Vac max.), and both manual and automatic fan operation in both the heat and cool modes.

G. Control Relays: All control relays shall be UL listed, with contacts rated for the application, and mounted in minimum NEMA-1 enclosure for indoor locations, NEMA-4 for outdoor locations.

1. Control relays for use on electrical systems of 120 volts or less shall have, as a minimum, the following:

a. AC coil pull-in voltage range of +10%, -15% or nominal voltage.
b. Coil sealed volt-amperes (VA) not greater than four (4) VA.
c. Silver cadmium Form C (SPDT) contacts in a dustproof enclosure, with 8 or 11 pin type plug.
d. Pilot light indication of power-to-coil and coil retainer clips.
e. Coil rated for 50 and 60 Hz service.

f. Acceptable Manufacturers: Relays shall be Potter Brumfield, Model KRPA.

2. Relays used for across-the-line control (start/stop) of 120V motors, 1/4 HP, and 1/3 HP, shall be rated to break minimum 10 Amps inductive load. Relays shall be IDEC.
3. Relays used for stop/start control shall have low voltage coils (30 VAC or less), and shall be provided with transient and surge suppression devices at the controller interface.

H. General Purpose Power Contactors: NEMA ICS 2, AC general-purpose magnetic contactor. ANSI/NEMA ICS 6, NEMA type 1enclosure. Manufacturer shall be Square 'D' or Eaton.

I. Control Transformers: Furnish and install control transformers as required. Control transformers shall be machine tool type, and shall be US and CSA listed. Primary and secondary sides shall be fused in accordance with the NEC. Transformer shall be proper size for application, and mounted in minimum NEMA-1 enclosure.

1. Transformers shall be manufactured by Eaton, Square 'D', or Jefferson.

J. Time Delay Relays (TDR): TDRs shall be capable of on or off delayed functions, with adjustable timing periods, and cycle timing light. Contacts shall be rated for the application with a minimum of two (2) sets of Form C contacts, enclosed in a dustproof enclosure.

1. TDRs shall have silver cadmium contacts with a minimum life span rating of one million operations. TDRs shall have solid state, plug-in type coils with transient suppression devices.
2. TDRs shall be UL and CSA listed, Crouzet type.

K. Electric Push Button Switch:

1. Switch shall be momentary contact, oil tight, push button, with number of N.O. and/or N.C. contacts as required. Contacts shall be snap-action type, and rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen Bradley.
2. Critical Room, Type-I: An emergency operator station shall offer a highly visible method to shut down equipment, initiate alarms, or give a controller input during emergency conditions. Dedicated name plate shall clearly identify the system (e.g. Emergency Boiler Shut-Down). Operation is with the push of a red 40 mm mushroom-head push-button. The button may be reset with a pull or twist of the mushroom head, depending on the button style. Acceptable manufacturer: Kele "ESM" or equal.
3. Critical Room, Type-II: An emergency operator station that is exposed to public access shall conform to Type-I with a break glass function. Acceptable manufacturer: Kele "ESB" or equal.

L. Pilot Light: Panel-mounted pilot light shall be NEMA ICS 2 oil tight, transformer type, with screw terminals, push-to-test unit, LED type, rated for 120 VAC. Unit shall be 800T type, as manufactured by Allen-Bradley.

M. Audible & Visual Alarm:

1. Panel: Panel-Face mounted audible & LED visual alarm shall be a continuous tone. Acceptable manufacturer: Mallory "Sonalert" or equal.
2. Remote Station: Wall-mounted audible & LED visual alarm on a stainless steel plate. Any contact closure alarm initiating device that can switch 24 VAC or DC can be used. When 24 VAC or DC is applied, through an alarm initiating device, the red alarm LED shall light, the horn shall sound and the alarm status relay will energize. Acceptable manufacturer: Kele "RAD-1" or equal.
3. Critical Room: Wall-mounted or panel-mounted 24VAC, 24VDC, OR 12VAC strobe (amber) and horns shall be provided as shown on design sheets. Audible alarm shall be at 90 dba @ 10-feet, minimum. Acceptable manufacturer: Edwards Signaling "868STR" or equal.

N. Electric Selector Switch (SS): Switch shall be maintained contact, NEMA ICS 2, oil-tight selector switch with contact arrangement, as required. Contacts shall be rated for minimum 120 Vac operation. Switch shall be 800T type, as manufactured by Allen-Bradley.

2.25 DUCT SMOKE DETECTOR

A. Photoelectric detector with sampling tube that spans the entire width of duct. .

B. Velocity Rating: 100 to 4000 fpm or 500 to 4000fpm depending on the minimum velocity in the duct. Provide the 100 to 4000 fpm detector if the min duct velocity is below 550 fpm.

C. Output Contact: Alarm, two sets form “C” rated at 10amps 115V resistive. One set of alarm contacts for BAS monitoring and fan shutdown. Trouble, one set of contacts.

D. Temperature & RH limits: 32 to 120°F and 10 to 85% relative humidity.

E. Acceptable Manufacturer:

1. Sensor Systems D4120
2. Air Products and Controls SL-2000

2.26 NAMEPLATES

A. Provide engraved phenolic or micarta nameplates for all equipment, components, and field devices furnished. Nameplates shall be 1/8 thick, black, with white center core, and shall be minimum 1" x 3", with minimum 1/4" high block lettering. Nameplates for devices smaller than 1" x 3" shall be attached to adjacent surface.

B. Each nameplate shall identify the function for each device.

2.27 TESTING EQUIPMENT

A. Contractor shall test and calibrate all signaling circuits of all field devices to ascertain that required digital and accurate analog signals are transmitted, received, and displayed at system operator terminals, and make all repairs and recalibrations required to complete test. Contractor shall be responsible for test equipment required to perform these tests and calibrations. Test equipment used for testing and calibration of field devices shall be at least twice as accurate as respective field device (e.g., if field device is +/-0.5% accurate, test equipment shall be +/-0.25% accurate over same range).

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Contractor.

3.2 INSTALLATION OF CONTROL SYSTEMS

A. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings. Install electrical components and use electrical products complying with requirements of National Electric Code and all local codes.

B. Control Wiring: The term "control wiring" is defined to include providing of wire, conduit and miscellaneous materials as required for mounting and connection of electric control devices.

1. Wiring System: Install complete wiring system for electric control systems. Install all control wiring external to panels in electric metallic tubing or raceway. On Renovation projects, wiring in finished areas shall be routed in wire mold. The routing of wiring in finished areas must be specifically approved by the AOR/EOR. Installation of wiring shall generally follow building lines. Install in accordance with National Electrical Code and Division 26 of the contract documents. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly.

2. Control Wiring Conductors: Install control wiring conductors, without splices between terminal points, color-coded. Install in neat workmanlike manner, securely fastened. Install in accordance with National Electrical Code and Division 26 of the contract documents.
3. Communication wiring, signal wiring and low voltage control wiring shall be installed separate from any wiring over thirty (30) volts. Signal wiring shield shall be grounded at controller end only, unless otherwise recommended by the controller manufacturer.
4. All WAN and LAN Communication wiring shield shall be terminated as recommended by controller manufacturer. All WAN and LAN Communication wiring shall be labeled with a network number, device ID at each termination and shall correspond with the WAN and LAN system architecture and floor plan submittals. All WAN and LAN cabling shall comply with applicable Division 26 requirements.
5. Number-code or color-code conductors appropriately for future identification and servicing of control system. Code shall be as indicated on approved installation drawings.

C. Control Valves: Install so that actuators, wiring, and tubing connections are accessible for maintenance. Where possible, install with valve stem axis vertical, with operator side up. Where vertical stem position is not possible, or would result in poor access, valves may be installed with stem horizontal. Do not install valves with stem below horizontal, or down.

D. Freezestats: Install freezestats in a serpentine fashion where shown on drawing. Provide one foot of element for each square foot of coil face area. The length of element not just down-stream of the coil shall not be included in the coverage calculation. Where coil face area exceeds required length of element, provide multiple devices, wired in parallel for normally open close on trip application, wired in series for normally closed, open on trip application. Adequately support with coil clips such that sensor is not in direct contact with equipment. Coordinate the location of the switch such that it is normally accessible.

E. Room Temperature Sensors: Install sensors as shown on the drawings. Provide approved security screws for mounting, matching those installed in other areas of the project. Provide 3 tools to the Owner for installation and removal of the security screws. Seal conduit penetrations at the wall box airtight. Install batt insulation in the wall box to completely fill the box. Electrical connections shall be made using a twist-on sealant filled connectors suitable for the installation.

F. Averaging Temperature Sensors: Cover no more than three square feet per linear foot of sensor length except where indicated. Generally, the sensor shall be located where flow is sufficiently homogeneous/adequately mixed, consult AE for requirements.

G. Airflow Measuring Stations: Install per manufacturer's recommendations in an unobstructed straight length of duct (except those installations specifically designed for installation in fan inlet). For installations in fan inlets, provide on both inlets of double inlet fans and provide inlet cone adapter as recommended by AFM station manufacturer.

H. Fluid Flow Sensors: Install per manufacturer's recommendations in an unobstructed straight length of pipe.

I. Relative Humidity Sensors: Provide element guard as recommended by manufacturer for high velocity installations. For high limit sensors, position remote enough to allow full moisture absorption into the air stream before reaching the sensor.

J. Differential Pressure Transmitters: Provide valve bypass arrangement to protect against over pressure damaging the transmitter.

K. Flow Switches: Where possible, install in a straight run of pipe at least 15 diameters in length to minimize false indications.

L. Current Switches for Motor Status Monitoring: Adjust so that setpoint is below minimum operating current and above motor no load current.

M. Supply Duct Pressure Transmitters:

1. General: Install pressure tips with at least 4 'round equivalent' duct diameters of straight duct with no takeoffs upstream. Install pressure tips securely fastened with tip facing upstream in accordance with manufacturer's installation instructions. Locate the transmitter at an accessible location to facilitate calibration.
2. VAV System 'Down-Duct' Transmitters: Locate pressure tips approximately 2/3 of the hydraulic distance to the most remote terminal in the air system.

N. Cutting and Patching Insulation: Repair insulation to maintain integrity of insulation and vapor barrier jacket. Use hydraulic insulating cement to fill voids and finish with material matching or compatible with adjacent jacket material.

END OF SECTION

SECTION 230922 - BUILDING AUTOMATION SYSTEM (BAS) - FIELD PANELS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:

1. Building Controllers (BC).
2. Application Specific Controllers (ASC).
3. Advanced Application Controllers (AAC).

1.2 DESCRIPTION OF WORK

A. Furnish and install DDC Control units and/or Smart Devices required to support specified building automation system functions.

B. Refer to Division 23 Section “Building Automation System (BAS)” for general requirements.

C. Warranty Period: Refer to specification 23 09 20, section 1.13 for Warranty requirements.

PART 2 - PRODUCTS

2.1 STAND-ALONE FUNCTIONALITY

A. General: These requirements clarify the requirement for stand-alone functionality relative to packaging I/O devices with a controller. Stand-alone functionality is specified with the controller and for each Application Category specified in PART 3. This item refers to acceptable paradigms for associating the points with the processor.

B. Functional Boundary: Provide controllers so that all points associated with and common to one unit or other complete system/equipment shall reside within a single control unit. The boundaries of a standalone system shall be as dictated in the contract documents. Generally systems specified for the Application Category shall dictate the boundary of the standalone control functionality. See related restrictions below. When referring to the controller as pertains to the standalone functionality, reference is specifically made to the processor. One processor shall execute all the related I/O control logic via one operating system that uses a common programming and configuration tool.

C. The following configurations are considered acceptable with reference to a controller’s standalone functionality:

1. Points packaged as integral to the controller such that the point configuration is listed as an essential piece of information for ordering the controller (having a unique ordering number).
2. Controllers with processors and modular back planes that allow plug in point modules as an integral part of the controller.
3. I/O point expander boards, plugged directly into the main controller board to expand the point capacity of the controller.
4. I/O point expansion devices connected to the main controller board via wiring and as such shall be remote from the controller and that communicate via a sub LAN protocol. These arrangements to be considered standalone shall have a sub LAN that is dedicated to that controller and include no other controller devices. All wiring to interconnect the I/O expander board shall be:

a. Contained in the control panel enclosure;
b. Or run in conduit. Wiring shall only be accessible at the terminations.

5. General purpose I/O or Smart Devices racked with a processor module in the same contiguous physical enclosure. The controller shall also include its own dedicated processor module and bridge or router making the controllers LAN communication a subnet or LAN segment dedicated to that controller as specified under Application Categories below. The following are additional requirements of this configuration:

a. Configuration must meet the requirements for battery back up.
b. If processor fails, the I/O devices shall go to their fail condition.
c. Contractor shall provide a network bandwidth analysis of the controller segment or subnet. The analysis shall document network bandwidth utilization does not exceed 30% for a continuous one hour period.
d. Logic must provide for orderly sequencing of I/O during a power interruption and restart of program logic upon restoration of power.
e. Programming must facilitate a robust uploading scheme and limit available bandwidth during upload.
f. Trending shall be buffered in the processor or dedicated data logging module and uploaded to a Building or Network Controller.

2.2 BUILDING CONTROLLER (BC)

A. General Requirements:

1. The BC(s) shall provide fully distributed control independent of the operational status of the OWSs and CSS. All necessary calculations required to achieve control shall be executed within the BC independent of any other device.
2. BCs shall be connected to a controller network that qualifies as a Primary Controlling LAN. BCs shall share information with the entire network of BCs and AACs/ASCs for full global control.
3. BCs shall be programmable from an operator workstation, portable operator's terminal, or hand held operating device. Each controller shall permit multi-user operation from multiple owner interfaces connected either locally or over the Primary Controller LAN.
4. All control strategies performed by the BCs shall be both operator definable and modifiable through the Operator Interfaces. All point data, algorithms and application software within each BC shall be modifiable from the Operator Workstation.
5. Each BC shall be capable of standalone direct digital operation utilizing its own processor, non-volatile memory, input/output, wiring terminal strips, A/D converters, real-time clock/calendar and voltage transient and lightning protection devices.
6. BCs shall perform overall system coordination, accept control programs, perform automated HVAC functions, control peripheral devices and perform all necessary mathematical and logical functions.
7. Each unit shall have its own internal RAM, non-volatile memory, microprocessor, battery backup, regulated power supply, power conditioning equipment, ports for connection of operating interface devices, and control enclosure.
8. BC shall contain sufficient memory for all specified global control strategies, user defined reports and trending, communication programs, and central alarming.
9. All BCs shall be protected from any memory loss due to a loss of power by one or a combination of the following:

a. Volatile RAM shall have a battery backup using a lithium battery with a rated service life of fifty (50) hours, and a rated shelf life of at least five years. Self-diagnostic routine shall report an alarm for a low battery condition.
b. EEPROM, EPROM, or NOVROM non-volatile memory

10. Each BC shall provide for point mix flexibility and expandability. This requirement shall be met via either a family of expander boards, modular input/output configuration, or a combination thereof.
11. Each BC shall execute application programs, calculations, and commands via a microprocessor resident in the BC.

12. The database and all application programs for each BC shall be stored in non-volatile or battery backed volatile memory within the BC and shall be able to upload/download to/from the OWS and/or CSS.
13. BCs shall provide buffer for holding alarms, messages, trends etc.
14. Each BC shall include self-test diagnostics, which allow the BC to automatically alarm any malfunctions, or alarm conditions that exceed desired parameters as determined by programming input.
15. Each BC shall contain software to perform full DDC/PID control loops.
16. For systems requiring end-of-line resistors those resistors shall be located in the BC, if it has I/O capability.
17. Input-Output Processing

a. Digital Outputs (DO): Outputs shall be rated for a minimum 24 Vac or Vdc, 1 amp maximum current. Each shall be configurable as normally open or normally closed. Each output shall have an LED to indicate the operating mode of the output and Each DO shall be discrete outputs from the BC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.
b. Analog Inputs (AI): AI shall be O-5 Vdc, 0-10 Vdc, 0-20 Vdc, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the BC's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of 12 bits.
c. Digital Inputs (DI): Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board. Software multiplexing of an AI and resistors shall only be done in non-critical applications and only with prior approval of Architect/Engineer.
d. Universal Inputs (UI-AI or DI): To serve as either AI or DI as specified above.
e. Electronic Analog Outputs (AO): Voltage mode: 0-5 Vdc and 0-10 Vdc; Current mode: 4-20 mA. Provide zero and span calibration and circuit protection.
f. Pulse Width Modulated (PWM) analog via a DO and transducer are not acceptable.
g. Analog Output Pneumatic (AOP), 0-20 psi: Pneumatic outputs via an I/P transducer, or digital to pneumatic transducer are acceptable. Multiplexed digital to pneumatic transducers are acceptable provided they are supplied as a standard product and part of the BC and provide individual feedback. Multiplexed pneumatic outputs of a separate manufacturer are unacceptable.
h. Pulsed Inputs: Capable of counting up to 8 pulses per second with buffer to accumulate pulse count. Pulses shall be counted at all times.

18. A communication port for operator interface through a terminal shall be provided in each BC. It shall be possible to perform all program and database back-up, system monitoring, control functions, and BC diagnostics through this port. Standalone BC panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers, or workstations.
19. Each BC shall be equipped with loop tuning algorithm for precise proportional, integral, derivative (PID) control. Loop tuning tools provided with the Operator Workstation software is acceptable. In any case, tools to support loop tuning must be provided such that P, I, and D gains are automatically calculated.
20. Slope intercepts and gain adjustments shall be available on a per-point basis.
21. BC Power Loss:

a. Upon a loss of power to any BC, the other units on the primary controlling network shall not in any way be affected.
b. Upon a loss of power to any BC, the battery backup shall ensure that the energy management control software, the Direct Digital Control software, the database parameters, and all other programs and data stored in the RAM are retained for a minimum of fifty (50) hours.
c. Upon restoration of power within the specified battery backup period, the BC shall resume full operation without operator intervention. The BC shall automatically reset its clock such that proper operation of any time dependent function is possible without manual reset of the clock. All monitored functions shall be updated.
d. Should the duration of a loss of power exceed the specified battery back-up period or BC panel memory be lost for any reason, the panel shall automatically report the condition (upon resumption of power) and be capable of receiving a download via the network, and connected computer. In addition, the owner shall be able to upload the most current versions of all energy management control programs, Direct Digital Control programs, database parameters, and all other data and programs in the memory of each BC to the operator workstation via

the local area network, or via the telephone line dial-up modem where applicable, or to the laptop PC via the local RS-232C port.

22. BC Failure:

a. Building Controller LAN Data Transmission Failure: BC shall continue to operate in stand-alone mode. BC shall store loss of communication alarm along with the time of the event. All control functions shall continue with the global values programmable to either last value or a specified value. Peer BCs shall recognize the loss, report alarm and reconfigure the LAN.
b. BC Hardware Failure: BC shall cease operation and terminate communication with other devices.

23. Each BC shall be equipped with firmware resident self-diagnostics for sensors and be capable of assessing an open or shorted sensor circuit and taking an appropriate control action (close valve, damper, etc.).
24. BCs shall include LAN communications interface functions for controlling secondary controlling LANs Refer to Division 23 Section " Building Automation System (BAS) - Communications Devices" for requirements if this function is packaged with the BC.
25. A minimum of four levels of password protection shall be provided at each BC.
26. BCs shall be mounted on equipment, in packaged equipment enclosures, or locking wall mounted in a NEMA 1 enclosure.

B. BACnet Building Controller (B-BC) Requirements:

1. The BC(s) shall support all BIBBs defined in the BACnet Building Controller (B-BC) device profile as defined in the BACnet standard.
2. BCs shall communicate over the BACnet Building Controller LAN.
3. Each BC shall be connected to the BACnet Building Controller LAN communicating to/from other BCs.
4. Provide routers and repeaters as required to combine different BACnet IP networks onto the primary Ethernet/IP network, or as required to segment groups of BACnet devices to meet minimum throughput requirements.
5. Provide all necessary bridge or routers and gateways in order to connect BCs to the primary network, and subsequently, connect to the BAS WAN network.
6. Device to device communication shall be event driven and peer to peer.
7. Propagation of data from a PCU to a Router for the execution of supervisory control logic shall be event driven at the device and not based on polling from the Router.
8. Propagation of data from a PCU to a Router to support non-alarm dynamic data display or for trending purposes shall be based on polling from the Router.
9. Propagation of data from a PCU to a Router to support the reporting of alarm conditions shall be event driven at the device and not based on polling from the Router.
10. The programming of all output network variables shall include the send on delta concept; minimum send time and maximum send time parameters.

a. Send on delta parameters shall be non-zero values selected to ensure efficient use of the available bandwidth but not exceeding the following:

1) Temperatures: 0.30 Degrees Fahrenheit
2) Pressures in Air Systems: 0.025 Inches-of-Water
3) Building Static Pressure: 0.0125 Inches-of-Water
4) Flow: Approximately 10 Cfm or 2% of the system operating range
5) Relative Humidity: 3%
6) Analog Position: 2%
7) Enthalpy: Approximately 0.2 Btu per Lb.
8) Binary Alarm Data: Change of State

b. If the minimum send time parameters can be set on a point by point basis, they shall not exceed the following:

9) Alarms: 1 second

10) Temperatures at Zone Level: 60 seconds

11) Temperatures at Central Station Level: 10 seconds for data reporting, 5 seconds for control purposes

12) Pressures: 5 seconds for data reporting, 1 second for control purposes.

c. If the minimum send time parameters can only be set on a controller basis, set the parameter at a value of 5 seconds.

11. The error rate for each channel shall be verified by a one hour test using the network analysis tool. The error rate shall not exceed 1%.
12. The bandwidth utilization for each channel shall be verified by a one hour test using the network analysis tool. The utilization shall not exceed 30%.
13. All products shall be BACnet certified, and shall be designed according to the BACnet Interoperability Guidelines. Product documentation and devices shall display the BACnet symbol, indicating conformance to the BACnet Testing Laboratory (BTL) Standards.
14. For each BC control panel, an Uninterrupted Power Supply shall be provided.

2.3 ADVANCED APPLICATION SPECIFIC CONTROLLER (AAC) AND APPLICATION SPECIFIC CONTROLLER (ASC)

A. General Requirements:

1. AACs and ASCs shall provide intelligent, standalone control of HVAC equipment.
2. Each unit shall have its own internal RAM, non-volatile memory and shall continue to operate all local control functions in the event of a loss of communications on the ASC LAN or sub-LAN.
3. Refer to standalone requirements by application specified in PART 3 of this Section.
4. In addition, it shall be able to share information with every other BC and AAC /ASC on the entire network.
5. Each AAC and ASC shall include self-test diagnostics that allow the AAC /ASC to automatically relay to the BC, LAN Interface Device or workstation, any malfunctions or abnormal conditions within the AAC /ASC or alarm conditions of inputs that exceed desired parameters as determined by programming input.
6. AACs and ASCs shall include sufficient memory to perform the specific control functions required for its application and to communicate with other devices.
7. Each AAC and ASC must be capable of stand-alone direct digital operation utilizing its own processor, non-volatile memory, input/output, minimum 8 bit A to D conversion, voltage transient and lightning protection devices. All volatile memory shall have a battery backup of at least fifty- (50) hrs with a battery life of five years.
8. All point data; algorithms and application software within an AAC /ASC shall be modifiable from the Operator Workstation.
9. AAC and ASC Input-Output Processing

a. Analog Inputs (AI): AI shall be 0-5 Vdc, 0-10Vdc, 0-20Vdc, and 0-20 mA. Provide signal conditioning, and zero and span calibration for each input. Each input shall be a discrete input to the BC's board (multiplexing to a separate manufacturers board is unacceptable unless specifically indicated otherwise). A/D converters shall have a minimum resolution of 8-10 bits depending on application.
b. Digital Inputs (DI): Monitor dry contact closures. Accept pulsed inputs of at least one per second. Source voltage for sensing shall be supplied by the BC and shall be isolated from the main board. Software multiplexing of an AI and resistors shall only be done in non-critical applications and only with prior approval of Architect/Engineer
c. Universal Inputs (UI): To serve as either AI or DI as specified above.
d. Electronic Analog Outputs (AO): Voltage mode: 0-5 Vdc and 0-10 Vdc; Current mode: 4-20 mA. Provide zero and span calibration and circuit protection.
e. Pulse Width Modulated (PWM) analog via a DO and transducer are not acceptable.

f. Digital Outputs (DO): Outputs shall be rated for a minimum 24 VAC or VDC, 1 amp maximum current. Each shall be configurable as normally open or normally closed. Each output shall have an LED to indicate the operating mode of the output and Each DO shall be discrete outputs from the AAC/ASC's board (multiplexing to a separate manufacturer's board is unacceptable). Provide suppression to limit transients to acceptable levels.

g. Universal Outputs (UO): To serve as either AO or DO as specified above.

h. Analog Output Pneumatic (AOP), 0-20 psi: Pneumatic outputs via an I/P transducer, or digital to pneumatic transducer are acceptable. Multiplexed digital to pneumatic transducers are acceptable provided they are supplied as a standard product and part of the AAC /ASC and provide individual feedback. Multiplexed pneumatic outputs of a separate manufacturer are unacceptable.

B. BACnet AAC(s) and ASC(s) Requirements:

1. The AAC(s) and ASC(s) shall support all BIBBs defined in the BACnet Building Controller (B-AAC and B-ASC) device profile as defined in the BACnet standard.
2. Each AAC shall communicate over the BACnet Building Controller LAN.
3. Each ASC shall communicate over the BACnet Building Controller LAN or AAC sub-LAN.
4. Each BC shall be connected to the BACnet Building Controller LAN communicating to/from other BCs.

C. Terminal Box Controllers:

1. Terminal box controllers controlling damper positions to maintain a quantity of supply or exhaust air serving a space shall have an automatically initiated function that resets the volume regulator damper to the fully closed position on a scheduled basis. The controllers shall initially be set up to perform this function once every 24 hours. The purpose of this required function is to reset and synchronize the actual damper position with the calculated damper position and to assure the damper will completely close when commanded. The software shall select scheduled boxes randomly and shall not allow more than 5% of the total quantity of controllers in a building to perform this function at the same time. When possible the controllers shall perform this function when the supply or exhaust air system is not operating or is unoccupied.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Contractor.

3.2 SYSTEM ACCESS:

A. Provide an Ethernet connection and 5 port hub at each panel housing a controller or controllers that provides access to the Local Supervisory LAN and to the Control System Server for all Controllers, other than an Application Category 1 Controllers. The user shall be able to access each controller on the system using this connection via the Control System Server database for graphics, schedules, programming, controller configuration etc.

3.3 INSTALLATION OF CONTROL SYSTEMS:

A. General: Install systems and materials in accordance with manufacturer's instructions, contract documents, roughing-in drawings, and details shown on drawings. Contractor shall install all controllers in accordance with manufacturer's installation procedures and practices.

3.4 HARDWARE APPLICATION REQUIREMENTS

A. Here is where you assert your concept of optimal mix of power/quality/cost effectiveness. There are multiple levels of controller/application defined, the higher Category numbers being more powerful and

expensive. The AE defines - within each category - what system(s) must be controlled (in standalone fashion) by controllers that meet that category. This item needs specific attention on every project.

B. General: The functional intent of this specification is to allow cost effective application of manufacturers standard products while maintain the integrity and reliability of the control functions. Specific requirements indicated below are required for the respective application. Manufacturer shall apply the most cost-effective unit that meets the requirement of that application.

C. Standalone Capability: Each Control Unit shall be capable of performing the required sequence of operation for the associated equipment. All physical point data and calculated values required to accomplish the sequence of operation shall originate within the associated CU with only the exceptions enumerated below. Refer to Item 2.01 above for physical limitations of standalone functionality. Listed below are functional point data and calculated values that shall be allowed to be obtained from or stored by other CUs or SDs via LAN.

D. Where associated control functions involve functions from different categories identified below, the requirements for the most restrictive category shall be met.

E. Application Category Type 0 (Distributed monitoring)

1. Applications in this category include the following:

a. Monitoring of variables that are not used in a control loop, sequence logic, or safety.

2. Points on BCs, AACs, and ASCs may be used in these applications as well as Ds and/or general-purpose I/O modules.
3. Where these points are trended, contractor shall verify and document that the network bandwidth is acceptable for such trends and is still capable of acceptable and timely control function.
4. LAN Restrictions: These points may reside on any controller

F. Application Category Type-1:

1. Applications in this category include the following:

a. Airflow Control Boxes (VAV Terminal Units)
b. Terminal Control Dampers/Reheat Valves
c. Unitary equipment <15 tons (Package Terminal AC Units, Split-System AC Units)

2. Standalone Capability: Provide capability to execute control functions for the application for a given setpoint or mode, which shall generally be occupied mode control. Only the following data (as applicable) may be acquired from other controllers via LANs. In the event of a loss of communications with any other controller, or any fault in any system hardware that interrupts the acquisition of any of these values, the ASC shall use the last value obtained before the fault occurred. If such fault has not been corrected after the specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

Physical/Virtual Point	Default Value
Scheduling Period	Normal
Morning Warm-Up	Off (cold discharge air)
Load Shed	Off (no shedding)
Summer/Winter	Winter
Trend Data	N/A

3. Mounting:

a. ASCs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure and shall be rated for plenum use.

b. ASCs that control equipment mounted in a mechanical room shall either be mounted in, on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
c. ASCs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical/utility space.
d. Contractor for this Section may furnish ASCs to the terminal unit manufacturer for factory mounting.

4. LAN Segment Restrictions:

a. BACnet Systems: Limit the number of AAC's/ASC's servicing any one of these applications on the LAN Segment to 32. VAV terminals or zone dampers/reheat coils served by a single air handler are to be located on the same segment of the LAN with the AHU. Multiple AHU's may reside on a LAN segment if all the associated/served terminal boxes and zone dampers/reheat coils are located on the same LAN segment. If more than 40 VAV terminals or zone dampers/reheat coils are served by a single air handler, then one LAN segment shall be fully populated with the parent air handler and terminal unit Nodes with the balance of the served terminal units Nodes located on the secondary channel located on the same BC controller.

G. Application Category Type 2

1. Applications in this category include the following:

a. Unitary Equipment (Air Conditioners, packaged Heating/Cooling Units, and the like)
b. Constant Volume Pump (Start/Stop or Status)
c. Misc. Equipment (Exhaust Fan) Start/Stop
d. Misc. Monitoring (not directly associated with a control sequence and where trending is not critical)
e. Variable Speed Drive (VSD) controllers not requiring safety shutdowns of the controlled device

2. Standalone Capability: Only the following data (as applicable) may be acquired from other AACs via LANs. In the event of a loss of communications with any other AACs, or any fault in any system hardware that interrupts the acquisition of any of these values, the AAC shall use the last value obtained before the fault occurred. If such fault has not been corrected after the specified default delay time, specified default value(s) shall then be substituted until such fault has been corrected.

Physical/Virtual Point	Default Delay Time	Default Value
Outside Air Temperature	3 minutes	80°F
Outside Air Humidity	3 minutes	60%RH
Outside Air Enthalpy	3 minutes	30 Btu/lb
Trend Data		N/A
Cooling/Heating Requests	3 minutes	none

3. Mounting:

a. AACs that control equipment located above accessible ceilings shall be mounted on the equipment in an accessible enclosure and shall be rated for plenum use.
b. AACs that control equipment mounted in a mechanical room may either be mounted in, on the equipment, or on the wall of the mechanical room at an adjacent, accessible location.
c. AACs that control equipment mounted outside or in occupied spaces shall either be located in the unit or in a proximate mechanical/utility space.

4. LAN Segment Restrictions:

a. BACnet Systems: Limit the number of AAC's servicing any one of these applications on the LAN Segment to 32.

H. Application Category Type 3

1. Applications in this category include the following:

a. Boiler Factory Integrated Control (unit specific)
b. Central Heating Plant
c. Sequenced or Variable Speed Pump Control
d. Air Handlers (greater than 25 tons)

2. LAN Segment Restrictions:

a. BACnet Systems: BCs shall be used in these applications.

3.5 CONTROL UNIT REQUIREMENTS

A. Refer to Division 23 Section "Building Automation System (BAS)" for requirements pertaining to control unit quantity and location.

END OF SECTION

SECTION 230923 - BUILDING AUTOMATION SYSTEM (BAS) – NETWORK, SOFTWARE/PROGRAMMING, AND INTERFACE

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes network integration devices.

B. Section includes owner interface devices. Includes the following:

1. Control System Server (CSS).
2. Operator Workstation (OWS).
3. Panel LCD or Touchscreen Displays (TCP_D)

C. Section includes Software & Programming. Includes the following:

1. System Software.
2. Programming Description.
3. Control Algorithms.
4. Energy Management Applications.
5. Password Protection.
6. Alarm Reporting.
7. Trending.
8. Data Acquisition and Storage.
9. Point Structuring.
10. Dynamic Color Graphics.

1.2 DESCRIPTION OF WORK:

A. Communication Devices:

1. Contractor shall provide all interface devices and software to provide an integrated system connecting Advanced Application Controllers, Application Specific Controllers, Building Controllers, Gateways, and Control System Server.
2. The Control System Server shall be the only equipment connected to the Owner's secured WAN.

B. Owner Interfaces:

1. Furnish and install all Operator Interfaces and Control System Servers for the BAS functions specified. All computers shall be warranted by the manufacturer for a period as stated in 230920 after final acceptance. CSS computers shall also be Dell computers.
2. Control System Servers: The new BAS system shall be integrated to a remote centralized BAS servers.
3. Local BAS Workstation: The new BAS system shall be integrated to the new CSS centralized BAS server.

C. Software and Programming:

1. Fully configure systems and furnish and install all software, programming and dynamic color graphics for a complete and fully functioning system as specified.

D. Refer to entirety of Division 23 Section "Building Automation System (BAS)" for all requirements.

E. Warranty Period: Refer to specification 23 09 20, section 1.13 for Warranty requirements.

1.3 LICENSING

A. Include licensing for all software packages at all required Control System Server (CSS) Operator Work Stations (OWS).

B. Any operator interface, programming environment, networking, database management and any other software used by the Contractor to install the system or needed to operate the system to its full capabilities shall be fully licensed (non-subscription) and fully provided to the Owner.

C. Include licensing for all software packages at all required Web Server, OWS's, and/or POT's. Licensing shall allow access to all aspects of the system including system access, workstations, points, programming, database management, graphics etc. No restrictions shall be placed on the licensing; no exception. All operator interfaces, programming environment, networking, database management and any other software used by the Contractor to install the system or needed to operate the system to its full capabilities shall be fully licensed (non-subscription) and provided to the Owner.

D. All software should be available on all Web Servers and OWS's provided, and/or on all Portable Operator Terminals. Hardware and software keys to provide all rights shall be installed on all workstations. At least 2 sets of CDs (or flash drives) shall be provided with backup software for all software provided, so that the Owner may reinstall any software as necessary. Include all licensing for workstation operating systems, and all required third-party software licenses. These backup shall include a backup of all program data files, graphics etc. and shall allow the owner to completely restore the system in the case of a computer malfunction.

E. Provide evidence of licensing including version and original software copies for each WEB Server OWS's and POT's. Licenses shall allow for access to any site device and shall not be restricted to accessing, database management, configuring, etc. the LANs included in this project. The licensing and registration proof shall be provided when the system is installed on site.

F. Upgrade all software packages to the release (version) in effect at the end of the Warranty Period and provide a letter indicating the current release/version date at the end of the warranty period.

PART 2 - PRODUCTS

2.1 NETWORK CONNECTION

A. The Owner's WAN:

1. Internet-based network connecting multiple facilities with a central data warehouse and server, accessible via standard web-browser.
2. Only one (1) IP address shall be provided by the owner. This Contractor shall coordinate and comply with the owner's technology group's requirements.
3. This Contractor shall provide and configure an independent BAS network.

2.2 BACNET: BUILDING CONTROLLER (BC)

A. The BC shall be a microprocessor-based communications device which acts as a router between the Primary LAN and Supervisory LAN.

B. The BC shall perform information translation between the Primary LAN and the Supervisory LAN, supervise communications on a polling supervisory LAN, and shall be applicable to systems in which the same functionality is not provided in the BC.

C. BC shall support interrogation, full control, and all utilities associated with all AACs and ASCs under the Primary Controller LAN.

D. All BACnet Interoperability Building Blocks (BIBBs) are required to be supported for each native BACnet device.

2.3 INTEGRATION:

A. Modbus Node:

1. Modbus shall be utilized for Automatic Transfer Switches and/or Generators.

2. Modbus shall be utilized for Utility & Sub Meters.
3. Modbus shall be integrated to a BC level controller. No exception.

2.4 CONTROL SYSTEM SERVER (CSS) TO PROVIDE SECURED-DISTRIBUTED ACCESSIBILITY.

A. The BAS contractor shall provide their latest server specification requirements to the owner BAS Manager to assure the BAS network, software, and graphical capacities are met. Failure to provide such coordination shall require the BAS contractor to provide upgrades at no cost to the design team and owner.

B. Provide software registration cards and/or licenses to the Owner for all included software.

C. Provide network configuration tool, all programming applications, graphic creation tools and all other software required to configure and operate the system.

D. Provide all controller configuration and interface software and/or plug in's for all devices applicable. All shall be loaded and functional. Provide all required interface cables required to connect to all networks, routers, controllers, SDs etc.

E. Provide all enterprise software, licenses, cables, peripherals etc. for a complete system. Software and licenses shall unify all BC controllers on the Primary LAN to display a single GUI interface.

F. The CSS web server shall support browser access via latest version of Google, Microsoft Internet Explorer (11.0 or higher) or Mozilla Firefox.

G. The server shall have two (2), LAN network cards compatible with the Owner's WAN and BAS LAN systems or as shown on the BAS control riser diagram.

H. The server computer shall not function as the workstation. The web server shall provide the link between the owner's WAN and the site specific BAS LAN.

I. All information exchanged over Internet shall be optionally encrypted and secure via Secure Sockets Layer (SSL).

J. The system shall be able to generate e-mails automatically for alarming using a "MS Outlook" or similar platform that meets the requirements of the Owner's as published in the "Minimum Hardware, Software, and Network Standards".

K. The web server licensing options shall allow concurrent access by an unlimited number of browser connections.

L. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Google Chrome™, Internet Explorer™ or Netscape Navigator™. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable. For example, a webserver that requires a Java script to load would not be acceptable nor would the use of an alternate to a webserver such as Microsoft Terminal Services.

M. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the BAS shall not be acceptable.

N. The Web server shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

O. For CSSs that provide web services for presentation of data across the Internet, all Web components and services shall be installed with required licensing. CSS shall be configured to secure it to the extent practical inside the Local Supervisory LAN.

P. CSS shall always function from behind a firewall provided either by the Owner's network administrators in the case where they provide the LAN infrastructure, or by this contractor where the LAN is provided under this Division of the specifications.

Q. The CSS shall be placed as indicated on the drawings or as directed by the Owner.

2.5 OPERATOR WORKSTATION (OWS) TO PROVIDE SITE-SPECIFIC ACCESSIBILITY.

A. The BAS contractor shall provide their latest workstation specification requirements to the owner's BAS Manager to assure the BAS network, software, and graphical capacities are met. Failure to provide such coordination shall require the BAS contractor to provide upgrades at no cost to the design team and owner.

B. Provide software registration cards and/or licenses to the Owner for all included software.

C. Provide network configuration tool, all programming applications, graphic creation tools and all other software required to configure and operate the system.

D. Provide all controller configuration and interface software and/or plug in's for all devices applicable. All shall be loaded and functional. Provide all required interface cables required to connect to all networks, routers, controllers, SDs etc.

E. Operating system for operator workstation shall be Microsoft Windows 8.1 Pro with Office 2013 or greater. All software shall be at least the latest version available as of the date of contract completion.

F. Provide network card specifications to the owner approved by the BAS manufacturer to support Supervisory LAN communications (100 Mbps Ethernet TCP/IP).

2.6 OPERATOR INTERFACE:

A. Local Server Hardware:

1. The CSS web server shall support browser access via latest version of Microsoft Internet Explorer (11.0 or higher), Mozilla Firefox, or Google Chrome.
2. The server shall have two (2), LAN network cards compatible with the Owner's WAN and BAS LAN systems or as shown on the BAS control riser diagram.
3. The server computer shall not function as the workstation. The web server shall provide the link between the Owner's WAN and BAS LAN.
4. All information exchanged over Internet shall be optionally encrypted and secure via Secure Sockets Layer (SSL).
5. The system shall be able to generate e-mails automatically for alarming using a "MS Outlook" or similar platform that meets the requirements of the Owner's as published in the "Minimum Hardware, Software, and Network Standards".
6. The web server licensing options shall allow concurrent access by an unlimited number of browser connections.
7. Provide software registration cards to the Owner for all included software.
8. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Google Chrome™, Internet Explorer™ or approved equal. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable. For example, a webserver that requires a Java script to load would not be acceptable nor would the use of an alternate to a webserver such as Microsoft Terminal Services.
9. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the BAS shall not be acceptable.
10. The Web server shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical

User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.

11. Provide all enterprise software, licenses, cables, peripherals etc. for a complete system. Software and licenses shall unify all BC controllers on the Primary LAN to display a single GUI interface.
12. Provide network configuration tool, all programming applications, graphic creation tools and all other software required to configure and operate the system.
13. For CSSs that provide web services for presentation of data across the Internet, all Web components and services shall be installed with required licensing. CSS shall be configured to secure it to the extent practical inside the Local Supervisory LAN.
14. CSS shall always function from behind a firewall provided either by the Owner's network administrators in the case where they provide the LAN infrastructure, or by this contractor where the LAN is provided under this Division of the specifications.
15. Provide network card approved by BAS manufacturer to support Supervisory LAN communications (100 Mbps Ethernet TCP/IP).
16. Provide an uninterruptible power supply system providing battery backup for the operator workstation and peripheral devices, excluding the printer. UPS shall protect against blackouts, brownouts, surges and noise. UPS shall include LAN port and modem line surge protection. UPS shall be sized for a 4-minute full load runtime, 12-minute ½ load runtime, with a typical runtime of up to 30 minutes. Transfer time shall be 2-4 milliseconds. UPS shall provide a 480-joule suppression rating and current suppression protection for 36,000 amps and provide 90% recharge capability in 2-4 hours. Suppression response time shall be instantaneous. UPS low voltage switching shall occur when supply voltage is less than 94 volts. UPS shall be provided with phone and data surge suppression and LAN port connections. Provide all software, cables, peripherals etc. for a complete system including software to automatically shut-down the computer. Basis-of-Design: Functional Device, PSH600-UPS.
17. Provide a workstation locking cable and lock. Secure workstation onto the desk it shall reside on.
18. The CSS shall be placed as indicated on the drawings or as directed by the Owner.
19. The CSS shall meet or exceed the requirements for the OWS hardware.
20. Warranty: See specification section 23 09 20, section 1.13.
21. Basis-of-Design: Dell Precision 7920 Rack Series.

B. Local Workstation Hardware:

1. Provide one (1) desktop PC workstation for permanent on-site access to the BAS System.
2. Provide software registration cards to the Owner for all included software.
3. Local Workstation Operators Terminal shall support system management by connection to the controllers, by connection via the Internet, and by dial-up communications while serving as the remote workstation.
4. The workstation shall meet the following minimum requirements:
5. Processor: Intel Core i7-8700HQ Quad Core Processor (12M cache, up to 4.6GHz)
6. Operating System: Windows 10 Professional
7. Memory: 16GB 2666 MHz, DDR4, 64GB
8. Hard Drive: 1TB, 7200 rpm
9. Video Card: NVIDIA GeForce GTX1050Ti with 4GB GDDR5 graphics memory
10. Optical Drive: DVD-RW Drive
11. Ports: (1) HDMI, (1) VGA, (1) SD Reader, (2) USB-C, (4) USB 3.1, (2) USB 2.0, (1) GB Ethernet, (1) Display Port, (1) lock security slot
12. Keyboard: Logitech™ detachable keyboard with standard typewriter layout, function keys, and separate numeric keypad.
13. Mouse: Logitech™ Dark-Field™ Anywhere Mouse.
14. Microsoft Office: Include
15. Security Software: McAfee LiveSafe Subscription
16. Security Hardware: Include cable and lock
17. ENERGYSTAR: Required.

18. EPEAT Qualified: Required.
19. Monitor Requirements:

    a. Size: LG™ Widescreen 29” or equal.
    b. Ports: (2) HDMI, (1) Display Port and DVI-D Port.
    c. Resolution: 2560 x 1080. LED.

20. Workstation PC shall have the capability of changing serial port interrupt vectors and IOBASE addresses through software.
21. Provide an uninterruptible power supply system providing battery backup for the operator workstation and peripheral devices, excluding the printer. UPS shall protect against blackouts, brownouts, surges and noise. UPS shall include LAN port and modem line surge protection. UPS shall be sized for a 4-minute full load runtime, 12-minute ½ load runtime, with a typical runtime of up to 30 minutes. Transfer time shall be 2-4 milliseconds. UPS shall provide a 480-joule suppression rating and current suppression protection for 36,000 amps and provide 90% recharge capability in 2-4 hours. Suppression response time shall be instantaneous. UPS low voltage switching shall occur when supply voltage is less than 94 volts. UPS shall be provided with phone and data surge suppression and LAN port connections. Provide all software, cables, peripherals etc. for a complete system including software to automatically shut-down the computer. Basis-of-Design: Functional Device, PSH600-UPS.
22. Provide network configuration tool, all programming applications, graphic creation tools and all other software required to configure and operate the system.
23. Provide additional hardware, video drivers, etc., to facilitate all control functions and software requirements specified for the BAS.
24. OWS shall be placed as indicated on the drawings or as directed by the Owner.
25. Warranty: See specification section 23 09 20, section 1.13.
26. Basis-of-Design: Dell Precision 7820 Tower Series.

C. Panel LCD or Touchscreen Display (TCP_D):

1. Provide a high definition touch screen color display for local feedback and control for a wide range of HVAC, lighting, energy, commissioning, troubleshooting, and servicing.
2. The TCP_D shall be compatible with web-serving controllers, including Niagara AX and N4.
3. The TCP_D shall utilize an advanced processor to integrate a graphical engine that displays most any webpage, including advanced HTML5 visualization pages.
4. The TCP_D shall allow the owner to manage operating parameters of systems, such as monitoring, obtaining values, equipment and system status, and viewing alarms.
5. The TCP_D shall deliver interactive graphical user interfaces and an optimal user experience for building owners and facility managers with its web-based graphic design and visualization interface.
6. Warranty: See specification section 23 09 20, section 1.13.
7. Basis-of-Design: Lynxspring TSD-7.

2.7 SYSTEM SOFTWARE-GENERAL

A. Functionality and Completeness: The Contractor shall furnish and install all software and programming necessary to provide a complete and functioning system as specified. The Contractor shall include all software and programming not specifically itemized in these Specifications, which is necessary to implement, maintain, operate, and diagnose the system in compliance with these Specifications.

2.8 CONTROLLER SOFTWARE

A. All bindings, configuration values, addresses, calibration values, parameters, variables, tuning values, gains, test values, etc. for all software, programs, network configurations etc. shall be exposed and be available for setup, manipulation, adjustment, calibration, testing, etc. at all workstations, CSS’s/OWS’s, POT’s for use as allowed via applicable password protection for all controllers and devices throughout all networks and the entire BAS.

B. Building Controller (BC) Software Residency: Each BC as defined below shall be capable of control and monitoring of all points physically connected to it. All software including the following shall reside and execute at the BC:

1. Real-Time Operating System software
2. Real-Time Clock/Calendar and network time synchronization
3. BC diagnostic software
4. LAN Communication software/firmware
5. Direct Digital Control software
6. Alarm Processing and Buffering software
7. Energy Management software
8. Data Trending, Reporting, and Buffering software
9. I/O (physical and virtual) database
10. Remote Communication software

C. Advanced Application Controller (AAC) Application Specific Controller (ASC) Software Residency: Each AAC/ASC as defined below shall be capable of control and monitoring of all points physically connected to it. As a minimum, software including the following shall reside and execute at the AAC/ASC. Other software to support other required functions of the AAC/ASC may reside at the BC or LAN interface device (specified in Division 23 Section "Building Automation System (BAS) - Communication Devices") with the restrictions/exceptions per application provided in Division 23 Section "Building Automation System (BAS) - Field Panels":

1. Real-Time Operating System software
2. AAC/ASC diagnostic software
3. LAN Communication software
4. Control software applicable to the unit it serves that shall support a single mode of operation
5. I/O (physical and virtual) database to support one mode of operation

D. Stand Alone Capability: BC shall continue to perform all functions independent of a failure in other BC/AAC/ASC or other communication links to other BCs/AACs/ASCs. Trends and runtime totalization shall be retained in memory. Runtime totalization shall be available on all digital input points that monitor electric motor status. Refer also to Division 23 Section "Building Automation System (BAS) - Field Panels" for other aspects of stand alone functionality.

E. Operating System: Controllers shall include a real-time operating system resident in ROM. This software shall execute independently from any other devices in the system. It shall support all specified functions. It shall provide a command prioritization scheme to allow functional override of control functions. Refer also to Division 23 Section "Building Automation System (BAS) - Field Panels" for other aspects of the controller's operating system.

F. Network Communications: Each controller shall include software/firmware that supports the networking of CUs on a common communications trunk that forms the respective LAN. Network support shall include the following:

1. Controller communication software shall include error detection, correction, and re-transmission to ensure data integrity.
2. Operator/System communication software shall facilitate communications between other BCs, all subordinate AACs/ASCs, Gateways and LAN Interface Devices or Operator Workstations. Gateways and LAN Interface Devices or CSS's/OWS's. Software shall allow point interrogation, adjustment, addition/deletion, and programming while the controller is on line and functioning without disruption to unaffected points. The software architecture shall allow networked controllers to share selected physical and virtual point information throughout the entire system.

G. Point Database/Summary Table: All points included in the typical equipment point list must be represented in a common, open protocol format. Naming conventions for these points and network addressing are discussed in PART 3 of this Section. Point/system database creation and modification shall be via a user-friendly, menu-driven program. System software shall support virtual or logic point (points not representing a physical I/O) creation. Software shall support virtual points with all services

specified herein. Database software shall support definition of all parameters specified in PART 3 of this Section for a given point type. If database does not support all these parameters, software module shall be created and attached to the points which accomplish the respective function.

H. Diagnostic Software: Controller software shall include diagnostic software that checks memory and communications and reports any malfunctions

I. Alarm/Messaging Software: Controller software shall support alarm/message processing and buffering software as more fully specified below.

J. Application Programs: CUs shall support and execute application programs as more fully specified below:

1. All Direct Digital Control software, Energy Management Control software, and functional block application programming software templates shall be provided in a 'ready-to-use' state, and shall not require (but shall allow) the Owner's programming.
2. Line programs shall supply preprogrammed functions to support these energy management and functional block application algorithms. All functions shall be provided with printed narratives and/or flow diagrams to document algorithms and how to modify and use them.

K. Security: Controller software shall support multiple level password access restriction as more fully specified below.

L. Direct Digital Control: Controller shall support application of Direct Digital Control Logic. All logic modules shall be provided pre-programmed with written documentation to support their application. Provide the following logic modules as a minimum:

1. Proportional-Integral-Derivative (PID) control with analog, PWM and floating output
2. Two Position control (Hi or Low crossing with deadband)
3. Single-Pole Double-Throw relay
4. Delay Timer (delay-on-make, delay-on-break, and interval)
5. Hi/Low Selection
6. Reset or Scaling Module
7. Logical Operators (And, Or, Not, Xor)

M. Psychrometric Parameters: Controller software shall provide preprogrammed functions to calculated and present psychrometric parameters (given temperature and relative humidity) including the following as a minimum: Enthalpy, Wet Bulb Temperature.

N. Updating/Storing Application Data: Site-specific programming residing in volatile memory shall be uploadable/downloadable from an OWS or CSS connected locally, to the Primary LAN, to the Local Supervisory LAN and remotely via the internet and modem and telephone lines as applicable but all must be available. Initiation of an upload or download shall include all of the following methods; Manually, Scheduled, and Automatically upon detection of a loss or change.

O. Restart: System software shall provide for orderly shutdown upon loss of power and automatic restart upon power restoration. Volatile memory shall be retained; outputs shall go to programmed fail (open, closed, or last) position. Equipment restart shall include a user definable time delay on each piece of equipment to stagger the restart. Loss of power shall be alarmed at operator interface indicating date and time.

P. Time Synchronization: Operators shall be able to set the time and date in any device on the network that supports time-of-day functionality. The operator shall be able to select to set the time and date for an individual device, devices on a single network, or all devices simultaneously. Automatic time synchronization shall be provided.

Q. Misc. Calculations: System software shall automate calculation of psychometric functions, calendar functions, kWh/kW, and flow determination and totalization from pulsed or analog inputs, curve-fitting, look-up table, input/output scaling, time averaging of inputs and A/D conversion coefficients.

2.9 APPLICATION PROGRAMMING DESCRIPTION

A. The application software shall be user programmable.

B. This specification generally requires a programming convention that is logical, easy to learn, use, and diagnose. General approaches to application programming shall be provided by one, or a combination, of the following conventions:

1. Point Definition: provide templates customized for point type, to support input of individual point information.
2. Graphical Block Programming: Manipulation of graphic icon 'blocks', each of which represents a subroutine, in a functional/logical manner forming a control logic diagram. Blocks shall allow entry of adjustable settings and parameters via pop-up windows. Provide a utility that shall allow the graphic logic diagrams to be directly compiled into application programs. Logic diagrams shall be viewable either off-line, or on-line with real-time block output values.
3. Functional Application Programming: Pre-programmed application specific programs that allow/require limited customization via 'fill-in-the-blanks' edit fields. Typical values would be setpoints gains, associated point names, alarm limits, etc.
4. Line Programming: Textual syntax-based programming in a language similar to BASIC designed specifically for HVAC control. Subroutines or functions for energy management applications, setpoints, and adjustable parameters shall be customizable, but shall be provided preprogrammed and documented.

C. Provide a means for testing and/or debugging the control programs both off-line and on-line.

2.10 ENERGY MANAGEMENT APPLICATIONS

A. System shall have the ability to perform all of the following energy management routines via preprogrammed function blocks or template programs. As a minimum provide the following whether or not required in the software:

1. Time-of-Day Scheduling
2. Calendar-Based Scheduling
3. Holiday Scheduling
4. Temporary Schedule Overrides
5. Optimal Start/Optimal Stop-based on space temperature offset, outdoor air temperature, and building heating and cooling capacitance factors as a minimum
6. Night Setback and Morning Recovery Control, with ventilation only during occupancy
7. Economizer Control (enthalpy or dry-bulb)
8. Peak Demand Limiting and Load Shedding. The demand limiting function shall use demand data as the basis for the function and the load shedding program shall use space temperature adjustment or means acceptable to the Owner to provide load shedding response. The function selected for a given location shall be made by the Owner.
9. Dead Band Control

B. All programs shall be executed automatically without the need for operator intervention, and shall be flexible enough to allow operator customization. For example the load shedding program shall allow the operator to determine the spaces to be included in the load shed as well as the duration of the event. Programs shall be applied to building equipment as described in the Division 23 Section "Building Automation System (BAS) - Sequence of Operation."

2.11 PASSWORD PROTECTION

A. Multiple-level password access protection shall be provided to allow the Owner's authorized BAS Administrator to limit workstation control, display and database manipulation capabilities as deemed appropriate for each user, based upon an assigned user name with a unique password.

B. All passwords for the system shall be provided to the Owner including administrator, dealer, or factory level passwords for the systems provided under this project.

C. Passwords shall restrict access to all Control Units.

D. Each user name shall be assigned to a discrete access level. A minimum of five levels of access shall be supported. Alternately, a comprehensive list of accessibility/functionality items shall be provided, to be enabled or disabled for each user.

E. A minimum of 20 user names shall be supported and programmed per the Owner's direction. Provide ability to deactivate passwords without removal of the login and password. The Owner shall be provided with the highest level login and password so that the Owner controls the administrative passwords.

F. Operators shall be able to perform only those commands available for the access level assigned to their user name.

G. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving interface device software on-line. This timer shall not be the windows system screen saver feature.

2.12 ALARM AND EVENT MANAGEMENT REPORTING

A. Alarm management shall be provided to monitor, buffer, and direct alarms and messages to operator devices and memory files. Each BC shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic, and prevent alarms from being lost. At no time shall a BC's ability to report alarms be affected by either operator activity at an Operator Workstation or local handheld device, or by communications with other panels on the network.

1. Alarm Descriptor: Each alarm or point change shall include that point's English language description, and the time and date of occurrence. In addition to the alarm's descriptor and the time and date, the user shall be able to print, display and store an alarm message to more fully describe the alarm condition or direct operator response.
2. Alarm Prioritization: The software shall allow users to define the handling and routing of each alarm by their assignment to discrete priority levels. A minimum of ten priority levels shall be provided. For each priority level, users shall have the ability to enable or disable an audible tone whenever an alarm is reported and whenever an alarm returns to normal condition. Users shall have the ability to manually inhibit alarm reporting for each individual alarm and for each priority level. Contractor shall coordinate with the Owner on establishing alarm priority definitions.
3. Alarm Report Routing: Each alarm priority level shall be associated with a unique user-defined list of operator devices including any combination of local or remote workstations, printers and workstation disk files. All alarms associated with a given priority level shall be routed to all operator devices on the user-defined list associated with that priority level. For each priority level, alarms shall be automatically routed to a default operator device in the event that alarms are unable to be routed to any operator device assigned to the priority level.
4. Auto-Dial Alarm Routing: For alarm priority levels that include a remote workstation (accessed by modem) as one of the listed reporting destinations, the BC shall initiate a call to report the alarm, and shall terminate the call after alarm reporting is complete. System shall be capable of multiple retries and buffer alarms until a connection is made. If no connection is made, system shall attempt connection to an alternate dial-up workstation. System shall also be able to dial multiple pagers upon alarm activation.
5. Alarm Acknowledgment: For alarm priority levels that are directed to a workstation screen, an indication of alarm receipt shall be displayed immediately regardless of the application in use at the workstation, and shall remain on the screen until acknowledged by a user having a password that allows alarm acknowledgment. Upon acknowledgment, the complete alarm message string (including date, time, and user name of acknowledging operator) shall be stored in a selected file on the workstation hard disk.
6. Alarm Display: All alarms shall popup as described in Alarm Acknowledgement. The owner shall have the option to limit the pop up alarms based on alarm priority.

B. It shall be possible for any operator to receive a summary of all alarms, regardless of acknowledgement status; for which a particular recipient is enrolled for notification; based on current event state; based

on the particular event algorithm (e.g., change of value, change of state, out of range, and so on); alarm priority; and notification class.

C. Alarm Historical Database: The database shall store all alarms and events object occurrences in an ODBC or an OLE database-compliant relational database. Provide a commercially available ODBC driver or OLE database data provider, which would allow applications to access the data using standard Microsoft Windows Data Services.

2.13 TRENDING

A. The software shall display historical data in both a tabular and graphical format. The requirements of this trending shall include the following:

1. Trends may be buffered in the BC as long as the trend data in the BC and the historical data stored on hard disk is displayed seamlessly.
2. Provide trends for all physical points, virtual points and calculated variables.
3. Trend data shall be stored in relational database format as specified in herein under Data Acquisition and Storage.
4. In the graphical format, the trend shall plot at least 4 different values for a given time period superimposed on the same graph. The 4 values shall be distinguishable by using unique colors. In printed form the 4 lines shall be distinguishable by different line symbology. Displayed trend graphs shall indicate the engineering units for each trended value.
5. The sample rate and data selection shall be selectable by the operator.
6. The trended value range shall be selectable by the operator.
7. Where trended values on one table/graph are COV, software shall automatically fill the trend samples between COV entries.

B. Control Loop Performance Trends: Controllers incorporating PID control loops shall also provide high resolution sampling in less than six second increments for verification of control loop performance.

C. Data Buffering and Archiving: Trend data may be buffered at the BC, and uploaded to hard disk storage for archiving as needed based on the BC's memory constraints. All archived trends shall be transmitted to the on-site OWS as applicable. Uploads shall occur based upon a user-defined interval, manual command, or automatically when the trend buffers become full.

D. Time Synchronization: Provide a time master that is installed and configured to synchronize the clocks of all devices supporting time synchronization. Synchronization shall be done using Coordinated Universal Time (UTC). All trend sample times shall be able to be synchronized. The frequency of time synchronization message transmission shall be selectable by the operator.

2.14 DYNAMIC PLOTTING

A. Provide a utility to dynamically plot in real-time at least 4 values on a given 2-dimensional dynamic plot/graph with at least two Y-axes. At least 5 dynamic plots shall be allowed simultaneously.

2.15 DATA ACQUISITION AND STORAGE

A. All points included in the typical equipment point list must be represented in a common, open or accessible format. Naming conventions for these points and network addressing are discussed in the 'Point Naming Conventions' paragraph below.

B. Data from the BAS shall be stored in relational database format. The format and the naming convention used for storing the database files shall remain consistent across the database and across time. The relational structure shall allow for storage of any additional data points, which are added to the BAS in future. The metadata/schema or formal descriptions of the tables, columns, domains, and constraints shall be provided for each database.

C. The database shall allow applications to access the data while the database is running. The database shall not require shutting down in order to provide read-write access to the data. Data shall be able to be read from the database without interrupting the continuous storage of trend data being carried by the BAS.

D. The database shall be ODBC or OLE database compliant. Provide a commercially-available ODBC driver or OLE database data provider, which would allow applications to access the data via Microsoft Windows standard data access services.

E. All data shall be stored for a minimum of 5-years.

2.16 TOTALIZATION

A. The software shall support totalizing analog, digital, and pulsed inputs and be capable of accumulating, storing, and converting these totals to engineering units used in the documents. These values shall generally be accessible to the Operator Interfaces to support management-reporting functions.

B. Totalization of electricity use/demand shall allow application of totals to different rate periods, which shall be user definable.

C. When specified to provide electrical or utility Use/Demand, the Contractor shall obtain from the local utility all information required to obtain meter data, including k factors, conversion constants, and the like.

2.17 EQUIPMENT SCHEDULING

A. Provide a graphic utility for user-friendly operator interface to adjust equipment-operating schedules.

B. Scheduling feature shall include multiple seven-day master schedules, plus holiday schedule, each with start time and stop time. Master schedules shall be individually editable for each day and holiday.

C. Scheduling feature shall allow for each individual equipment unit to be assigned to one of the master schedules.

D. Timed override feature shall allow an operator to temporarily change the state of scheduled equipment. An override command shall be selectable to apply to an individual unit, all units assigned to a given master schedule, or to all units in a building. Timed override shall terminate at the end of an operator selectable time, or at the end of the scheduled occupied/unoccupied period, whichever comes first. A password level that does not allow assignment of master schedules shall allow a timed override feature.

E. A yearly calendar feature shall allow assignment of holidays, and automatic reset of system real time clocks for transitions between daylight savings time and standard time.

2.18 POINT STRUCTURING AND NAMING

A. General: The intent of this Section is to require a consistent means of naming points across the Owner requirements. Contractor shall configure the systems from the perspective of the Enterprise, not solely the local project. The following requirement establishes a standard for naming points and addressing Buildings, Networks, Devices, Instances, and the like. The interface shall always use this naming convention. The naming convention shall be implemented as much as practical. Naming convention shall be clearly documented and approved by the EOR and/or Owner.

B. Point Summary Table

1. The term ‘Point’ is a generic description for the class of object represented by analog and binary inputs, outputs, and values.
2. With each schematic, Contractor shall provide a Point Summary Table listing:

    a. Building number and abbreviation
    b. System type
    c. Equipment type
    d. Point suffix
    e. Full point name (see Point Naming Convention paragraph)
    f. English language point description
    g. Ethernet backbone network number,
    h. Network number
    i. Device ID
    j. Device MAC address

k. Engineering units

3. Point Summary Table shall be provided in both hard copy and in electronic format (ODBC-compliant).
4. Point Summary Table shall also illustrate Network Variables Bindings.
5. The Contractor shall coordinate with the Owner's representative and compile and submit a proposed Point Summary Table for review prior to any object programming or project startup.
6. The Point Summary Table shall be kept current throughout the duration of the project by the Contractor as the Master List of all points for the project. Project closeout documents shall include an up-to-date accurate Point Summary Table. The Contractor shall deliver to the Owner the final Point Summary Table prior to final acceptance of the system. The Point Summary Table shall be used as a reference and guide during the commissioning process.
7. The Point Summary Table shall contain all data fields on a single row per point. The Point Summary Table is to have a single master source for all point information in the building that is easily sorted and kept up-to-date. Although a relational database of Device ID-to-point information would be more efficient, the single line format is required as a single master table that shall reflect all point information for the building. The point description shall be an easily understandable English-language description of the point.
8. Point Summary Table shall also illustrate Network Variables/BACnet Data Links Bindings.

Point Summary Table Example

Row Headers and Examples

(Transpose for a single point per row format)

Building Number	0006 (the Owner's 4 digit Building Code)
System Type	Cooling
Equipment Type	Chiller
Point Suffix	CHLR1KW
*Point Name (Object Name)	0006.COOLING.CHILLER.CHLR1KW
*Point Description (Object Description)	Chiller 1 kW
Ethernet Network Number	600
Network Number	610
Device ID	1024006
Device MAC address	24
Point Type	AI
Instance Number	4
Engineering Units	KW
Network Variable?	True
Server Device	1024006
Client Devices	1028006

* Represents information that shall reside in the property for the point

C. Point Naming Convention

1. All point names shall adhere to the format as established below. Said objects shall include all physical I/O points, calculated points used for standard reports, and all application program parameters. For each BAS point, a specific and unique name shall be required.

2. For each point, four (4) distinct descriptors shall be linked to form each unique object name: Building, System, Equipment, and Point. All keyboard characters except a space are allowable. Each of the four descriptors must be bound by a period to form the entire object name. Reference the paragraphs below for an example of these descriptors.
3. The Owner shall designate the *Building* descriptor. The *System* descriptor shall further define the object in terms of air handling, cooling, heating, or other system. The *Equipment* descriptor shall define the equipment category; e.g., Chiller, Air Handler, or other equipment. The *Point* descriptor shall define the hardware or software type or function associated with the equipment; e.g., supply temperature, water pressure, alarm, mixed air temperature setpoint, etc. and shall contain any numbering conventions for multiples of equipment; e.g., CHLR1KW, CHLR2KW, BLR2AL (Boiler 2 Alarm), HWP1ST (Hot Water Pump 1 Status).
4. A consistent object (point) naming convention shall be utilized to facilitate familiarity and operational ease across the Owner's WAN. Inter-facility consistency shall be maintained to ensure transparent operability to the greatest degree possible. The table below details the object naming convention and general format of the descriptor string.

Point Name Requirements

Descriptors		Comment
Building Number	0006	The Master Building List also has the correct number for each building.
System	AIRHANDLING	
	EXHAUST	
	HEATING	Boilers and ancillary equipment
	COOLING	Chillers and ancillary equipment
	UTILITY	Main electrical and gas meters
	ENDUSE	Specific building loads by type
	MISC	
Equipment	AHU-1	
	BOILERS	Non-specific boiler system points
	CHILLERS	Non-specific chiller system points
	FACILITY	
	TOWERS	
	WEATHER	
Point Suffix	See Input/Output point summary table for conventions	

5. Examples: Within each point name, the descriptors shall be bound by a period. Within each descriptor, words shall not be separated by dashes, spaces, or other separators as follows:
    a. 0006.COOLING.CHILLERS.CHWP1ST
    b. 0006.HEATING.BOILERS.BLR1CFH

D. Device Addressing Convention:

1. BACnet - Network numbers and Device Object IDs shall be unique throughout the network.
2. BACnet - For each BAS object, a specific and unique BACnet object name shall be required.
3. All assignment of network numbers and Device Object IDs shall be coordinated with the Owner.

4. Each Network number shall be unique throughout all facilities and shall be assigned in the following manner unless specified otherwise:

    a. BBBFF, where: BBB = 1-655 assigned to each building, FF = 00 for building backbone network, 1-35 indicating floors or separate systems in the building.

5. Each Device Identifier property shall be unique throughout the system and shall be assigned in the following manner unless specified otherwise:

    a. XXFFBBB, where: XX = number 0 to 40, FF = 00 for building backbone network, 1-35 indicating floors or separate systems in the building. BBB = 1-655 assigned to each building.

6. The Contractor shall coordinate with the Owner or a designated representative to ensure that no duplicate Device Object IDs occur.
7. Alternative Device ID schemes or cross project Device ID duplication if allowed shall be approved before project commencement by the Owner.

2.19 OPERATOR INTERFACE GRAPHIC SOFTWARE

A. Graphic software shall facilitate user-friendly interface to all aspects of the System Software specified above. The intent of this specification is to require a graphic package that provides for intuitive operation of the systems without extensive training and experience. It shall facilitate logical and simple system interrogation, modification, configuration, and diagnosis.

B. Graphic software shall support multiple simultaneous screens to be displayed and resizable in a 'Windows'-like environment. All functions excepting text entry functions shall be executable with a mouse.

C. Graphic software shall provide for multitasking such that third-party programs can be used while the OWS software is on line. Software shall provide the ability to alarm graphically even when operator is in another software package.

D. Operating system software shall be Microsoft Windows 8.0 or higher.

E. The software shall allow for the Owner's creation of user-defined, color graphic displays of geographic maps, building plans, floor plans, and mechanical and electrical system schematics. These graphics shall be capable of displaying all point information from the database including any attributes associated with each point (i.e., engineering units, etc.). In addition, operators shall be able to command equipment or change setpoints from a graphic through the use of the mouse.

F. Screen Penetration: The operator interface shall allow users to access the various system graphic screens via a graphical penetration scheme by using the mouse to select from menus or 'button' icons. All screens shall be accessible out the use of outline type selection screens. Each graphic screen shall be capable of having a unique list of other graphic screens that are directly linked through the selection of a menu item or button icon.

G. Dynamic Data Displays: Dynamic physical point values shall automatically updated at a minimum frequency of 6 updates per minute without operator intervention. Point value fields shall be displayed with a color code depicting normal, abnormal, override and alarm conditions.

H. Point Override Feature: Provide the following:

1. An Operator from a work-station shall have the capability to place an end device under manual control, which shall prevent the control logic from making changes to the end device status, and provide the operator with the ability to position the end device. It must be possible to put a point under manual control and command the point to a specific state or value from a graphic page. Once under manual control the point shall be able to be released to automatic operation from the same graphics page. See the definition of Manual Control in the definition of terms Article in this Section.
2. An Operator from the operator work-station shall have the capability to place a sensor input into test mode. When in test mode, any changes from the physical sensor shall no longer be

recognized and the value reported to control logic shall take a value that is assigned to it by the operator from the operator work-station. It must be possible to put a point in test and assign a test value from a graphic page. See the definition of Test Mode in the definition of terms Article of this Section.

3. Points that are overridden shall be reported as an alarm, and shall be displayed in a coded color. The alarm message shall include the operator's user name. A list of points that are currently in an override state shall be available through menu selection. Such overrides or changes shall occur in the control unit, not just in the workstation software. The graphic point override feature shall be subject to password level protection.

I. Dynamic Symbols: Provide a selection of standard symbols that change in appearance based on the value of an associated point.

1. Analog symbol: Provide a symbol that represents the value of an analog point as the length of a line or linear bar.
2. Digital symbol: Provide symbols such as switches, pilot lights, rotating fan wheels, etc. to represent the value of digital input and output points.
3. Point Status Color: Graphic presentations shall indicate different colors for different point statuses. (For instance, green = normal, red = alarm, gray (or '???') for non-response.

J. Graphics Development Package: Graphic development and generation software shall be provided to allow the user to add, modify, or delete system graphic displays. The application of the graphic editing shall be controlled by password level at the programmer level or higher.

1. The Contractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g. fans, cooling coils, filters, dampers, etc.), mechanical system components (e.g., pumps, chillers, cooling towers, boilers, etc.), complete mechanical systems (e.g. constant volume-terminal reheat, VAV, etc.) and electrical symbols.
2. The Graphic Development Package shall use a mouse or similar pointing device to allow the user to perform the following:

a. Define symbols
b. Position items on graphic screens
c. Attach physical or virtual points to a graphic
d. Define background screens
e. Define connecting lines and curves
f. Locate, orient and size descriptive text
g. Define and display colors for all elements
h. Establish correlation between symbols or text and associated system points or other displays.
i. Create hot spots or link triggers to other graphic displays or other functions in the software.

PART 3 - EXECUTION

3.1 INSPECTION:

A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.2 INSTALLATION OF CONTROL NETWORK SYSTEMS:

A. General: Install systems and materials in accordance with manufacturer's instructions, roughing-in drawings and details shown on drawings.

B. Contractor shall fully configure and provide all interface devices and software to provide an integrated system.

C. Contractor shall closely coordinate with the Owner to establish an IP address and communications to assure proper operation of the building control system with the Owner's WAN, CSS's, OWS's, and/or OWSs.

D. Coordinate with the Data Contractor prior to construction to assure data infrastructure requirements are communicated to meet the BAS requirements.

3.3 INSTALLATION OF INTERFACES:

A. Set up the workstations and printers (where applicable) as indicated. Install all software and verify that the systems are fully operational. Ensure all official licenses are provided for all software.

B. No license, software component, key, etc. or any piece of information required to install, configure, operate, diagnose and maintain the system shall be withheld from the Owner.

C. Install electronic control system Operation and Maintenance Manuals, programming guides, network configuration tools, control shop drawings etc. on each OWS and CSS. Provide interface or shortcuts to guide user to the appropriate information.

D. Set up portable operator terminal (where applicable) and configure it as a remote workstation. Install all software and verify that the system is fully operational.

E. Set up panel-mounted LCD or touchscreen display(s) (where applicable) and configure it to operate the required DDC controllers that it serves. Install all software and verify that the system is fully operational.

F. Install systems and materials in accordance with manufacturer's instructions.

3.4 SYSTEM CONFIGURATION

A. Contractor shall thoroughly and completely configure the BAS software, supplemental software, network communications, CSS, OWS (where applicable), POT (where applicable), printer (where applicable), and remote communications for a fully complete operational system.

3.5 SITE-SPECIFIC APPLICATION PROGRAMMING

A. Provide all database creation and site-specific application control programming as required by these Specifications, national and local standards and for a fully functioning system. Contractor shall provide all initial site-specific application programming, thoroughly document programming, and meet the intent of the written sequences of operation. If a sequence is not clear, in the contractor's opinion, it is the Contractor's responsibility to request clarification at no additional cost to the owner.

B. All site-specific programming shall be fully documented and submitted for review and approval, both prior to downloading into the panel, at the completion of functional performance testing, and at the end of the warranty period.

C. This contractor shall include forty hours for the owner, AOR, or EOR to use for final graphical, trending, and adjustments at the end of the warranty period.

D. All programming, graphics and data files must be maintained in a logical system of directories with self-explanatory file names. All files developed for the project shall be the property of the Owner and shall remain on the workstation(s)/server(s) at the completion of the project.

3.6 PASSWORD SETUP

A. Set up the following password levels to include the specified capabilities:

1. Level 1: (the Owner's BAS Administrator)

    a. Level 2 capabilities
    b. View, add, change and delete user names, passwords, password levels
    c. All unrestricted system capabilities including all network management functions.

2. Level 2: (Programmer)

    a. Level 3 capabilities
    b. Configure system software
    c. Modify control unit programs
    d. Modify graphic software

e. Essentially unrestricted except for viewing or modifying user names, passwords, password levels

3. Level 3: (Chief Engineer)

a. Level 4 capabilities
b. Override output points
c. Change all setpoints and reset schedules.
d. Exit BAS software to use third party programs

4. Level 4: (Assistant)

a. Level 5 capabilities
b. Acknowledge alarms
c. Change equipment schedules
d. Change room temperature setpoints

5. Level 5: (View only Access)

a. Display all graphic data
b. Trend point data
c. Unless otherwise directed the Login shall be the Owner's name and the password shall be "ownerswebaccess".

B. Contractor shall assist the Owner's operators with assigning user names, passwords and password levels. There may be multiple login name and passwords for a given password level. The contractor shall be responsible for changing BAS administrator and Programmer level passwords if those are accidentally provided to other contractors or the Owner.

3.7 POINT PARAMETERS

A. Provide the following minimum programming for each analog input:

1. Name
2. Address
3. Scanning frequency or COV threshold
4. Engineering units
5. Offset calibration and scaling factor for engineering units
6. High and low alarm values and alarm differentials for return to normal condition
7. High and low value reporting limits (reasonableness values), which shall prevent control logic from using shorted or open circuit values.
8. Default value to be used when the actual measured value is not reporting. This is required only for points that are transferred across the primary and/or secondary controlling networks and used in control programs residing in control units other than the one in which the point resides. Events causing the default value to be used shall include failure of the control unit in which the point resides, or failure of any network over which the point value is transferred. All default values shall be provided in list format for evaluation by the Owner.
9. Selectable averaging function that shall average the measured value over a user selected number of scans for reporting.

B. Provide the following minimum programming for each analog output:

1. Name
2. Address
3. Output updating frequency
4. Engineering units
5. Offset calibration and scaling factor for engineering units
6. Output Range
7. Default value to be used when the normal controlling value is not reporting.

C. Provide the following minimum programming for each digital input:

1. Name
2. Address
3. Engineering units (on/off, open/closed, freeze/normal, etc.)
4. Debounce time delay
5. Message and alarm reporting as specified
6. Reporting of each change of state, and memory storage of the time of the last change of state
7. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.

D. Provide the following minimum programming for each digital output:

1. Name
2. Address
3. Output updating frequency
4. Engineering units (on/off, open/closed, freeze/normal, etc.)
5. Direct or Reverse action selection
6. Minimum on-time
7. Minimum off-time
8. Status association with a DI and failure alarming (as applicable)
9. Reporting of each change of state, and memory storage of the time of the last change of state.
10. Totalization of on-time (for all motorized equipment status points), and accumulated number of off-to-on transitions.
11. Default value to be used when the normal controlling value is not reporting.

3.8 TRENDS

A. Contractor shall establish and store trend logs at the CCS server. Trend logs shall be prepared for each physical input and output point. All dynamic virtual points such as setpoints subject to a reset schedule, intermediate setpoint values for cascaded control loops, and the like shall be trended as directed by the Owner

B. The Owner shall be able to analyze trend logs of the system operating parameters to evaluate normal system functionality. Contractor shall establish these trends and ensure they are being stored properly.

1. Data shall include a single row of field headings and the data thereafter shall be contiguous. Each record shall include a date and time field or single date stamp. Recorded parameters for a given piece of equipment or component shall be trended at the same intervals and be presented in a maximum of two separate 2-dimensional formats with time being the row heading and field name being the column heading.

C. Sample times indicated as COV ($\pm$) or change-of-value mean that the changed parameter only needs to be recorded after the value changes by the amount listed. When outputting to the trending file, the latest recorded value shall be listed with any given time increment record. The samples shall be filled with the latest values also if the points include different time intervals. If the BAS does not have the capability to record based on COV, the parameter shall be recorded based on the interval common to the unit.

D. Trending intervals or COV thresholds shall be dictated by the Owner or their representative, upon system start-up.

E. The Contractor shall demonstrate functional trends as specified for a period of 30 days after successful system demonstration before final acceptance of the system. The trend limit is 1 year from demonstration for LEED projects that require trend data for M&V purposes. The limit on the length of trend data shall be a function of the storage capacity of the computer.

3.9 TREND GRAPHS

A. Prepare controller and workstation software to display graphical format trends. Trended values and intervals shall be the same as those specified

B. Lines shall be labeled and shall be distinguishable from each other by using either different line types, or different line colors.

C. Provide a legend identifying the line color and symbol along side the point noun name for each point in the trend. Also, indicate engineering units of the y-axis values; e.g. degrees F., inches w.g., Btu/lb, percent open, etc.

D. The y-axis scales shall be chosen so that all trended values are in a readable range. Do not mix trended values on one graph if their unit ranges are incompatible.

E. Trend outside air temperature, humidity, and enthalpy during each period in which any other points are trended except for control loop performance trends.

F. Allow point groups to be saved for future trends. For example HW supply and return temperatures along with HX stm valve position and pump status.

3.10 ALARMS

A. Override Alarms: Any point that is overridden through the override feature of the graphic workstation software shall be reported as a Level 3 alarm.

B. Analog Input Alarms: For each analog input, program an alarm message for reporting whenever the analog value is outside of the programmed alarm limits. Report a 'Return-to-Normal' message after the analog value returns to the normal range, using a programmed alarm differential. The alarm limits shall be individually selected by the Contractor based on the following criteria:

1. Level-3: Space temperature (except as otherwise stated in sequence of operation)

   a. Low alarm: 64°F
   b. Low return-to-normal: 68°F
   c. High alarm: 85°F
   d. High return-to-normal: 80°F

2. Controlled media temperature other than space temperature (e.g. AHU discharge air temperature, steam converter leaving water temperature, condenser water supply, chilled water supply, etc.): Level 3 (If controlled media temperature setpoint is reset, alarm setpoints shall be programmed to follow setpoint)

   a. Low alarm: 3°F below setpoint
   b. Low return-to-normal: 2°F below setpoint
   c. High alarm: 3°F above setpoint
   d. High return-to-normal: 2°F above setpoint.

3. Level-4: AHU mixed air temperature (where applicable)

   a. Low alarm: 45°F
   b. Low return-to-normal: 46°F
   c. High alarm: 90°F
   d. High return-to-normal: 89°F

4. Level-4: Duct Pressure:

   a. Low alarm: 0.5" w.g. below setpoint
   b. Low return-to-normal: 0.25 "w.g. below setpoint
   c. High alarm: 0.5" w.g. above setpoint
   d. High return-to-normal: 0.25" w.g. above setpoint

5. Level-4: Space humidity:

   a. Low alarm: 35%
   b. Low return-to-normal: 40%
   c. High alarm: 75%
   d. High return-to-normal: 70%

C. Status versus Command Alarms: The Sequences of Operation are based on the presumption that motor starter Hand-Off-Auto (HOA) switches are in the 'Auto' position. BAS shall enunciate the following Level 5 alarm message if status indicates a unit is operational when the run command is not present or vice versa:

1. *DEVICE XXXX* FAILURE: Status is indicated on *{the device}* even though it has been commanded to stop. Check the HOA switch, control relay, status sensing device, contactors, and other components involved in starting the unit. Acknowledge this alarm when the problem has been corrected.

D. Maintenance Alarms: Enunciate Level 5 alarms when runtime accumulation exceeds a value specified by the operator.

1. *DEVICE XXXX REQUIRES MAINTENANCE*. Runtime has exceeded specified value since last reset.

E. See requirements for additional equipment-specific alarms specified in Division 23 Section "Building Automation System (BAS) - Sequences of Operation."

3.11 GRAPHIC SCREENS

A. Main Screen: The Main screen shall be the first screen displayed after login, no navigation required to get to the main screen. This screen shall have the following features:

1. The Owner shall have the option of providing a picture for the background.
2. There shall be a link button to the floor plans, Summary screen, and system schematic screens. In the event that there are more 10 to 15 AHU, Boiler and Chiller screens a button to groups of AHU's shall be provided.
3. Manufacturer/Installer Logo or information is not to be included in the screen.
4. Provide a global command to open heating or cooling valves to facilitate Test Adjust and Balance. The command shall be grouped so that an AHU can be balanced as well as total system balancing. The same function shall apply for VAV AHU's were all the boxes can be set at minimum or maximum flow.

B. Floor Plan Screens: The contract document drawings shall be made available to the Contractor in AutoCAD format upon request. These drawings may be used only for developing backgrounds for specified graphic screens; however the Owner does not guarantee the suitability of these drawings for the Contractor's purpose.

1. Provide graphic floor plan screens for each floor and/or wing of the building. Indicate the location of all equipment that is not located on the equipment room screens.

a. Indicate the location of temperature sensors associated with each temperature-controlled zone (i.e., VAV terminals, fan-coils, single-zone AHUs, etc.) on the floor plan screens.
b. Display the space temperature point adjacent to each temperature sensor symbol along with the room set point. Use a distinct line symbol to demarcate each terminal unit zone boundary. Use distinct background colors for each zone to demarcate the parent air-handling unit to which it is associated.
c. Indicate room numbers as provided by the Owner. Verify final room number/name assignments, as these are often different than initially assigned room numbers on the contract drawings.
d. Provide a drawing link from each space temperature sensor symbol and equipment symbol shown on the graphic floor plan screens to each corresponding zone equipment schematic graphic screen. Because the area available for the floor plans varies from system to system, the size of text used to display data such as room number and temperature shall be at least 1/8" high on the screen when the entire floor plan section is displayed.
e. The floor plan graphics shall also indicate the location of control panels. For control devices such as duct smoke detectors, system pressure or differential pressure sensors (water or air), airflow stations that are located outside the equipment rooms. All of these devices shall be linked to the associated system graphic. For terminal units the link to the

associated system graphic is sufficient and the associated unit control devices do not need to be located on the floor plan.

2. Provide graphic floor plan screens for each mechanical equipment room and a plan screen of the roof. Indicate the location of each item of mechanical equipment. Provide a drawing link from each equipment symbol shown on the graphic plan view screen to each corresponding mechanical system schematic graphic screen.
3. Provide a graphic building key plan that shall allow navigation at a floor level or from floor to floor. Use elevation views and/or plan views as necessary to graphically indicate the location of all of the larger scale floor plans. Link graphic building key plan to larger scale partial floor plans. Provide links from each larger scale graphic floor plan screen to the building key plan and to each of the other graphic floor plan screens.
4. When there is more than one building, provide a graphic site plan with links to and from each building plan.

C. System Schematic Screens: Provide graphic system schematic screen for each HVAC subsystem (AHU) controlled with each I/O point in the project appearing on at least one graphic screen. System graphics shall be have the same look as the submittal diagrams (do not use three dimensional graphics) with status, setpoints, current analog input and output values, operator commands, etc. as applicable. Input/output devices shall be shown in their schematically correct locations with the associated value, noun name and engineering units. The position of valves or dampers shall be % OPEN. For three way valves it shall be %OPEN to the device. The noun name (English language descriptors) shall be included for each point on all graphics; this may be accomplished by the use of a pop-up window accessed by selecting the displayed point with the mouse. Indicate all adjustable setpoints on the applicable system schematic graphic screen or, if space does not allow, on a supplemental linked-setpoint screen. Similar AHU's shall have the same organization of information.

1. Provide graphic screens for each air handling system. Indicate outside air temperature and enthalpy, and mode of operation as applicable (i.e., occupancy mode and heating, cooling, economizer etc based on the sequence of operations). Link screens for air handlers to the heating system and cooling system graphics. Link screens for supply and exhaust systems if they are not combined onto one screen.
2. Provide a graphic screen for each zone with the associated control devices or terminal unit with a link to the associated system schematic screen of the air handling unit that serves the zone.
3. Provide a cooling system graphic screen showing all points associated with the chillers, cooling towers and pumps. Indicate outside air dry-bulb temperature and calculated wet-bulb temperature. Link the chilled water and condenser water systems screens if they cannot fit onto one cooling plant graphic screen.
4. Link the heating and cooling system graphics to utility history reports showing current and monthly electric uses, demands, peak values, and other pertinent values.
5. For each system schematic screen, including AHU, Boiler, Chiller and terminal unit screen, provide a button linked to a text version of the sequence of operation for the device or system. The sequence shall be updated with the as-built sequence following completion of the demonstration.

D. System Summary Screens: On each graphic System Screen, provide drawing links to the graphic air handling unit schematic screens.

1. Where applicable, provide a chilled water valve screen showing the analog output signal of all chilled water valves with signals expressed as percentage of fully open valve (percentage of full cooling). Indicate the discharge air temperature and setpoint of each air handling unit, cooling system chilled water supply and return temperatures and the outside air temperature and humidity on this graphic. Provide drawing links between the graphic cooling plant screen and this graphic screen.
2. Where applicable, provide a heating water valve screen showing the analog output signal of all air handling unit heating water valves with signals expressed as percentage of fully open valve (percentage of full heating). Indicate the temperature of the controlled medium (such as AHU

discharge air temperature or zone hot water supply temperature) and the associated setpoint and the outside air temperature and humidity.

3. Where applicable, When there are more than one AHU's on the system provide a summary screen with the following type of information for each AHU, each fan command, status, alarms (smoke, freeze, duct static), DAT and duct pressure if applicable. For the heating system provide status and supply water temp or steam pressure and for the chiller provide status and chilled water supply temperature.
4. Provide a BAS system summary screen using the control system riser diagram to show the communication status of all controllers (BC, AAC and ASC's) on the BAS as well as all interface devices such as VFD's, chillers and boiler panels etcetera. Use green board concept, green means communicating, red is not communicating.
5. Provide a terminal unit summary screen grouped by floor or AHU. If the summary is grouped by floor then the AHU shall be shown for each terminal unit and vice versa. The points shown shall depend on the type of terminal unit and shall include room name, floor or AHU, room set point and temperature, DAT, valve position, command status, alarm and occupancy state.
6. Exhaust fans shall be show in a table format showing the command signal, the status, the alarm condition, and the occupancy state.

E. Alarms: Each programmed alarm shall appear on at least one graphic screen. In general, alarms shall be displayed on the graphic system schematic screen for the system that the alarm is associated with (for example, chiller alarm shall be shown on graphic cooling system schematic screen). For all graphic screens, display analog values that are in a 'high alarm' condition in a red color, 'low alarm' condition in a blue color. Indicate digital values that are in alarm condition in a red color. When an alarm first occurs it shall "popup" over the current screen so that the operator is immediately aware of an alarm.

1. Maintenance Alarms

a. Runtime alarm screen shall list all equipment with a BAS status. For each piece of equipment the screen shall display the current run time (since the last reset), the runtime alarm limit (adj.), its alarm status (red / green) and the total accumulated runtime. The total accumulated runtime would only be zeroed out if the equipment were replaced. For equipment with internal runtime meters ensure that the total accumulative runtime is synchronized.

F. Metering (where applicable): Provide a graphic for the gas, electric and water utility data required in the sequence of operations. This may entail multiple screens if submetering of the gas or electric usage is included in the project.

G. Naming convention shall be clearly documented and approved by the EOR and Owner.

H. All graphical screens, floor plans, alarms, trends, and point parameters shall be clearly documented and approved by the EOR and Owner.

END OF SECTION

SECTION 230924 - BUILDING AUTOMATION SYSTEM (BAS) – GENERAL SEQUENCE

PART 1 - GENERAL

1.1 SYSTEM DESCRIPTION

A. Refer to Division 23 Section and Control Drawings for a description of the systems to be controlled.

B. Refer to Control Drawings for detailed sequence of operations for major HVAC equipment.

C. This Section contains general sequence and alarming method for the owner.

D. Warranty Period: Refer to specification 23 09 20, section 1.13 for Warranty requirements.

1.2 SUBMITTALS

A. Refer to Division 23 Section "Building Automation System (BAS)" and Division 01 Sections for requirements for control shop drawings, product data, Users Manual, etc.

B. Programming Manual: Provide DDC system programming manual as well as documentation of site-specific programming prior to the start of Acceptance Phase.

1.3 PROJECT RECORD DOCUMENTS

A. Within two weeks of the completion of commissioning, provide record documents to represent the final control configuration with actual setpoints and tuning parameters as existed at acceptance.

B. Record documents shall be modified control drawings with the actual installed information. Drawings shall be delivered in both reproducible hard copy and electronic format in AutoCAD v13 or later. Provide all supporting files, blocks, fonts, etc. required by the drawings.

C. Provide final points list

D. Provide final detailed wiring diagrams with all wire numbers and termination points indicated

E. Accurately record final sequences and control logic made after submission of shop drawings.

1.4 DEFINITIONS/ABBREVIATIONS

A. Absolute Minimum OA: Minimum flow rate setpoint to which the OA or primary air may throttle down. This value is acceptable as long as CO_2 levels are within acceptable limits.

B. Design Minimum OA: Minimum flow rate setpoint based on code requirements or designed system and coil capacities.

C. OA: Outdoor Air

D. CHW: chilled water

E. HW: heating water

F. Physical Point: A point on the BAS that is physically connected to an I/O device such that a hardware point exists

G. Virtual Point: A point to store values (i.e.: a setpoint) that do not represent a physical device.

H. The following serves as a general guide of definitions:

1. Acknowledged: Data is broadcast repeatedly until an acknowledgement is received. Used for critical data using one to one bindings only. This type of service shall not be used for one to many bindings.
2. Analog Calibration Offsets: For all analog input measured variables, with the exception of velocity pressure, the value measured by the hardware based analog input point shall be adjusted to match the value reported by a certified test instrument. An analog calibration offset is a parameter that can be added or subtracted from the raw value measured by the sensor to produce a calibrated value used by the control logic and reported to the operator workstations. The initial value of this parameter is set at zero and it is adjusted when the calibration process is executed. This adjustment is referred to as a single point calibration. These parameters are

mandatory for all analog inputs except velocity pressure sensors. These offset values are configuration parameters and shall be written to EEPROM. It shall be possible to change the value of these parameters from a graphic page.

3. Application Programming Tool: A vendor unique software tool used to create applications for programmable controllers.

4. Application Protocol Data Unit (APDU): A unit of data specified in an application protocol and consisting of application protocol control information and application user data (ISO 9545).

5. Bandwidth Utilization: The average utilization of the network capacity. Network loading is controlled by the use of event driven broadcast based data propagation and the use of appropriate binding services.

6. Binding Services: When the network management tool within Niagara or Plexus is used to establish a binding, one of the following three types of binding services shall be selected:

a. Unacknowledged: The data being broadcast is sent one time and an acknowledgement of receipt is not required. Used for non-critical data where there is no significant impact when the receiving device have to wait for the next broadcast.

b. Unacknowledged Repeated: The data being broadcast is sent three times and an acknowledgement of receipt is not required. Used for most process control related data requiring timely receipt of the data.

c. Acknowledged: The data is broadcast repeatedly until an acknowledgement is received. Used for critical data using one to one bindings only. This type of service shall not be used for one to many bindings.

7. Binding: The concept of associating an output network variable from one device to the input network variable of a second device. There are three types of bindings:

a. One to One: A single output network variable is bound to a single input network variable

b. One to Many: A single output network variable is bound to input network variables on multiple devices.

c. Many to One: Output network variables from multiple devices are bound to a single input network variable on a different device.

8. Broadcasting: The propagation of data from a device to the control network. Software objects that broadcast data to the network shall include the following parameters:

9. Building Automation System (BAS): The entire integrated energy management and control system.

10. Bus Topology: A term used to describe the sequential connection of devices on a segment. The communication cable runs from device to device with no tees or stubs from the main communication cable to a device.

11. Change of Value (COV): An event that occurs when a measured or calculated analog value changes by a predefined amount (ASHRAE/ANSI 135-1995).

12. Channel: A network consisting of two segments connected by a physical layer repeater or router configured as a repeater. Each segment can support a theoretical limit of 64 connections.

13. Client: A device that is the requestor of services from a server. A client device makes requests of, and receives responses from, a server device.

14. Configuration Parameter: An input network variable to a controller that is written to the EEPROM.

15. Connection: Made when a device is physically connected to a communication cable. Devices that count against the number of connections limit include adapters, any sensor, actuator, or controller, and a router or repeater. Terminators are not considered to be a connection.

16. Continuous Monitoring: Sampling and recording of a variable based on time or change of state (e.g. trending an analog value, monitoring a binary change of state).

17. Controller or Control Unit (CU): Intelligent stand-alone control panel. Controller is a generic reference and is a PCU.

18. Error Rate: A measurement of communication quality that assesses the number of defective data packets as a percentage of the total number of data packets. Defective data packets are generally the result of poor installation practices or improper cable selection.

19. Event Driven Communication: A term used to describe the propagation of data from a device to the network based on broadcasting rather than polling. The send on delta parameter is used to define the event and the data propagation is further controlled by the minimum and maximum send time parameters.

20. Free Topology: A data wiring topology that allows for loops, tees, y-connections etc. When this topology is used only one terminator of a specific design is required and allowable cable lengths are significantly reduced.

21. Functional Profile: A collection of variables required to define the key parameters for a standard application. As this applies to the HVAC industry, this would include applications like VAV terminal, fan coil units, and the like.
22. Gateway (GTWY): A device, which contains two or more dissimilar networks/protocols, permitting information exchange between them (ASHRAE/ANSI 135-1995).
23. Hand Held Device (HHD): Manufacturer's microprocessor based device for direct connection to a Controller.
24. Local Supervisory LAN Interface Device (LANID): Device used to facilitate communication and sharing of data throughout the BAS and the Owner.
25. Media Access Control address (MAC): Hardware address that uniquely identifies each node of a network. Each different type of network medium requires a different MAC layer.
26. Managed Communication: Transmission of data from a controller to a data manager, which in turn re-broadcasts the data to a second controller.
27. Manual Control: Where the operator takes control of an end device and forces a specific position or state. The manual mode and the desired manual position or states are parameters that are set by the operator.
28. Many to One: Output network variables from multiple devices are bound to a single input network variable on a different device.
29. Maximum Send Time Parameter: Parameter used to ensure the periodic update of network data. If a time period equal to the value of this parameter has expired without a broadcast of the variable, a re-broadcast of the current value shall be executed. See also "Send on Delta" and "Maximum Send Time."
30. Maximum Send Time: Adjustable parameter that defines the maximum time period between broadcasts of a software object's data to the network. Should the value of a software object remain constant over an extended period of time, the value will be rebroadcast once every maximum time period.
31. Minimum Send Time Parameter: Parameter used to control unnecessary broadcasting of data onto the network. Broadcast of an updated value shall not occur unless a time period equal to the value of this parameter has expired. The expiration of the time period does not mandate a re-broadcast. See also "Send on Delta" and "Maximum Send Time" definitions.
32. Minimum Send Time: Adjustable parameter that defines a mandatory time period during which no broadcasting of data will occur. Once this time period has been exceeded without a broadcast, the send on delta parameter or the maximum send time parameter shall determine when a broadcast is initiated.
33. Multiple Controller Integrated Control (MCIC): Where multiple controllers with I/O are used to control a single mechanical system, which is sub-divided into a collection of processes to be controlled. All primary measured variables and the end device associated with a single process along with the primary control logic for the process shall be contained within a single controller. Secondary data from one process that affects the control of another process may be sent from one controller to the primary controller controlling the process. When data is sent from one controller to another controller, broadcasting concepts as defined above must be used. If the data being received over the network only affects the general thermodynamic or psychometric performance of the process but does not have a significant affect on safety or equipment protection then unacknowledged repeated binding services shall be used. If the data being received over the network has a safety or equipment protection impact, then acknowledged repeated binding services shall be used. In both cases peer-to-peer communication is mandatory. All controllers must be on the same channel. Managed communication shall not be used to move data between the multiple controllers.
34. Network Controller: Term used to describe a BAS hardware component that serves several key functions:

a. Serve as the LANID.
b. Transmission of data to operator workstations on the TCP/IP network.
c. Capable of collecting/integrating with different protocol data such as BACnet IP, BACnet MS/TP, Modbus, LON, OPC, etc.
d. Location for time schedules to support all of the devices.
e. Location for trend logs for all data to be trended from the devices.
f. Location for alarm handling software.
g. Shall process event broadcasted data from the devices (alarm indication) and enter the appropriate alarm information in the alarm reporting system at the TCP/IP level.

35. Open Database Connectivity (ODBC): Open standard application-programming interface (API) for accessing a database, making access to any data, regardless of which database management system (DBMS) is handling the data, possible.
36. Operator Interface (OI): A device used by the operator to manage the BAS.
37. Operator Workstation (OWS): Used to interface with the BAS system via the internet or the Local Supervisory LAN.
38. PANEL LCD OR TOUCHSCREEN DISPLAY (TCP_D): A human-user graphical interface for direct connection to a local group of controllers.
39. Peer-to-Peer Communication: Data is broadcast from its origin and is received by the final device requiring the data without being received and retransmitted by a third device.
40. Polling Communication: The concept of a control device requesting a network variable from a second control device at a specified interval. Polling communication is typically used to populate dynamic data on an active graphic page and for temporary or short term trending of data where the trend data is not stored at the controller level.
41. Portable Operators Terminal (POT): Laptop PC used both for direct connection to a controller and for remote dial up connection.
42. Primary Control Unit (PCU): A fully programmable device capable of carrying out a number of tasks including control and monitoring via direct digital control (DDC) of specific systems.
43. Protocol Implementation Conformance Statement (PICS): A written document, created by the manufacturer of a device, identifying the particular options specified by BACnet that are implemented in the device.
44. Repeater: A physical device used to connect two segments and isolate physical problems. Typically required to allow the use of additional devices or additional cable length.
45. Router: A device that connects two or more networks at the network layer.
46. Send on Delta Parameter: A parameter used to control unnecessary broadcasting of data onto the network. For binary data the send on delta parameter is assumed to be a change of state.
47. Send on Delta: Adjustable parameter that defines a requirement to broadcast when the data generated by the software object changes by an amount that exceeds this parameter's value. For binary data this parameters defaults to a change of state. The broadcast of data is initiated when this criteria and the minimum send time requirement have been met.
48. Smart Device: A control I/O device such as a smart sensor (SS) or smart actuator (SA) that can directly communicate with the controller network to which it is connected rather than through a binary or analog signal.
49. Standardized Query Language (SQL): Standardized means for requesting information from a database.
50. Terminator: An electronic component that consists of a resistive and capacitive circuit specifically designed to enhance the quality of communications on a segment. On a bus topology, a terminator is connected to each end of a segment. For a channel consisting of two bus topology segments, a total of 4 terminators are required, one at each end of each segment.
51. Test Mode: A concept where the operator from the operator workstation can interrupt the flow of data from a sensor to the control logic and insert a mandatory test value or test state to be used by the control logic. The test mode and the desired test value or states are parameters that are set by the operator.
52. Unacknowledged Repeated: The data being broadcast is sent three times and an acknowledgement of receipt is not required. This type of service shall be used for most process control related data requiring timely receipt of the data.
53. Unacknowledged: The data being broadcast is sent one time and an acknowledgement of receipt is not required. This type of service shall be used for non-critical data where there is no significant impact should the receiving device have to wait for the next broadcast.
54. Web Server: Refer to "Control System Server."
55. XML (Extensible Markup Language): A specification developed by the World Wide Web Consortium.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 GENERAL SEQUENCE NOTES

A. Sequences specified herein indicate the functional intent of the systems operation and may not fully detail every aspect of the programming that may be required to obtain the indicated operation. Contractor shall provide all programming necessary to obtain the sequences/system operation indicated.

B. When an air handling unit is not in operation, control devices shall remain in their "off" positions. "Off" positions may differ from the "normal" (meaning failed) position. Except as specified otherwise, "off" and "normal" positions of control devices shall be as follows:

Device	"Off" Position	"Normal" Position
Heating coil valves	closed/ controlling	open
Cooling coil valves	closed	closed
Outside air damper	closed	closed
Return air damper	open	open
Exhaust/relief air damper	closed	closed
Var. Freq. Drive	Off	Min. Speed

C. Except as specified otherwise, throttling ranges, proportional bands, and cycle differentials shall be centered on the associated setpoint. All modulating feedback control loops shall include the capability of having proportional, integral, and derivative action. Unless the loop is specified "proportional only" or "P+I", Contractor shall apply appropriate elements of integral and derivative gain to each control loop which shall result in stable operation, minimum settling time, and shall maintain the primary variable within the specified maximum allowable variance.

D. Scheduling Terminology: When air handlers are scheduled throughout the day, the following defines the terminology used:

1. Occupied Period: period of time when the building is in use and occupied. Generally systems will be fully operational throughout this period and ventilation air shall be continuously introduced. Space temperature setpoints will generally be in the "normal" range of 69°-76°F.
2. Unoccupied period: period of time when the building or zone is not in use and unoccupied. Ventilation air shall not be introduced.
3. Preoccupancy Period: Time prior to the Occupied period when the systems are returning the space temperatures from setback to "normal" or occupied setpoints (warm-up and cool-down). Ventilation air shall not be introduced unless outside air conditions permit free-cooling. Time period shall be determined by an optimum start strategy unless otherwise specified.
4. Setback Period: Setback start will typically coincide with the end of the occupied period and end with the start of the preoccupacy period, however it shall be provided with its own schedule. Generally systems will be off except to maintain a "setback" temperature.

E. Temperature-Compensated Duty Cycling

1. The DCCP (Duty Cycle Control Program) shall periodically stop and start loads according to various patterns.
2. The loads shall be cycled such that there is a net reduction in both the electrical demands and the energy consumed.

F. Automatic Daylight Savings Time Switchover

1. The system shall provide automatic time adjustment for switching to/from Daylight Savings Time.

G. Night Setback Control

1. The system shall provide the ability to automatically adjust setpoints for night control.

H. Enthalpy Switchover (Economizer)

1. The Building Controller Software shall control the position of the air handler relief, return, and outside air dampers. If the outside air enthalpy falls below changeover set point the BCS shall modulate the dampers to provide 100% outside air. The user shall be able to quickly changeover to an economizer system based on dry bulb temperature and shall be able to override the economizer cycle and return to minimum outside air operation at any time.

I. Loop Control

1. A Model-Free Adaptive Control algorithm or alternatively a PID (proportional-integral-derivative) closed-loop control algorithm with direct or reverse action and anti-windup shall be supplied. The algorithm shall calculate a time-varying analog value that is used to position an output or stage a series of outputs. The controlled variable, set point, and weighting parameters shall be user-selectable.

J. Staggered Start

1. This application shall prevent all controlled equipment from simultaneously restarting after a power outage. The order in which equipment (or groups of equipment) is started, along with the time delay between starts, shall be user definable.
2. Upon the resumption of power, each Building Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

K. Sequencing

1. Provide application software based upon the sequences of operation specified to properly sequence equipment.

L. All setpoints shall be adjustable (adj.), they shall be modifiable, with the proper password level, from the operator interface or via a function block menu. For these points, it is unacceptable to have to modify programming statements to change the setpoint.

M. Where reset action is specified in a sequence of operation, but a reset schedule is not indicated on the drawings, one of the following methods shall be employed:

1. Contractor shall determine a fixed reset schedule which shall result in stable operation and shall maintain the primary variable within the specified maximum allowable variance.
2. A floating reset algorithm shall be used which increments the secondary variable setpoint (setpoint of control loop being reset) on a periodic basis to maintain primary variable setpoint. The recalculation time and reset increment shall be chosen to maintain the primary variable within the specified maximum allowable variance.
3. [Primary variable shall control the devices directly using a PID feedback control loop without resetting the secondary variable. However, the control devices shall still modulate as necessary to maintain upper and lower limits on the secondary variable. Proportional band, integral gain, and derivative term shall be selected to maintain the primary variable within the specified maximum allowable tolerance while minimizing overshoot and settling time. Contractor shall gain prior approval for implementing this method of reset.]

N. Where a supply air temperature or duct pressure setpoint is specified to be reset by the space temperature of the zones calling for the most cooling/heating, the following method shall be employed:

1. A floating reset algorithm shall be used which increments the secondary variable (e.g., supply air temperature or duct pressure) setpoint on a periodic basis to maintain primary variable (e.g. space temperature) setpoint. The reset increment shall be determined by the quantity of “need heat” or “need cool” requests from individual terminal units. A terminal unit’s “need heat” virtual point shall activate whenever the zone’s space temperature falls below the currently applicable (occupied or unoccupied) heating setpoint throttling range. A

terminal unit's "need cool" virtual point shall activate whenever the zone's space temperature rises above the currently applicable (occupied, unoccupied, or economy) cooling setpoint throttling range. The recalculation time and reset increment shall be chosen to maintain the primary variable within the specified maximum allowable variance while minimizing overshoot and settling time. Reset range maximum and minimum values shall limit the setpoint range.

O. Where a supply air temperature, duct pressure, or differential water pressure setpoint is specified to be reset by valve or damper position of the zone or zones calling for the most cooling/heating, the following method shall be employed:

1. A floating reset algorithm shall be used which increments the secondary variable (e.g., supply air temperature, pipe or duct pressure) setpoint on a periodic basis to maintain primary variable (e.g. cooling valve, heating valve, damper position) setpoint of 85% open. The reset increment shall be calculated based on the average position of the quantity of the worst (most open valve/damper) zone(s) as specified. The recalculation time, reset increment and control device position influence shall be chosen to maintain the primary variable within the specified maximum allowable variance while minimizing overshoot and settling time. The BAS analog output value shall be acceptable as indicating the position of the control device.

2. Alternatively to continuously calculating the average of the quantity of worst valve/damper positions, a method similar to the one described above may be employed whereby the "need heat" or "need cool" virtual point shall increment by one unit each time a zone's valve/damper position rises to greater than 95%. The quantity of "need heat" or "need cool" points shall then be the basis for reset.

P. Where "prove operation" of a device (generally controlled by a digital output) is indicated in the sequence, it shall require that the BAS, after an adjustable time delay & after the device is commanded to operate (feedback delay,) confirm that the device is operational via the status input. If the status point does not confirm operation after the time delay or anytime thereafter for an adjustable time delay (debounce delay) while the device is commanded to run, an alarm shall be enunciated audibly and via an alarm message at the operator interface and print at the alarm printers. A descriptive message shall be attached to the alarm message indicating the nature of the alarm and actions to be taken. Contractor shall provide messages to meet this intent.

Q. The BAS shall provide for adjustable maximum rates of change for increasing and decreasing output from the following analog output points:

1. Speed control of variable speed drives
2. Chiller supply water temperature setpoint reset
3. Chiller demand limit
4. Travel rate of tower isolation and chiller isolation valves

R. Wherever a value is indicated to be dependent on another value (i.e.: setpoint plus 5°F) the BAS shall use that equation to determine the value. Simply providing a virtual point that the operator must set is unacceptable. In this case three virtual points shall be provided. One to store the parameter (5°F), one to store the setpoint, and one to store the value which is the result of the equation.

S. Some sequences rely on integration with third-party manufacturer control equipment. See the control equipment specifications, equipment schedules and equipment specifications for more information on this integration.

3.2 GENERAL ALARMING NOTES

A. Override Alarms: Any point that is overridden through the override feature of the graphic workstation software shall be reported as a Level 3 alarm.

B. Analog Input Alarms: For each analog input, program an alarm message for reporting whenever the analog value is outside of the programmed alarm limits. Report a 'Return-to-Normal' message after the analog value returns to the normal range, using a programmed alarm differential. The alarm limits shall be individually selected by the Contractor based on the following criteria:

1. Space temperature, except as otherwise stated in sequence of operation: Level 3

a.	Low alarm:	64°F
b.	Low return-to-normal:	68°F

c. High alarm: 85°F
d. High return-to-normal: 80°F

2. Controlled media temperature other than space temperature (e.g. AHU discharge air temperature, steam converter leaving water temperature, condenser water supply, chilled water supply, etc.): Level 3 (If controlled media temperature setpoint is reset, alarm setpoints shall be programmed to follow setpoint)

a. Low alarm: 3°F below setpoint
b. Low return-to-normal: 2°F below setpoint
c. High alarm: 3°F above setpoint
d. High return-to-normal: 2°F above setpoint.

3. AHU mixed air temperature: Level 4

a. Low alarm: 45°F
b. Low return-to-normal: 46°F
c. High alarm: 90°F
d. High return-to-normal: 89°F

4. Duct Pressure:

a. Low alarm: 0.5”w.g. below setpoint
b. Low return-to-normal: 0.25”w.g. below setpoint
c. High alarm: 0.5”w.g. above setpoint
d. High return-to-normal: 0.25”w.g. above setpoint

5. Space humidity:

a. Low alarm: 35%
b. Low return-to-normal: 40%
c. High alarm: 75%
d. High return-to-normal: 70%

C. Status versus Command Alarms: The Sequences of Operation are based on the presumption that motor starter Hand-Off-Auto (HOA) switches are in the ‘Auto’ position. BAS shall enunciate the following Level 5 alarm message if status indicates a unit is operational when the run command is not present or vice versa:

1. *DEVICE XXXX* FAILURE: Status is indicated on *{the device}* even though it has been commanded to stop. Check the HOA switch, control relay, status sensing device, contactors, and other components involved in starting the unit. Acknowledge this alarm when the problem has been corrected.

D. Maintenance Alarms: Enunciate Level 5 alarms when runtime accumulation exceeds a value specified by the operator.

1. *DEVICE XXXX REQUIRES MAINTENANCE*. Runtime has exceeded specified value since last reset.

3.3 DAMPER FAIL POSITION

A. Control dampers shall fail to “safe” position

1. *Outdoor air economizer damper – Fail closed*
2. *“Minimum outdoor air" damper – Fail closed*
3. *Relief air economizer damper – Fail closed*
4. *Return air economizer damper – Fail open*
5. *Exhaust fan dampers – Typically fail closed*
6. *Associated makeup air dampers – Typically fail closed*
7. *VAV terminal unit dampers – Typically fail open*
8. *Face and bypass dampers – Typically fail open to face, closed to bypass*

END OF SECTION

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED WORK

A. Specified elsewhere:

1. 23 81 26 Split-System Air-Conditioning
2. 23 81 27 Variable Refrigerant Flow Systems.

1.2 SUMMARY

A. Section includes refrigerant piping and fitting materials, joining methods, and specialties used for air conditioning and VRF systems.

1.3 SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:

1. Thermostatic expansion valves.
2. Solenoid valves.
3. Hot-gas bypass valves.
4. Filter dryers.
5. Strainers.
6. Pressure-regulating valves.

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.

1. Shop Drawing Scale: 1/4 inch equals 1 foot.

C. Welding certificates.

D. Field quality-control test reports.

1. Submit written reports documenting the activities required to be performed in PART 3. These reports are to be submitted two weeks after the startup is completed.

E. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.5 DELIVERY STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.6 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.7 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig.
2. Suction Lines for Heat-Pump Applications: 535 psig.
3. Hot-Gas and Liquid Lines: 535 psig.

1.8 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 9100 Commissioning. Testing of these systems is required, in cooperation with the CDB and the Commissioning Authority. Refer to Section 01 9100 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Refrigerants:

a. Atofina Chemicals, Inc.
b. DuPont Company; Fluorochemicals Div.
c. Honeywell, Inc.; Genetron Refrigerants.
d. INEOS Fluor Americas LLC.

2.2 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 280, Type ACR or type K complying with ASTM B88 or ASTM B819.

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Brazing Filler Metals: AWS A5.8.

E. 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-inch (20-mm) misalignment in minimum 7-inch-(180-mm-) long assembly.

4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.3 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

B. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

C. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and 115-V ac coil.

6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.
8. Manual operator.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig.
6. Maximum Operating Temperature: 240 deg F.

G. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: See Equipment Schedules
6. Superheat: Adjustable.
7. Reverse-flow option (for heat pump applications).
8. End Connections; Socket, flare, or threaded union.
9. Working Pressure Rating: 700 psig.

H. Hot-Gas Bypass Valves: Comply with UL 429, listed and labeled by NRTL.

1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
5. Seat: Polytetrafluoroethylene.
6. Equalizer: Internal or External.
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and [24] [115] [208]-V ac coil.
8. End connections: Socket.
9. Set Pressure: As required.
10. Throttling Range: Maximum 5 psig.
11. Working Pressure Range: 500 psig.
12. Maximum Operating temperature: 240 deg F.

I. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig.
5. Maximum Operating Temperature: 275 deg F.

J. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.

5. Working Pressure Rating: 500 psig.
6. Maximum Operating Temperature: 275 deg F.

K. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 240 deg F.

L. Replaceable-Core Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated charcoal.
4. End Connections: Socket.
5. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
6. Maximum Pressure Loss: 2 psig.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 240 deg F.

M. Permanent Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated charcoal.
4. End Connections: Socket.
5. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
6. Maximum Pressure Loss: 2 psig.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 240 deg F.

N. Mufflers:

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

O. Receivers: Comply with ARI 495.

1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

P. Liquid Accumulators: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

2.4 REFRIGERANTS

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

1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 REFRIGERANT PIPE SIZING:

A. All refrigerant pipe sizing shall be the responsibility of the Contractor in accordance with the equipment manufacturer's recommendations.

B. Pipe sizing shall be in accordance with the recommendations in the 2010 ASHRAE Handbook – Refrigeration, Chapter 2 – System Practices for Halocarbon Refrigerants.

C. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines NPS 3-1/2 and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

B. Hot-Gas and Liquid Lines: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed or soldered joints.

C. Hot-Gas and Liquid Lines: Copper, Type ACR, drawn-temper tubing and wrought-copper fittings with 95-5 tin-antimony brazed joints.

D. Safety-Relief-Valve Discharge Piping: Copper, Type ACR, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.

3.3 VALVE AND SPECIALTY APPLICATIONS

A. Install packed-angle valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install packed-angle valves on inlet and outlet side of filter dryers.

E. Install a full-sized, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Hot-gas bypass valves.
4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at compressors.

3.4 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 Division 23 Sections "Building Automation System (BAS)" and "Building Automation System (BAS) - Sequence of Operation" 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 Division 08 Section "Access Doors and Frames" 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 pipe sleeves at penetrations in exterior walls and floor assemblies.

R. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping."

S. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

T. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.

U. Seal pipe penetrations through exterior walls according to Division 07 Section "Joint Sealants" for materials and methods.

V. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC."

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: 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.

3.6 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports for Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6 m) or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) 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 sizes:

1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.
2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
4. NPS 1-1/4: Maximum span, 96 inches; minimum rod size, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
2. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.

E. Support multifloor vertical runs at least at each floor.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. 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 Part 1 "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.

C. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 9100 Commissioning.

3.8 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 (67 Pa). 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 (14 kPa).
4. Charge system with a new filter-dryer core in charging line.

3.9 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

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

A. Single-wall rectangular ducts and fittings.

B. Single-wall round and flat-oval ducts and fittings.

C. Sheet metal materials.

D. Duct liner (not used on this project).

E. Sealants and gaskets.

F. Hangers and supports.

1.2 RELATED WORK

A. Specified elsewhere:

1. Section 23 05 93 “Testing, Adjusting and Balancing for HVAC” for testing, adjusting, and balancing requirements for metal ducts.
2. Division 23 33 00 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

B. Materials Installed but furnished by others: NA

C. Furnished, but installed by others: NA

1.3 SUMMARY

A. Section includes metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus four (4)- inch wg to plus ten (10)-inch wg. Metal ducts include the following:

1. Rectangular ducts and fittings.
2. Single-wall, round, and flat-oval spiral-seam ducts and formed fittings.
3. Duct liner.
4. Duct Sealants and gaskets.
5. Hangers and supports.

1.4 DEFINITIONS

A. Sealing Requirements Definitions: For the purposes of duct systems sealing requirements specified in this Section, the following definitions apply:

1. Seams: A seam is defined as joining of two longitudinally (in the direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on the perimeter are deemed to be joints.
2. Joints: Joints include girth joints; branch and sub-branch intersections; so-called duct collar tap-ins; fitting subsections; louver and air terminal connections to ducts; access door and access panel frames and jambs; duct, plenum, and casing abutments to building structures.

1.5 PERFORMANCE REQUIREMENTS

A. Delegated Hanger and Support Design: Hangers and supports shall comply with SMACNA's "HVAC Duct Construction Standards – Metal and Flexible."

1.6 SUBMITTALS

A. Shop Drawings: Drawn at a scale of not less than 1/4" = 1'-0". Show fabrication and installation details for metal ducts.

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Duct layout indicating sizes and pressure classes.
3. Elevations of top and bottom of ducts.
4. Dimensions of main duct runs from building grid lines.
5. Fittings.
6. Reinforcement and spacing.
7. Seam and joint construction.
8. Penetrations through fire-rated and other partitions.
9. Equipment installation based on equipment being used on Project.
10. Duct accessories, including access doors and panels.
11. Hangers and supports, including methods for duct and building attachment and vibration isolation.

B. Delegated-Design Submittal:

1. Spacing of hangers and supports.
2. Design calculations: Calculations, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Other systems installed in same space as ducts.
3. Ceiling- and wall-mounting access doors and panels required to provide access to dampers and other operating devices.
4. Ceiling-mounting items, including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

D. Field quality-control test reports.

1.7 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. NFPA Compliance:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

C. Comply with NFPA 96, "Ventilation Control and Fire Protection of Commercial Cooking Operations," Ch. 3, "Duct System," for range hood ducts, unless otherwise indicated.

1.8 DELIVERY, STORAGE AND HANDLING

A. All materials shall be stored in a designated area and protected from inclement weather.

B. All materials shall be secured so as not to be a hazard during the construction process.

C. Store ductwork with tight-fitting seals on open ends to ensure ductwork is free of all dirt, debris and moisture during the installation process.

1.9 COMMISSIONING

A. This section specifies a system, or a component of a system being commissioned as defined in section 01 9100 commissioning. Testing of these systems is required, in cooperation with the CDB and the commissioning authority. Refer to section 01 9100 commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

A. 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: Lock-forming quality; complying with ASTM A 653/A 653M and having G90 coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. PVC-Coated Galvanized Steel: Acceptable by authorities having jurisdiction for use in fabricating ducts with UL 181, Class 1 listing. Lock-forming-quality, galvanized sheet steel complying with ASTM A 653/A 653M and having G90 coating designation. Factory-applied PVC coatings shall be 4 mils thick on sheet metal surfaces of ducts and fittings exposed to corrosive conditions and 4 mils thick on opposite surfaces.

D. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets; commercial quality; with oiled, matte finish for exposed ducts.

E. Stainless Steel: ASTM A 480/A 480M, Type 304 & 316.

F. Aluminum Sheets: ASTM B 209, alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

G. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts.

H. 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.

I. Insulated Flexible Ducts: Flexible ducts wrapped with flexible glass fiber insulation, enclosed by seamless aluminum pigmented plastic vapor barrier jacket; maximum 0.23 K value at 75 degrees F.

2.2 SEALANT MATERIALS

A. Joint and Seam Sealants, General: The term "sealant" is not limited to materials of adhesive or mastic nature but includes combinations of open-weave fabric strips and mastics.

B. Water-Based Joint and Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.

C. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C 920, Type S, Grade NS, Class 25, Use O.

D. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

2.3 HANGERS AND SUPPORTS

A. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

B. Hanger Materials: Galvanized sheet steel or threaded steel rod.

1. Hangers Installed in Corrosive Atmospheres: All-thread rods used in pool areas, pool equipment rooms, and pool supporting spaces shall be aluminum if the ducts are aluminum and stainless steel if the ducts are stainless steel.
2. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for steel sheet width and thickness and for steel rod diameters.
3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

C. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

D. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
3. Supports for Aluminum Ducts: Aluminum support materials..

2.4 RECTANGULAR DUCT FABRICATION

A. Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" and complying with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, and joint types and intervals.

1. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure class.
2. Deflection: Duct systems shall not exceed deflection limits according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

B. Transverse Joints: Prefabricated slide-on joints and components constructed using manufacturer's guidelines for material thickness, reinforcement size and spacing, and joint reinforcement.

C. Formed-On Flanges: Construct according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," Figure 1-4, using corner, bolt, cleat, and gasket details.

1. Duct Size: Maximum 30 inches wide and up to 2-inch wg pressure class.
2. Longitudinal Seams: Pittsburgh lock sealed with noncuring polymer sealant.

D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of nonbraced panel area unless ducts are lined.

2.5 ROUND AND FLAT-OVAL DUCT AND FITTING FABRICATION

A. Manufacturers: applicable to factory-fabricated duct and fittings:

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

1. Ductmate Industries, Inc.
2. Lindab.
3. Lockformer.
4. McGill Airflow.
5. Nexus Inc.
6. Semco, Inc.
7. Ward Industries.

C. Diameter as applied to flat-oval ducts in this Article is the diameter of a round duct with a circumference equal to the perimeter of a given size of flat-oval duct.

D. Round, Longitudinal- and Spiral Lock-Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."

E. Flat-Oval, Spiral Lock-Seam Ducts: Fabricate supply ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible. Fabricate ducts larger than 72 inches in diameter with butt-welded longitudinal seams.

F. Duct Joints:

1. Ducts up to 20 Inches in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
2. Ducts 21 to 72 Inches in Diameter: Three-piece, gasketed, flanged joint consisting of two internal flanges with sealant and one external closure band with gasket.
3. Ducts Larger Than 72 Inches in Diameter: Companion angle flanged joints per SMACNA "HVAC Duct Construction Standards--Metal and Flexible," Figure 3-2.
4. Round Ducts: Prefabricated connection system consisting of double-lipped, EPDM rubber gasket. Manufacture ducts according to connection system manufacturer's tolerances.
5. Flat-Oval Ducts: Prefabricated connection system consisting of two flanges and one synthetic rubber gasket.

G. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal-seam straight ducts.

H. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.

I. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1-1/2 times duct diameter. Unless elbow construction type is indicated, fabricate elbows as follows:

1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.
2. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from minus 2- to plus 2-inch wg:

    a. Ducts 3 to 36 Inches in Diameter: 0.034 inch.
    b. Ducts 37 to 50 Inches in Diameter: 0.040 inch.
    c. Ducts 52 to 60 Inches in Diameter: 0.052 inch.

3. Round Mitered Elbows: Welded construction with the following metal thickness for pressure classes from 2- to 10-inch wg:

    a. Ducts 3 to 26 Inches in Diameter: 0.034 inch.
    b. Ducts 27 to 50 Inches in Diameter: 0.040 inch.

4. Flat-Oval Mitered Elbows: Welded construction with same metal thickness as longitudinal-seam flat-oval duct.
5. 90-Degree, 2-Piece, Mitered Elbows: Use only for supply systems or for material-handling Class A or B exhaust systems and only where space restrictions do not permit using radius elbows. Fabricate with single-thickness turning vanes.
6. Round Elbows 8 Inches and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
7. Round Elbows 9 through 14 Inches in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
8. Round Elbows Larger Than 14 Inches in Diameter and All Flat-Oval Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.
9. Die-Formed Elbows for Sizes through 8 Inches in Diameter and All Pressures 0.040 inch thick with 2-piece welded construction.
10. Flat-Oval Elbow Metal Thickness: Same as longitudinal-seam flat-oval duct specified above.
11. Pleated Elbows for Sizes through 14 Inches in Diameter and Pressures through 10-Inch wg: 0.022 inch.

2.6 DUCTWORK LINING

A. Ductwork liner shall be Johns Manville, Knauf, Owens-Corning or Certain-Teed. The product name is to be imprinted on the air stream surface.

B. Ductwork Liner shall be installed in accordance with the Sheet Metal and Air Conditioning Contractor's National Association Duct Liner Application Standard, Second Edition, shall meet ASTM C1071 standards and liner facing must meet EPA registration requirements for antimicrobial protection.

C. Transfer air ductwork shall be provided with a minimum of 1 duct lining with reinforced air side coating.

1. Liner to be 1-1/2 pcf density, shall have a minimum sound NRC of 0.55 based on a Type “A” mounting, and a “K” factor not exceeding 0.46 at 75° F mean temperature.

D. Rectangular ductwork indicated to be lined shall be provided with a minimum of 1 ½” duct lining with reinforced air side coating and anti-microbial protection.

1. 1 1/2” thick liner to be 1-1/2 pcf density, shall have a minimum sound NRC of 0.85 based on a Type “A” mounting, and a “K” factor not exceeding 0.16 at 75° F mean temperature.

E. Unless otherwise indicated, the duct dimensions given on the drawings are to be clear inside dimensions after lining is applied.

F. Round ductwork indicated to be lined shall be lined with 1 1/2” thick from “Permacote Spiracoustic Plus” insulation manufactured by Johns Manville or CertainTeed Toughgard Ultrasound or Owens Corning Quietr. Liner shall be installed per manufacturer’s recommendations and requirements.

PART 3 - EXECUTION

3.1 DUCT APPLICATIONS

A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:

1. Supply Ducts (constant volume units): +2".
2. Supply Ducts (before Air Terminal Units): +4”.
3. Supply Ducts (after Air Terminal Units): +2”.
4. Supply Ducts (between fan and first system fire damper): +8”.
5. Return Ducts (Negative Pressure): -2”.
6. Return Ducts (between nearest fire damper and return fan inlet): -4”.
7. Return Ducts (return fan discharge and AHU intake / exhaust damper): -4”.
8. Exhaust Ducts (Negative Pressure): Listed Fan negative static.

B. All ducts shall be galvanized steel except as follows:

a. Range Hood Exhaust Ducts: Comply with NFPA 96Concealed: 16 Gauge carbon-steel sheet or 18 gauge, Type 304 stainless steel.
b. Exposed: 18 gauge, Type 304, stainless steel with finish to match kitchen equipment and range hood.
c. Welded seams and joints.

2. Dishwasher Hood Exhaust Ducts:

a. AluOkminum or type 304, stainless steel with finish to match dishwasher equipment and hood. Welded/flanged seams and joints.

3. Fab Lab Laser Cutter Ductwork:

a. Type 316, stainless-steel sheet. Welded seams and joints.

4. Dark Room Exhaust Ducts:

a. Poly Vinyl Coated (PCD) spiral round ductwork with hot dipped G=90 galvanized steel coated on two sides.

5. Exposed Supply Ducts In Occupied Spaces

a. Spiral round/oval galvanized sheet steel with paint grip finish.

3.2 DUCT INSTALLATION

A. Construct and install ducts according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," unless otherwise indicated.

B. Install round and flat-oval ducts in lengths not less than 12 feet unless interrupted by fittings.

C. Install ducts with fewest possible joints.

D. Install fabricated fittings for changes in directions, size, and shape and for connections.

E. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.

F. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

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. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

J. Coordinate layout with suspended ceiling, fire- and control dampers, lighting layouts, and similar finished work.

K. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

L. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

M. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.

N. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 23 Section "Air Duct Accessories." Firestopping materials and installation methods are specified in Division 07.

O. 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."

P. Protect duct openings from damage and prevent entrance of foreign materials.

Q. PVC-COATED DUCT, SPECIAL INSTALLATION REQUIREMENTS

1. Repair damage to PVC coating with manufacturer's recommended materials.

R. RANGE HOOD EXHAUST DUCTS, SPECIAL INSTALLATION REQUIREMENTS

1. Install ducts to allow for thermal expansion through 2000 deg F temperature range.
2. Install ducts without dips or traps that may collect residues unless traps have continuous or automatic residue removal.
3. Install access panels at each change in direction and at intervals defined by NFPA 96; locate on sides of duct a minimum of 1-1/2 inches from bottom; and fit with grease-tight covers of same material as duct.
4. Do not penetrate fire-rated assemblies except as permitted by applicable building codes.

3.3 SEAM AND JOINT SEALING

A. Seal all duct seams and joints to the most severe requirement between the latest Chicago Building Code and SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure class indicated.

B. Utilize sealant designed for outdoor use with ductwork exposed to the outdoors.

C. Seal ducts before external insulation is applied.

3.4 HANGING AND SUPPORTING

A. Support horizontal ducts within 24 inches of each elbow and within 48 inches of each branch intersection.

B. Support vertical ducts at maximum intervals of 16 feet and at each floor.

C. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

3.5 CONNECTIONS

A. Make connections to equipment with flexible connectors according to Division 23 Section "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 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual" and prepare test reports:

1. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
2. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
3. Maximum Allowable Leakage: Comply with requirements for Leakage Class 3 for round and flat-oval ducts, Leakage Class 12 for rectangular ducts in pressure classes lower than and equal to 2-inch wg (both positive and negative pressures), and Leakage Class 6 for pressure classes from 2- to 10-inch wg.
4. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

B. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 9100 Commissioning.

3.7 DUCT LINER:

A. Liner shall be applied to the following rectangular and square ductwork ductwork.

1. All Exposed Outside Air and Fresh Air ductwork.
2. Transfer Air Ductwork
3. Exhaust ductwork within 10'-0" of fan.

B. Duct liner shall be cut to assure overlapped and compressed longitudinal corner joints. Cut edges shall be properly sealed with mastic to assure no erosion of insulation.

C. Fasteners shall start within 3" of the upstream transverse edges of the duct liner and 3" from the longitudinal joints and shall be spaced at a maximum of 12" o.c. except that they shall be placed not more than 6" from a longitudinal joint of the liner nor 12" from a corner break.

D. Duct liner shall be adhered to the sheet metal (with 100% coverage) and edges coated with one (1) of the adhesives conforming to the Standard for Adhesives for Duct Liner, ASC-A-7001C -1972 of the Adhesive and Sealant Council, Inc.

E. Duct liner shall be further secured with fasteners conforming to the Mechanical Fastener Standard, MF-1-1975 on Page 22 of the Duct Liner Application Standard, Second Edition, of the Sheet Metal and Air Conditioning Contractor's National Association.

F. Duct liner in medium pressure ductwork shall be installed per manufacturer's recommendations for velocities above 2,000 fpm.

G. The leading edge of duct liner joints (in direction of air flow) shall be provided with metal nosing or a hardening mastic to prevent lining from coming loose.

END OF SECTION

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED WORK

A. Specified elsewhere:

1.1 Section 23 05 93 "Testing, Adjusting and Balancing for HVAC”.
1.2 Section 23 31 13 "Metal Ducts”.
1.3 Section 23 37 13 “Diffusers, Registers and Grilles”

B. Materials Installed but furnished by others: NA

1.1 Duct Smoke Detectors.

C. Furnished, but installed by others: NA

1.2 SUMMARY

A. Section includes the following:

1.1 Backdraft dampers.
1.2 Volume dampers.
1.3 Fire dampers.
1.4 Turning vanes.
1.5 Duct-mounting access doors.
1.6 Flexible connectors.
1.7 Flexible ducts.
1.8 Duct accessory hardware.

1.3 SUBMITTALS

A. Product Data: For the following:

1.1 Backdraft dampers.
1.2 Volume dampers.
1.3 Fire dampers.
1.4 Turning vanes.
1.5 Duct-mounting access doors.
1.6 Flexible connectors.
1.7 Flexible ducts.

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.

1.1 Special fittings.
1.2 Backdraft dampers.
1.3 Manual-volume damper installations.
1.4 Motorized-control damper installations.
1.5 Fire-damper and combination fire- and smoke-damper installations, including sleeves and duct-mounting access doors.
1.6 Duct mounted access doors.
1.7 Flexible connectors.

1.8 Flexible ducts.
1.9 Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

1.5 DELIVERY, STORAGE AND HANDLING

A. Materials delivered to the site must be coordinated with the site supervisor prior to delivery.

B. All materials shall be stored in a designated area and protected from the environment.

C. All materials shall be secured so as not to be a hazard during the construction process.

D. All materials must be free of all dirt, debris and moisture during the installation process.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

2.1 Backdraft Dampers:

a. Greenheck.
b. Ruskin.
c. Vent Products Company.

2.2 Volume Dampers

a. Nailor.
b. Ruskin.
c. Vent Products Company.

2.3 Fire Dampers:

a. Greenheck.
b. Ruskin.
c. Nailor.

2.4 Duct-Mounting Access Doors:

a. CESCO Products.
b. Ductmate Industries.
c. Greenheck.

2.5 Flexible Connectors:

a. Ductmate Industries.
b. Ventfabrics, Inc.
c. Ward Industries.

2.6 Flexible Ducts:

a. Flexmaster USA.
b. Hart & Cooley, Inc.
c. McGill Airflow Corp.

2.2 SHEET METAL MATERIALS

A. Comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods, unless otherwise indicated.

B. Galvanized Sheet Steel: Lock-forming quality; complying with ASTM A 653/A 653M and having G90coating designation; ducts shall have mill-phosphatized finish for surfaces exposed to view.

C. Stainless Steel: ASTM A 480/A 480M Type 304 (specify Type 314 as required by the application).

D. Aluminum Sheets: ASTM B 209 alloy 3003, temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

E. Extruded Aluminum: ASTM B 221, alloy 6063, temper T6.

F. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

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.

2.3 BACKDRAFT DAMPERS

A. Description: Multiple-blade, parallel action gravity balanced, with center-pivoted blades of maximum 6-inch width, with sealed edges, assembled in rattle-free manner with 90-degree stop, steel ball bearings, and axles; adjustment device to permit setting for varying differential static pressure.

B. Frame: 0.063-inch thick extruded aluminum, with welded corners and mounting flange.

C. Blades: 0.050-inch thick aluminum sheet.

D. Blade Seals: Neoprene.

E. Blade Axles: Galvanized steel.

F. Tie Bars and Brackets: Galvanized steel.

G. Return Spring: Adjustable tension.

2.4 VOLUME DAMPERS

A. General Description: Factory fabricated, with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.

2.1 Pressure Classes of 3-Inch wg or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.

B. Standard Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, standard leakage rating, with linkage outside airstream and suitable for horizontal or vertical applications.

2.1 Steel Frames (For use in steel ductwork): Hat-shaped, galvanized sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
2.2 Roll-Formed Steel Blades (For use with steel frames): 0.064-inch- thick, galvanized sheet steel.
2.3 Aluminum Frames (For use in stainless steel or aluminum ductwork): Hat-shaped, 0.10-inch-thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
2.4 Roll-Formed Aluminum Blades (For use with aluminum frames): 0.10-inch- thick aluminum sheet.
2.5 Extruded-Aluminum Blades (For use with aluminum frames): 0.050-inch- thick extruded aluminum.
2.6 Blade Axles: Galvanized steel. Drive shaft will be the full length of the blade.
2.7 Bearings: Stainless-steel sleeve.
2.8 Tie Bars and Brackets: Aluminum (aluminum or stainless steel ductwork applications), Galvanized steel (galvanized steel ductwork applications).

C. Low-Leakage Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.

2.1 Steel Frames (For use in steel ductwork) : galvanized sheet steel channels, minimum of 0.064 inch thick, with mitered and welded corners; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
2.2 Roll-Formed Steel Blades (For use with steel frames): 0.064-inch- thick, galvanized sheet steel.
2.3 Aluminum Frames (For use in stainless steel or aluminum ductwork) : 0.10-inch- thick, aluminum sheet channels; frames with flanges where indicated for attaching to walls and flangeless frames where indicated for installing in ducts.
2.4 Roll-Formed Aluminum Blades (For use with aluminum frames): 0.10-inch- thick aluminum sheet.
2.5 Extruded-Aluminum Blades (For use with aluminum frames): 0.050-inch- thick extruded aluminum.
2.6 Blade Axles: Galvanized steel. Drive shaft will be the full length of the blade.
2.7 Bearings: Stainless-steel sleeve thrust or ball.
2.8 Blade Seals: Neoprene.
2.9 Jamb Seals: Cambered stainless steel.
2.10 Tie Bars and Brackets: Aluminum (aluminum or stainless steel ductwork applications), Galvanized steel (galvanized steel ductwork applications).

D. Jackshaft: 1-inch- diameter, galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.

2.1 Length and Number of Mountings: Appropriate to connect linkage of each damper in multiple-damper assembly.

E. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

F. Remote cable-controlled volume dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.

2.1 Dampers shall be adjusted via a universal worm gear drive that is actuated by an unsheathed rotary cable which is captured at the damper end by a shaft coupling integral to the worm gear assembly. The rotary cable shall be terminated at the ceiling line or in a wall opening and concealed inside a ceiling/wall cap that is secured to the ceiling (or wall) framing. The caps shall provide a secure, unobtrusive appearance flush with the finished wall or ceiling.

2.2 Ceiling cap, rotary cable, and worm gear (damper drive system) shall be furnished as one piece for installation in the field with no linkage adjustment required or miscellaneous small parts.

2.5 FIRE DAMPERS

A. Fire dampers shall be labeled according to UL 555.

B. Fire Rating: Insert rating as required by application hours.

C. Frame: Curtain type with blades outside airstream fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.

D. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

2.1 Minimum Thickness: 0.052 or 0.138 inch thick as indicated and of length to suit application.

2.2 Exceptions: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor, and thickness of damper frame complies with sleeve requirements.

E. Mounting Orientation: Vertical or horizontal as indicated.

F. 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.

G. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

H. Fusible Links: Replaceable, 165 deg F rated.

2.6 TURNING VANES

A. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for vanes and vane runners. Vane runners shall automatically align vanes.

B. Manufactured Turning Vanes: Fabricate 1-1/2-inch- wide, single-vane, curved blades of galvanized sheet steel set 3/4 inch o.c.; support with bars perpendicular to blades set 2 inches o.c.; and set into vane runners suitable for duct mounting.

C. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

2.7 DUCT-MOUNTING ACCESS DOORS

A. General Description: Fabricate doors airtight and suitable for duct pressure class.

B. Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated. Include piano hinge and cam latches.

2.1 Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
2.2 Provide number of hinges and locks as follows:

a. Less than 12 Inches Square: Secure with two sash locks.
b. Up to 18 Inches Square: Continuous hinge and two sash locks.
c. Larger than 18 inches square: Continuous hinge and two compression latches with outside and inside handles.

C. Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch thickness. Include cam latches.

2.1 Frame: Galvanized sheet steel, with spin-in notched frame.

D. Pressure Relief Access Door: Double wall and duct mounting; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated, latches, and retaining chain.

2.1 Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

E. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

F. Insulation: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.8 FLEXIBLE CONNECTORS

A. General Description: Flame-retardant or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.

B. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 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. Select metal compatible with ducts.

C. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

2.1 Minimum Weight: 26 oz./sq. yd..
2.2 Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
2.3 Service Temperature: Minus 40 to plus 200 deg F.

D. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

2.1 Minimum Weight: 24 oz./sq. yd..
2.2 Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
2.3 Service Temperature: Minus 50 to plus 250 deg F.

2.9 FLEXIBLE DUCTS

A. Insulated-Duct Connectors: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; aluminized vapor barrier film.

2.1 Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.

2.2 Maximum Air Velocity: 4000 fpm.
2.3 Temperature Range: Minus 10 to plus 160 deg F

B. Flexible Duct 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.

2.10 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.

PART 3 - EXECUTION

3.1 APPLICATION AND 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. Provide 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 on exhaust fans or exhaust ducts nearest to outside and where indicated.

D. Provide balancing dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing. Install at a minimum of two duct widths from branch takeoff.

E. Where standard balancing dampers are not accessible or would require access doors to operate provide remote cable control balancing dampers. This includes drywall ceilings, millwork, soffits, etc.

F. Provide test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire dampers, with fusible links, according to manufacturer's UL-approved written instructions.

H. Install duct access doors to allow for inspecting, adjusting, and maintaining duct accessories, control devices - sensors and terminal units as follows:

3.1 On both sides of duct coils. On terminal units coordinate upstream coil access door with equipment supplier.
3.2 Downstream from volume dampers, turning vanes, and duct mounted equipment.
3.3 Adjacent to fire dampers, providing access to reset or reinstall fusible links.
3.4 To interior of ducts for cleaning; before and after each change in direction, at maximum 50-foot spacing.
3.5 On sides of ducts where adequate clearance is available.
3.6 Where indicated on plans.
3.7 Upstream and downstream of ducted fans.

I. Label access doors according to Division 23 Section "Identification for HVAC."

J. Install flexible connectors immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.

K. For fans developing static pressures of 5-inch wg and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

L. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

M. Connect diffusers or light troffer boots to low pressure ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

N. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.

O. Install duct test holes where indicated and required for testing and balancing purposes.

P. Provide turning vanes in all short radius / square elbows (>45 degrees) and tees.

3.2 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire dampers for proper action.

C. Final positioning of manual-volume dampers is specified in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.3 DEMONSTRATION AND COMMISSIONING

A. Engage a factory-authorized service representative to train Using Agency's maintenance personnel to adjust, operate, and maintain the duct accessories.

3.1 Train Owner's maintenance personnel on troubleshooting, servicing, and maintaining duct accessories. The training will occur after all devices are installed including all access doors. The trainer will provide two (2) Installation and Operations manuals for the use of the owner’s personnel during training.
3.2 Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational trouble shooting. If the IOM does not include a written trouble shooting guide one will be provided.
3.3 Schedule training with Owner, through Architect, with at least seven days' advance notice.
3.4 Training will occur in one (1) two (2) hour session and will include the dropping and resetting of 3 fire dampers selected by the owner. This portion of the training may not take longer than 30 minutes of the training session.

B. Demonstrate proper operation of equipment to commissioning agent or designated owner’s personnel. The scope of the demonstration will include functional performance requirements under both local and building automation control as well as any commissioning requirements in Division 01 or 23.

3.1 For all fire dampers or access doors for fire dampers installed on this project the Contractor will demonstrate that any fire dampers selected by the owner can be dropped and reset using the provided access doors.

END OF SECTION

SECTION 233600 – AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:

1. Shutoff single-duct air terminal units.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.

1. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
2. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

D. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.

1. Instructions for resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.

E. Field Quality-Control Test Reports: Submit reports documenting the activities required to be performed in PART 3. These reports are to be submitted two weeks after the startup is completed.

F. Training Reports: Submit reports on training documenting dates and attendance.

1.3 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacturer of air terminals with characteristics, sizes, and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards

1. Air Diffusion Council (ADC) Compliance: Provide air terminals which have been tested and rated in accordance with ADC standards, and bear ADC Seal.

2. ARI Compliance: Provide air terminals which have been tested and rated in accordance with ARI 880 “Industry Standard for Air Terminals” and bear ARI certification seal.
3. NFPA Compliance: Install air terminals according to NFPA 90A, “Standard for the Installation of Air Conditioning and Ventilating Systems.”
4. Comply with NFPA 70 for electrical components and installation.
5. Comply with City of Chicago Building Code.

1.4 DELIVERY, STORAGE AND HANDLING

A. Deliver air terminals wrapped in factory-fabricated fiberboard type containers. Identify on outside of container type of air terminal and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in boxes.

B. Store air terminals in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

1.5 COORDINATION

A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

1. This coordination will include clear indication on the drawings of the required access clearances for the control panel, and equipment access panels to allow maintenance, minimum 2 feet or as required by code. Conduit, pipe or duct may not be routed in the area required for any access to the unit.

1.6 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 9100 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 9100 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

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

1. Air Terminal Units:

a. Environmental Technologies, Inc. ; Enviro-Air Div.
b. Nailor Industries of Texas Inc.
c. Price Industries.
d. Titus.
e. Krueger

2.2 SHUTOFF SINGLE-DUCT AIR TERMINAL UNITS

A. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.

B. Casing: 0.034-inch steel or 0.032-inch aluminum.

1. Casing Lining: Adhesive attached, 3/4-inch- thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections, size matching inlet size.
4. Access: Removable insulated panels for access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches. Access to the component will only require removing the access door.

C. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.

1. Automatic Flow-Control Assembly: Combined spring rates shall be matched for each volume-regulator size with machined dashpot for stable operation.
2. Factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: ARI 880 rated, 3 percent of nominal airflow at 3-inch wg inlet static pressure.
2. Damper Position: Normally closed.

2.3 CONTROLS

A. VAV boxes are controlled by the Temperature Control System under Section 230920. The velocity sensor and 24v secondary transformer shall be furnished by manufacturer and coordinated with temperature controls contractor. The controller and actuator shall be furnished under Section 230920 and installed under this Section. Temperature sensors and control wiring shall be furnished and installed under by the temperature controls contractor.

2.4 SOURCE QUALITY CONTROL

A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, and ARI certification seal.

B. Verification of Performance: Rate air terminal units according to ARI 880.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance, 2 foot minimum or as required by code for all access doors or panels.

3.2 CONNECTIONS

A. Connect ducts to air terminal units according to Division 23 Section “Metal Ducts.”

B. Connect wiring according to Division 26 Section “Conductors and Cables for Electrical Systems.”

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 and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust] field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. 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.

C. Remove and replace malfunctioning units and retest as specified above.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Using Agency's maintenance personnel to adjust, operate, and maintain air terminal units.

B. Training of the Owner's operation and maintenance personnel is required in cooperation with the Commissioning Authority. The instruction shall be scheduled in coordination with the Commissioning Authority after submission and approval of formal training plans. Refer to Demonstration and Training, Section 01 7900, for contractor training requirements. Refer to Section 01 9100 and the Commissioning Plan for further contractor training requirements.

3.5 CLEANING

A. Clean interiors to remove foreign material and construction debris. Vacuum clean cabinet.

3.6 CONTRACTOR STARTUP AND REPORTING

A. Engage a factory-authorized service representative to perform startup service. Startup service includes the testing, inspections and startup test reports.

1. Complete installation and startup checks according to manufacturer's written instructions and do the following:

a. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
b. Verify that controls and control enclosure are accessible.
c. Verify that control connections are complete.
d. Verify that nameplate and identification tag are visible.
e. Verify that controls respond to inputs as specified.

2. Provide written report to CDB documenting all of the above requirements.

3.7 DEMONSTRATION AND COMMISSIONING

A. Engage a factory-authorized service representative to train Using Agency's maintenance personnel to adjust, operate, and maintain the fans.

1. Train Using Agency's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining the terminal units. The training will occur after the startup and Test, Adjust and Balance reports have been provided to the CDB. The trainer will provide two (2) Installation and Operations manuals for the use of the using agency's personnel during training.
2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational trouble shooting. If the IOM does not include a written trouble shooting guide one will be provided.
3. Schedule training with CDB, through Architect, with at least seven days' advance notice.
4. Training will occur in two separate two hour sessions, neither on the same day nor on a day that the terminal units are started up.

B. Demonstrate proper operation of equipment to commissioning authority or designated CDB personnel. The scope of the demonstration will include functional performance requirements under both local and building automation control as well as any commissioning requirements in Division 01 and 23.

3.8 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 9100. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

1.2 DEFINITIONS

A. Diffuser: Circular, square, or rectangular air distribution outlet, generally located in the ceiling and comprised of deflecting members discharging supply air in various directions and planes and arranged to promote mixing of primary air with secondary room air.

B. Grille: A louvered or perforated covering for an opening in an air passage, which can be located in a sidewall, ceiling, or floor.

C. Register: A combination grille and damper assembly over an air opening.

1.3 SUBMITTALS

A. Product Data: For each 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, color, finish, and accessories furnished.

B. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

1.4 QUALITY ASSURANCE

A. ARI Compliance: Test and rate diffusers, registers, and grilles in accordance with ARI 650 "Standard for Diffusers, registers, and grilles".

B. ASHRAE Compliance: Test and rate diffusers, registers, and grilles in accordance with ASHRAE 70 "Method of Testing for Rating the Air Flow Performance of Outlets and Inlets".

C. ADC Compliance: Test and rate diffusers, registers, and grilles in certified laboratories under requirements of ADC 1062 "Certification, Rating and Test Manual".

D. ADC Seal: Provide diffusers, registers, and grilles bearing ADC Certified Rating Seal.

E. NFPA Compliance: Install diffusers, registers, and grilles in accordance with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems".

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver diffusers, registers, and grilles wrapped in factory-fabricated fiber- board type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.

B. Store diffusers, registers, and grilles in original cartons and protect from weather and construction work traffic. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

1.6 WARRANTY

A. Provide warranty on materials and labor for 18 months starting from date of delivery, or one year from date of substantial completion, whichever is longer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Ceiling Air Diffusers:

a. Nailor.
b. Titus Products Div.; Philips Industries, Inc.
c. Price Industries.
d. Krueger

2. Wall Registers and Grilles

a. Nailor.
b. Titus Products Div.; Philips Industries, Inc.
c. Price Industries.
d. Krueger
e.

2.2 CEILING AIR DIFFUSERS

A. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.

D. Types: Provide ceiling diffusers of type, capacity, and with accessories and finishes as listed on diffuser schedule.

2.3 WALL REGISTERS AND GRILLES

A. General: Except as otherwise indicated, provide manufacturer's standard wall registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide wall registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Wall Compatibility: Provide registers and grilles with border styles that are compatible with adjacent wall systems, and that are specifically manufactured to fit into wall construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of wall construction which will contain each type of wall register and grille.

D. Types: Provide wall registers and grilles of type, capacity, and with accessories and finishes as listed on schedule.

2.4 DOOR AND TRANSFER GRILLES

A. General: Except as otherwise indicated, provide manufacturer's standard wall registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

B. Performance: Provide wall registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

C. Construction: Outer borders shall be constructed of heavy extruded aluminum and shall have countersunk screw holes for a neat appearance. Border shall be interlocked at the four corners and mechanically staked to form a rigid frame. Extruded aluminum inverted V-blades with a deflection shall be used to create a sight proof design and provide additional stiffness to the grille.

D. Types: Provide wall grilles of type, capacity, and with accessories and finishes as listed on schedule.

2.5 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. 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 practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 CLEANING

A. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove burrs, dirt, and smudges. Replace diffusers, registers, and grilles that have damaged finishes.

3.4 CONTRACTOR STARTUP AND REPORTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION

SECTION 237414 – DEDICATED OUTDOOR AIR ROOFTOP UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes custom built packaged dedicated outdoor air system roof top units with the following components and accessories:

1. Cabinet and Frame.
2. Air-Cooled Condensing Section.
3. Compressors.
4. Evaporator Coil
5. Modulating heat pump reversing valve.
6. Hot Gas Reheat Coil
7. Auxiliary Electric Heating Coil.
8. Air filters
9. Energy recovery wheel
10. Supply and return/exhaust fans
11. Outside Air and Exhaust Air Dampers.
12. Outside Air Louvers.
13. Access Sections
14. Main Control Panel
15. Options and accessories.

1.2 DEFINITIONS

A. DDC: Direct-digital controls.

B. RTU: As used in this Section, this abbreviation means packaged roof top HVAC units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

1.3 SUBMITTALS

A. Product Data: Include manufacturer's technical data for each CBRTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories. Including but not limited to the following data:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound power ratings at system operating conditions.
3. Certified ARI heating and cooling coil capacity ratings.
4. Motor ratings and electrical characteristics of motor and fan accessories.
5. Materials gauges and finishes.
6. Filters with performance characteristics.
7. Dampers, including housings, linkages, and operators.
8. Supply fan, return fan, and compressor vibration isolation including vibration analysis.
9. Material Safety Data Sheets.
10. Installation and maintenance manuals containing all system components.
11. Laboratory data for sound testing of fans.
12. Performance at ARI standard conditions and at conditions scheduled (provide EER & IPLV).
13. ASHRAE/IESNA 90.1 for energy compliance statement.

B. LEED Submittals:

1. Prerequisite EA2: Provide certification that the minimum efficiency is equal to or better than the requirements of the latest ASHRAE standard. Include performance at ARI standard/unloading conditions, and at conditions scheduled (provide EER).
2. Credit EA4: Certification that refrigerants are free of HCFCs.
3. Credit EA5: Product Data of continuous metering equipment for outdoor airflow and energy consumption.
4. Credit EQ5: Certification that equipment has been provided with MERV 13 filters.

C. Shop Drawings: Detail equipment assemblies, including control panel, and indicate dimensions, weights, loads, required clearances, method of field assembly, components, location and size of each field connection and rigging and hoisting requirements.

1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed wiring and field-installed wiring.
2. Provide as part of the shop drawing details a complete compressor and condenser cross section.

D. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Components of multi-zone CBRTUs.
2. Structural members to which CBRTUs are to be attached.
3. Roof openings.
4. Roof curbs and flashing.

E. Factory quality-control test reports: Factory start-up, inspection, and check-out reports to be provided to engineer for review prior to final equipment acceptance, startup, or commissioning.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For CBRTUs to incorporate in emergency, operation, and maintenance manuals. Include all unit components including but not limited to dampers, fans, motors, filters, belts, and controls.

H. Startup Test Reports: Submit written test reports documenting the activities required by Part 3 “Contractor Startup and Reporting”. These reports are to be submitted two weeks after the startup is completed.

I. Training Reports: Submit reports on training, documenting dates and attendance.

1.4 QUALITY ASSURANCE

A. AMCA Compliance:

1. Comply with AMCA 300 and 301 for testing and rating airborne sound emissions of fans. Submit laboratory test data.
2. Comply with AMCA 500 for testing and rating of dampers and louvers.
3. Comply with AMCA 204 for testing and rating balance quality and vibration levels for fans.

B. ARI Compliance:

1. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for CBRTUs.
2. Comply with ARI 270 for testing and rating sound performance for CBRTUs.
3. Comply with ARI 430 for testing and rating equipment performance for CBRTU’s.

4. Comply with ARI 410 for testing and rating coil capacities.
5. CBRTU's to be certified in accordance with ARI Certification Program.

C. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 52.1 for filter efficiency.
3. Comply with ASHRAE/IESNA 90.1 for minimum efficiency of heating and cooling.

D. NFPA Compliance: Comply with NFPA 90A, NFPA 90B and NFPA 79.

E. UL Compliance: Comply with UL 1995 for Safety Heating and Cooling Equipment and UL 900 for Air Filters.

F. 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. Unit shall comply with Chicago Electrical & Refrigeration Codes and applicable NEMA standards.

G. Safety Standards:

1. Design, manufacture and installation of mechanical refrigeration equipment: ANSI B9.1
2. Machinery Guards: Provide guards as shown in AMCA 410 for belts, chains, couplings, pulleys, sheaves, shafts, gears and other moving parts regardless of height above the floor. Drive guards may be excluded where motors and drives are inside factory fabricated unit casings. Comply with the latest OSHA standard.
3. Comply with Local Building Codes.
4. Comply with Local Building Code requirement for smoke detection in supply air to shut down unit and notify unit status.

H. Corrosion Prevention: Unless specified otherwise, equipment fabricated from ferrous metals that do not have a zinc-coating conforming to ASTM A386 or a duplex coating of zinc and paint shall be treated for prevention of rust with a factory coating or paint system that shall withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall be tested for 500 hours. The salt-spray fog test shall be in accordance with ASTM B117 using a 20 percent sodium chloride solution. Immediately after completion of the test, the coating shall show no signs of blistering, wrinkling or cracking, no loss of adhesion, and the specimen shall show no signs of rust creepage beyond 1/8 inch on either side of the scratch mark. The film thickness of the factory coating or paint system applied on the equipment shall be not less than film thickness used on the test specimen.

1.5 DELIVERY, STORAGE AND HANDLING

A. Follow manufacturer's instructions for unloading, rigging and storage of equipment.

B. Unit shall be shipped with door handles locked shut with door handle set screws and outside air hood closed to prevent damage during transport and temporary storage.

C. Maintain manufacturer's recommended temperature and humidity limits during storage and installation. Protect equipment from dirt, dust and other jobsite contaminants and conditions detrimental to the equipment.

1.6 COORDINATION

A. Verify dimensions of existing roof curbs and duct connections.

B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with equipment provided.

C. Coordinate locations of connecting utilities including: electric, controls, and condensate with equipment provided

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: One set for each belt-driven fan.
2. Filters: Two sets of filters for each unit.

1.8 WARRANTY

A. Warranty: Provide warranty on materials and labor for 18 months starting from date of delivery, or one year from date of preliminary acceptance whichever is longer.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of preliminary acceptance. Warranty shall be on compressor exchange. Parts only warranty is not acceptable.

1.9 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 9100 Commissioning. Testing of these systems is required, in cooperation with the and the Commissioning Authority. Refer to Section 01 9100 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Basis of Design

a. Trane

2. Approved Equal

a. Comparable manufactured products to the basis of design equipment scheduled on the drawings meeting similar design performance, electrical power requirements, dimensions and weight, will be considered on a case-by-case basis by the Construction Manager and Engineer of Record. All submitted equipment must meet the warranty requirements as listed in this section.

2.2 GENERAL DESCRIPTION

A. Furnish and install rooftop unit of size, type and capacity as indicated on the Drawings. Cooling capacity ratings shall be based upon test in accordance with ARI Standard 360. Units shall consist of insulated weather tight casing, compressors, evaporator coil, electronic expansion valve, refrigerant reversing valve, air-cooled condenser coil, condenser fans, condensate drain pan, evaporator fan, auxillary heater,

return/exhaust fans, motors and drives, and main control panel. Units shall also include filters, return/exhaust fans and controls as herein specified.

1. Units shall include draw through or blow-through with DX cooling with heat pump heating , supply fan section, return fan section, energy recovery wheel, condensing unit section, filter section and control dampers for outside air, exhaust air and return air.
2. Capacities, characteristics, and accessories shall be as shown and/or scheduled on drawings.
3. Units shall be factory fabricated, assembled and factory finished.
4. Motors shall not be installed above any fans.
5. Max. operating weight shall not exceed equipment schedule weights shown on the design drawings including roof curb, if provided. Provide certified weights with submittals.
6. . Unit should include outdoor air monitoring and controller.
7. BAS communication with BACnet over IP.

B. Units shall bear UL, CSA or ETL labels.

2.3 CAPACITIES AND CHARACTERISTICS:

A. Efficiency:

1. Air conditioners shall have a EER and IPLV better than ASHRAE Standard 90.1 – latest edition under ARI test procedures. When air conditioners with higher efficiencies then the Standard are scheduled on the drawings, the more efficient value shall be the minimum project requirement.

2.4 CABINET AND FRAME

A. The unit framework shall be welded structural tubing or integrally formed steel around perimeter or 12 gauge formed galvanized metal with integral curb flashing, electrically welded and painted with primer and one finish coat of paint for maximum protection from rust. Decks shall be double wall construction fabricated from minimum 18 gauge, galvanized steel. perforated. Entire top panel and deck under the filter section shall have inner liners fabricated from 22 gauge galvanized steel either solid or perforated.

B. Formed outer panels shall be secured to a welded tubular steel frame. Casings, panels, frame channels, and floors shall be constructed to withstand specified operating pressures including safety factors.

C. The roof of the unit shall be pitched to provide positive drainage. Top seams shall be covered with cap strips to prevent water leakage into the unit. All seams shall be sealed to prevent air and water leakage.

D. All exterior panels shall be insulated 2 inches double wall fabricated from 18 gauge galvanized steel or aluminum of equivalent strength.

E. Ceiling, walls, deck and doors shall be double wall as specified above with minimum 2 inches of R-8 insulation. No exposed insulation shall be permitted. Single wall or un-insulated doors shall not be acceptable.

F. Lifting lugs shall be provided on the base of the unit for rigging and shall accept cable or chain hooks.

G. Each panel shall be water and moisture tight to prevent water damage, electrical hazard and mold contamination within the unit.

H. The following requirements apply to individual components:

1. Base Frame:

a. Provide a full perimeter welded base frame constructed of minimum 12 gauge rectangular structural steel tubing or formed and welded structural members with integral curb flashing and minimum 14 gauge structural steel cross members. Formed metal base rails bolted or screwed together are not acceptable.
b. Cross members shall be welded to the perimeter frame at a minimum of one member per every two feet.
c. Base frame shall be painted with industrial direct to metal (DTM) finish with built-in rust inhibitors.
d. Base frame shall be attached to unit at factory.

2. Wall and Roof Frame:

a. Wall and roof frame are to be minimum 14 gauge rectangular structural steel tubing welded to form a unitized assembly for support of all internal components. Formed, screwed, and bolted metal is not acceptable.
b. The frame is to be coated with corrosion resistant phenolic primer.

3. Floor:

a. R-8 insulation “double bottom” floor with minimum 16 gauge G-90 galvanized outer surface and minimum 16 gauge G-90 galvanized inner walk-on surface is to be provided.
b. All floor seams are to be sealed airtight.
c. Single walled floors with glued and pinned insulation are not acceptable.

4. Casing /Panels:

a. 2 inches double wall construction fabricated from 18 gauge galvanized steel or 18 gauge (.04 inches) prepainted aluminum with baked acrylic enamel exterior and 22 gauge galvanized steel or aluminum of equivalent strength interior panels with R-8 insulation.
b. Flat panel design is not acceptable.
c. Panels shall not to exceed 24 inches without a structural steel support member in one axis.
d. Casing structure shall use insulating thermal breaks so that there is no path of continuous metal-to-metal conduction from inner to outer spaces.
e. Panels shall be gasketed and secured to tubular steel or formed frame with zinc plated fasteners and neoprene washers. Fasteners shall be of design using double locknuts/locktite. Aluminum panels shall be isolated from steel frame with dielectric gaskets to prevent galvanic corrosion.
f. Roof and internal components shall be supported from a structural frame, rather than side panels.
g. All panels shall be sealed airtight.
h. All sections shall be independent to preclude airflow between sections except airflows within the unit.
i. Install gutter over the access doors and electrical panels.

2.5 AIR COOLED CONDENSING SECTION

A. Two condenser fans minimum shall be coated steel and have a steel hub locked on a 316 stainless steel motor shaft. Fans shall be direct drive 3 phase RPM NEMA compliant motors.

B. Condenser coils shall be a seamless copper tubes, expanded into aluminum fins with a maximum of ten fins per inch. Each coil shall be provided with 15 degrees F sub cooling circuit. The mechanical refrigeration system shall be capable of operating at ambient conditions down to 45 degrees F.

C. Provide easily removable hail guards over condenser surface.

D. The unit manufacturer shall manufacture the condensing section. Third party condensing sections bolted to the unit are not acceptable.

E. Condenser section floor shall be crowned for water drainage and constructed of 16 gauge. stainless steel or aluminum of equivalent strength to resist corrosion.

F. All refrigerant piping shall be Type K Copper and installed and factory pressure tested prior to shipment of the unit.

G. Condenser fan motors shall have a shaft slinger to prevent liquid/ moisture from seeping into the motor.

2.6 COMPRESSORS

A. Unit shall have a minimum of two compressors. Compressors shall be heavy duty suction cooled, hermetic scroll type, complete with forced feed lubrication, suction and discharge service valves, suction strainer, crankcase heater, and 3 phase solid state thermal motor protection. The compressors must be mounted on rubber in-shear isolators to prevent transmission of any noise and vibration to the space below. Compressors shall be either modulating digital scroll type, or inverter duty variable speed type, For units with variable speed inverter duty type compressors, at least one of the compressors shall be variable speed be inverter duty.

B. Each compressor shall have an independent refrigeration circuit completely piped, tested, dehydrated, and fully charged with oil and refrigerant [R-410A]. The refrigerant circuit components shall include compressor, electronic expansion valve, bypass valve between suction and discharge for low head pressure start, condenser with integral liquid sub cooler, liquid line service charging valve, removable core filter drier, sight glass and relief valve. Suction piping shall be insulated.

C. Capacity reduction shall be by inverter duty compressor modulation, or with multiple digital scroll compressors.

D. Compressors shall be mechanically air cooled, and shall be located so as to not allow leaking refrigerant to enter the airflow into occupied space.

E. Compressors shall not be located in the same compartment as electrical contactors and control panels.

F. Controls shall include compressor anti-short cycle timers.

G. Provide Low and high-pressure refrigerant safety shut offs.

2.7 EVAPORATOR COIL

A. Direct expansion coil shall be staggered ½ inch O.D. x 0.029 inch wall seamless copper tubes expanded into aluminum fins and shall not be less than three rows in depth, nor have more than twelve fins per inch. Coil casings shall be constructed of heavy gauge galvanized steel. Headers shall be copper. Evaporator coils shall be provided with thermostatic expansion valves, adjustable superheat controls, and external equalizers. Expansion devices to be located out of airstream. Coil capacities and pressure drops are rated in accordance with ARI Standard 410.

B. The evaporator coil drain pan shall be 22 gauge 316 stainless steel and coil shall be provided with vibration dampening stiffeners, thermal insulation and discharge pipe. This applies to each coil. Where coils are stacked, unit shall be equipped with intermediate drain pan and internal drain pipes to the lowest pan.

C. Provide a condensate drain connection on both sides of the unit fitted to allow field piping to nearest roof drain.

2.8 HOT GAS REHEAT COIL

A. Hot-gas reheat coil shall be separated from the evaporator coil by a minimum of 6” in the direction of airflow to prevent the re-evaporation of condensate, provide room for coil cleaning, and allow control system to monitor evaporator coil leaving dew point temperature.

B. Coil shall be rated in accordance to AHRI standards, designed to withstand 250 psig working pressure at 300 degrees F, and pressure tested to 600 psig.

C. Coil casing shall be constructed of 16 gage galvanized steel.

D. Coil tubes shall be constructed of 5/16" diameter, 0.012" thick seamless copper tubing.

E. Coil fins shall be constructed of 0.0060" thick aluminum fins.

F. Hot-gas reheat shall be controlled through a factory-supplied and controlled modulating 3-way valve.

G. Coil shall be hydrogen or helium leak tested.

2.9 HEAT PUMP HEATING

A. The refrigerant circuit contains a 4 way reversing valve to provide heat

B. The outdoor coil includes an electronic controlled expansion valve to control the refrigerant flow during heat pump operation

C. The unit controller modulates the expansion valve to maintain compressor operation within the compressor operational envelope

D. The refrigerant system includes a pump-down cycle for durable operation

2.10 FANS

A. Fan assemblies shall be plenum type direct-drive without the use of belts or adjustable sheaves.

B. Fan motors to have ECM type motors, or variable frequency drive (VFD) shall be provided for each fan section. VFD shall be mounted, wired, and programmed by the equipment manufacturer. VFD shall be located in an enclosed compartment outside of the supply or exhaust air stream.

C. Fan wheels shall be constructed of a minimum of seven, stitch welded backward curved aluminum blades (APD) or welded aluminum with airfoil blades (APH).

D. Fan wheel shall be tested in accordance to AMCA 210. Fan speed shall not exceed 2400 RPM.

E. Fans may be full width or partial width. Fans modified to partial width through the use of banding or other blade reduction method are not acceptable.

F. Fans shall be mounted on minimum 1” tall neoprene isolators.

G. Fan motor shall be VFD rated, ODP type, EPACT compliant, and shall be of premium efficiency (PE).

H. Provide grease lubricated fan bearings with grouped accessible fittings, located within one foot of a door for lubrication. Both bearings shall have the same bore, type and manufacturer

I. Variable frequency drives shall be factory wired and mounted in the unit for each fan. Fan motors shall be premium efficiency.

2.11 FAN MOTORS

A. The fan motor shall be heavy duty TEFC, three phase, 1800 rpm, NEMA Premium (per the latest NEMA standard). The motor and fan shall be mounted on the common isolated steel frame assembly.

B. Motors shall be selected so that they do not operate within the 1.15 service factor at total fan pressures +/-10% from design selection point.

2.12 FILTER

A. Outdoor air filters

1. Outdoor air filter rack shall accommodate factory-provided 2" aluminum filters
2. Filter sections shall be accessible through a 2" foam-injected, double-wall, hinged access door with quarter-turn latches.

B. Supply air filters

1. Supply air filter rack shall accommodate factory-provided 4" MERV 13 filters.
2. Filter sections shall be accessible through a 2" thick, foam-injected, double-wall, hinged access door with quarter-turn latches.
3. Filter section shall include magnehelic gauge and/or dirty filter pressure switch.

C. Exhaust air filters

1. Exhaust air filter rack shall accommodate 2” MERV8 pleated filters.
2. Filter sections shall be accessible through a 2" foam-injected, double-wall, hinged access door with quarter-turn latches.

D. Interface with CBRTU control panel ready for tie-in to the building automation system.

2.13 OUTSIDE AIR AND EXHAUST MOTORIZED DAMPERS

A. Frame shall be constructed of a 16 gage galvanized steel hat-channel.

B. Blades shall be constructed of 16 gage galvanized steel strengthened by three longitudinal 1 inch deep “vee” grooves.

C. Blades shall be symmetrical relative to its axle pivot point.

D. Axle bearings shall be synthetic sleeve-type and rotate inside extruded holes in the damper frame.

E. Blade seals shall be extruded vinyl permanently bonded to the appropriate blade edges.

F. Frame shall include flexible stainless steel compression-type jamb seals.

G. Modulating spring-return actuators shall be provided by the factory, installed on the damper, and wired to the control center. Each damper shall have a dedicated actuator. Single actuators with gear trains are not acceptable.

H. Damper leakage shall be no more than 3 cfm/sq.ft. at 1 in.wg static pressure.

I. Exhaust: Powered, 2 position damper and actuator combination. The exhaust air damper will only open when there is a signal to the exhaust air damper. The damper will close when the exhaust air fan no longer receives a signal to run.

J. All dampers shall be motorized. Damper motors/operators shall be provided and installed by unit manufacturer. Refer to Division 23 Section "Digital Control System for HVAC" for actuator requirements.

2.14 OUTSIDE AIR LOUVERS

A. Outside air hood or louvers shall be of a storm proof design and provided with a ½ inch x ½ inch galvanized bird screen. A fully insulated divider deck shall be provided to separate outside air from return air.

B. Outside air louvers and ductwork shall be sized for 100% unit supply air economizer cycle requirements. Velocity shall not exceed 500 FPM over the net free area.

2.15 ACCESS DOORS

A. Access doors shall be a minimum of 18 gauge steel double wall construction with R-8 insulation between inner and outer wall.

B. Access doors shall have handles inside and outside of unit.

C. Access door frame shall be welded structural steel with low-leakage air-bulb type seal. Seal shall be secured to the frame with rivets or weatherproof mastic or sealant.

D. Hinges shall be stainless steel, continuous (piano-type), heavy duty, 10 gauge galvanized steel, and shall be riveted to the access door and frame.

E. Doors shall open against pressure.

F. Provide hinged access doors on both sides of unit for fan, filter, control damper, and coil section. Also, provide doors for furnace and compressor access.

G. Access doors shall have locking type door retainer to prevent wind damage when door is open. Top and bottom retainers shall be installed for large doors to prevent racking.

H. Access door to be minimum 60 inches or full height minus 4 inches for units less than 60 inches tall.

I. Provide high compression single handle multiple closure type hatches/handles for quick access and positive air seal.

J. Access doors shall be equipped with gutters extending 3 inches on either side of the door opening.

2.16 MAIN CONTROL PANEL

A. The main operating and control panel enclosure shall be a minimum 8 inches deep and equivalent to NEMA type 3R (rain-tight) and Chicago Electrical Code compliant. The panel front shall be piano hinged at the top or have two outward swinging doors, key lockable at the bottom and have hold open devices for protection and safe maintenance in all weather conditions.

B. Panel shall have an insulated divider between power and control sections. Each section shall have terminal strips numbered to match wiring diagrams that identify field wiring and factory wiring. The

control panel shall be structurally isolated from the unit curb so that conduits do not penetrate the curb.

C. The main panel shall accommodate an external electric service feeder consisting of four copper wires in a 3 inches IMC conduit to energize the unit.

D. Adjacent to the control panel provide a quad GFI outlet for unit maintenance on the unit exterior and capable of receiving a ¾ inch IMC conduit and wiring. This is to provide maintenance capability with the control panel main switch de-energized.

E. Provide unit interior lighting which is to be switched on the interior wall of the main access door. The circuit shall be extended through the exterior panel and terminated in a NEMA 3R junction box to allow others to field connect a separate lighting circuit to allow maintenance with unit main power switched off.

F. Panel access doors shall be equipped with gutters extending 3 inches beyond sides of the door opening.

G. High voltage wiring shall be separated from low voltage wiring on the same panel.

H. Any external mounted disconnect switch shall be installed in a weather protected enclosure.

2.17 HEAT RECOVERY DEVICE: HEAT WHEEL – POLYMER SUBSTRATE WITH SILICA GEL DESICCANT.

A. Energy recovery shall be an integral part of unit from the manufacturer. No field assembly, ducting, or wiring shall be required with the energy recovery option.

B. Energy recovery media shall be accessible through a 2" thick, foam-injected, double-wall, hinged access door with quarter-turn latches.

C. Energy recovery shall be provided through a total enthalpy wheel providing sensible and latent energy transfer per the scheduled performance.

D. Energy recovery wheel shall be constructed of lightweight polymer substrate with permanently-bonded silica gel desiccant.

E. Energy recovery wheel shall be mounted perpendicular (90°) to the base of the unit.

F. A VFD shall be required to modulate the speed of the wheel and to provide soft start to extend the life of the belt.

G. Individual pie-shaped wheel sections shall be removable from wheel cassette for maintenance.

H. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours.

I. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.

J. Energy wheel shall include seals, drive motor, and urethane drive belt.

K. Latent energy shall be transferred entirely in the vapor phase with no condensation.

L. Thermal performance shall be certified by the wheel manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment.

2.18 DDC TEMPERATURE CONTROL SYSTEM

A. General Description

1. Each unit shall be furnished complete with all operations controls.. These controls include the hardware and software required to operate the factory built rooftop unit (RTU) according to the sequence of operations specified in other Division 23 Sections and as shown on the drawings. Each of the RTU local DDC controllers shall be integrated into the temperature control system specified in other Division 23 Sections. The equipment manufacturer is responsible for all wiring in the RTU.
2. The RTU manufacturer shall supply and wire the local controller for the RTU. The RTU manufacturer shall factory install the controller in each RTU.
3. All input, output and DDC local devices are to be factory installed and wired, except the room thermostat/sensor, and supplied to the RTU manufacturer by the contractor supplying the local controller. All the devices in the RTU shall comply with the requirements of the temperature control specification in Division 23. Room temperature sensors shall be furnished and installed by the control contractor connected to the local controller at the RTU.
4. See drawings and Division 23 for control diagrams, points list and sequence of operation. Additional sensors shall be by temperature control contractor and shall be factory installed by the RTU manufacturer.
5. Outside Air / Exhaust damper actuators shall be full modulating type and to be supplied by equipment manufacturer. Refer to other Division 23 Sections for additional damper actuator requirements.
6. Airflow measuring stations shall be supplied by equipment manufacturer.
7. Factory-mounted and wired controls also include system on/off switches, lights and safety controls.

B. The above components are in addition to electrical components associated with other Sections, which shall be incorporated in the main control panel to facilitate maintenance and troubleshooting.

C. The following sensors shall be factory supplied, mounted, and wired inside the unit:

1. Outdoor air humidity sensor.
2. Outdoor air temperature sensor.
3. Evaporator coil leaving air temperature sensor.
4. Supply air filter pressure monitoring switch and/or magnehelic gauge.
5. Energy wheel rotation sensor.
6. Condensate overflow switch

D. The following devices shall be factory-supplied for field installation and wiring:

1. Supply air temp temperature sensor.
2. Wall-mounted room air temperature sensor with manual adjuster.
3. Wall-mounted room air humidity sensor.
4. Wall-mounted CO2 sensor.
5. Space static pressure sensor.
6. Supply duct static pressure sensor.
7. Smoke detectors.
8. Digital display space temperature sensor.

2.19 FACTORY VERIFICATION TESTING AND SHIPPING

A. The complete system including sensors (heating, air handling and controls) shall be factory run-tested as a component as well as part of the total unit prior to leaving the factory.

B. Each unit shall ship from the factory fully charged, in one piece with all options factory installed and factory run-tested as a complete unit.

C. Unit shall be thoroughly run tested prior to shipment from the factory.

D. Factory run test report shall be provided at the request of the engineer, contractor, or CDB.

E. Testing Procedures:

1. Unit shall be subjected to and pass a dielectric (hipot) test.
2. All motorized dampers shall be cycled one full stroke while installed in the unit using the factory-provided motorized actuators.
3. Supply fan

    a. Visually inspect ramp-up, ramp-down, and rotation direction of fan when enabled.
    b. Verify fan pressure proving switch operation.
    c. Measure and record current draw through supply fan motor(s).

4. Exhaust fan

    a. Visually inspect ramp-up, ramp-down, and rotation direction of fan when enabled.
    b. Verify fan pressure proving switch operation.
    c. Measure and record current draw through exhaust fan motor(s).

5. Energy recovery wheel

    a. Visually inspect energy recovery wheel cassette is free to rotate within cassette.
    b. Visually inspect energy recovery belt drive mechanism.
    c. Enable energy recovery wheel motor and ensure proper rotation.
    d. Measure and record current draw through energy recovery wheel motor.

6. Condensing fans

    a. Ensure fans rotate freely without obstruction.
    b. Energize fans and ensure proper rotation.
    c. Measure and record the amount of current draw through each condensing fan.

7. Refrigeration system

    a. Measure and record subcooling and superheat on circuit A with hot-gas reheat valve closed (0%) after 15 minutes of steady-state operation.
    b. Measure and record subcooling and superheat on circuit A with hot-gas reheat valve open (100%) after 15 minutes of steady-state operation.
    c. Measure and record subcooling and superheat on circuit B after 15 minutes of steady-state operation.
    d. Test report shall be provided prior to unit startup and available from the factory upon request.

2.20 ADDITIONAL ITEMS

A. Provide GFI service outlets with separate transformers so that circuit is energized even when main disconnect is off.

B. All motors and electric devices shall be separately fused for over-current protection to minimize total unit out of service conditions. Fuses shall be integral to the unit.

C. Internal wiring for all electrical devices/controls shall be properly sized for ampacity and to match connections without damaging/stripping the conductor.

D. All internal electrical power wiring shall be in conduit.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation, tolerances and other conditions affecting performance of CBRTUs.

B. Examine roughing-in for CBRTUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roof condition before CBRTUs are installed. Document any defects and deficiencies.

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

3.2 CONNECTIONS

A. Handle and install units and accessories in accordance with the manufacturer's printed instructions for the model.

B. Provide "P" trap at condensate drain sized to allow for units pressure and pipe over to nearest roof drain receptor.

C. Install piping adjacent to CBRTUs to allow service and maintenance.

D. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to CBRTUs with flexible duct connectors specified in Division 23 Section "Air Duct Accessories". Make new connections to each individual zone duct with flexible ductwork connection.
4. Install return-air duct continuously through roof structure.

3.3 ADDED INSULATION

3.4 CLEANING

A. After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

B. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face; comb coil fins.

C. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

3.5 CONTRACTOR STARTUP AND REPORTING

A. Manufacturer's Field Service: Engage a factory-authorized service representative to observe unloading and placement of unit and inspect, test, and adjust components, assemblies, equipment installations, and connections including piping, ductwork and electrical connections. Report results in writing with recommendations for corrective action.

B. Perform tests and inspections and prepare test reports. All testing and inspection requirements identified in this document or required as part of the manufacturer's startup shall be documented in writing.

C. Final Checks Before Start-Up: Perform the following operations and checks before start-up; document in writing.

1. Verify that shipping bolts, blocking, tie-down straps and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete.
3. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
4. Perform cleaning and adjusting.
5. Disconnect fan drive from motor, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
6. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
7. Set outside-air and return-air mixing dampers to minimum outside-air setting.
8. Comb coil fins for parallel orientation.
9. Install clean filters.
10. Verify manual and automatic volume controls, and fire dampers in connected ductwork systems are in the full-open position.
11. Disable automatic temperature control operators.

D. Tests and Inspections:

1. After installing CBRTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

    a. Energize motor, verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.
    b. Replace fan and motor pulleys as required to achieve design conditions.
    c. Measure and record motor electrical values for voltage and amperage

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
4. Shut unit down and reconnect automatic temperature control operators.

E. Remove and replace malfunctioning units and retest as specified above.

F. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for Procedures for air-handling-system testing, adjusting, and balancing

G. Engage a factory-authorized service representative to perform startup service.

H. Complete installation and startup checks according to manufacturer's written instructions and do the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to furnace combustion chamber.
3. Inspect for visible damage to compressor, coils, and fans.
4. Inspect internal insulation.
5. Verify that labels are clearly visible.
6. Verify that clearances have been provided for maintenance.
7. Verify that controls are connected and operable.
8. Verify that filters are installed.
9. Clean condenser coil and inspect for construction debris.
10. Clean furnace flue and inspect for construction debris.
11. Connect and purge gas line.
12. Remove packing from vibration isolators.
13. Verify lubrication on fan and motor bearings.
14. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
15. Adjust fan belts to proper alignment and tension.
16. Start unit according to manufacturer's written instructions.

    a. Start refrigeration system.
    b. Do not operate below recommended low-ambient temperature.
    c. Complete startup sheets and attach copy with Contractor's startup report.

17. Inspect and record performance of interlocks and protective devices; verify sequences.
18. Operate unit for an initial period as recommended or required by manufacturer.
19. Calibrate thermostats.
20. Adjust and inspect high-temperature limits.
21. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers. (in conjunction with contractor supplying local controller)
22. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:

    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.

23. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown. (in conjunction with contractor supplying local controller)
24. Measure and record the following minimum and maximum airflows and plot fan volumes on fan curve. This is to be done by a Testing and Balance Certified Contractor according to Division 23 requirements.

    a. Supply-air volume.
    b. Return-air volume.
    c. Relief-air volume.
    d. Outdoor-air intake volume.

25. Simulate maximum cooling demand and inspect the following:

    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.

26. Verify operation of remote panel and failure modes. Inspect the following:

    a. Low-temperature safety operation.

b. Filter high-pressure differential alarm.
c. Economizer to minimum outdoor-air changeover.
d. Relief-air fan operation.
e. Smoke and firestat alarms.

27. After startup and performance testing and prior to preliminary acceptance, replace existing filters with new filters.

I. Occupancy Adjustments: When requested within 12 months of date of preliminary acceptance provide on-site assistance by a factory authorized service representative in adjusting system to suit actual occupied conditions. Provide up to two visits to site during other-than-normal occupancy hours for this purpose.

J. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 9100 Commissioning.

3.6 DEMONSTRATION AND COMMISSIONING

A. Arrange for a factory-authorized service representative to train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, maintenance, preventative maintenance, and how to obtain replacement parts. The training will occur after the startup report has been provided to the Owner. The trainer shall provide four (4) Installation and Operations Manuals (IOM) for the use of the Owner's personnel during training. Training shall also follow the requirements of Division 01 Sections "Operation and Maintenance" and "Demonstration and Training."

B. Review data to familiarize Owner's personnel with contents of IOM and Operating and Maintenance Data specified in Division 01 Section "Project Closeout". All required and recommended maintenance shall be reviewed as well as operational troubleshooting. Provide a written troubleshooting guide if the IOM does not include one.

C. Schedule training with CDB, through AOR/EOR, with at least seven days' advance notice.

D. Demonstrate proper operation of equipment to commissioning agent or designated Owner's personnel. The scope of the demonstration shall include functional performance requirements under both local and building automation control as well as any commissioning requirements in Division 01 and 23. Manufacturer's representative shall participate in all commissioning activities related to the CBRTU, including demonstration by contractor supplying local controller.

E. Factory test all sequences of operation prior to shipping.

F. Training of the Owner's operation and maintenance personnel is required in cooperation with the Commissioning Authority. The instruction shall be scheduled in coordination with the Commissioning Authority after submission and approval of formal training plans. Refer to Demonstration and Training, Section 01 7900, for contractor training requirements. Refer to Section 01 9100 and the Commissioning Plan for further contractor training requirements.

3.7 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 9100. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 237417 – PACKAGED ROOFTOP HVAC UNITS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes packaged rooftop heating, ventilating and air conditioning units with the following components and accessories:

1. Cabinet and Frame.
2. Air-Cooled Condensing Section.
3. Compressors.
4. Evaporator Coil
5. Modulating heat pump reversing valve and heat pump components.
6. Refrigerant Hot Gas Reheat Coil
7. Aux Electric Heating Coil
8. Fans
9. Fan Motors.
10. Filters
11. Outside Air and Exhaust Air Dampers.
12. Outside Air Louvers.
13. Access Doors.
14. Main Control Panel.
15. Energy Recovery Wheel

1.2 DEFINITIONS

A. DDC: Direct-digital controls.

B. RTU: As used in this Section, this abbreviation means packaged roof top HVAC units. This abbreviation is used regardless of whether the unit is mounted on the roof or on a concrete base on ground.

1.3 SUBMITTALS

A. Product Data: Include manufacturer's technical data for each RTU, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories. Including but not limited to the following data:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound power ratings at system operating conditions.
3. Certified ARI heating and cooling coil capacity ratings.
4. Motor ratings and electrical characteristics of motor and fan accessories.
5. Materials gauges and finishes.
6. Filters with performance characteristics.
7. Dampers, including housings, linkages, and operators.
8. Supply fan, return /exhaust fan, and compressor vibration isolation including vibration analysis.
9. Material Safety Data Sheets.
10. Installation and maintenance manuals containing all system components.
11. Laboratory data for sound testing of fans.
12. Performance at ARI standard conditions and at conditions scheduled (provide EER & IPLV).
13. ASHRAE/IESNA 90.1 for energy compliance statement.

B. LEED Submittals:

1. Prerequisite EA2: Provide certification that the minimum efficiency is equal to or better than the requirements of the latest ASHRAE standard. Include performance at ARI standard/unloading conditions, and at conditions scheduled (provide EER).
2. Credit EA4: Certification that refrigerants are free of HCFCs.
3. Credit EA5: Product Data of continuous metering equipment for outdoor airflow and energy consumption.
4. Credit EQ5: Certification that equipment has been provided with MERV 13 filters.

C. Shop Drawings: Detail equipment assemblies, including control panel, and indicate dimensions, weights, loads, required clearances, method of assembly, components, location and size of each field connection and rigging and hoisting requirements.

1. Wiring Diagrams: Power, signal, and control wiring. Differentiate between manufacturer-installed wiring and field-installed wiring.
2. Provide as part of the shop drawing details a complete compressor and condenser cross section.

D. Coordination Drawings: Plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Components of RTUs.
2. Structural members to which RTUs are to be attached.
3. Roof openings.
4. Roof curbs and flashing.

E. Factory quality-control test reports: Factory start-up, inspection, and check-out reports to be provided to engineer for review prior to final equipment acceptance, startup, or commissioning.

F. Field quality-control test reports.

G. Operation and Maintenance Data: Include emergency, operation, and maintenance manuals.

H. Startup Test Reports: Submit written test reports documenting the activities required by Part 3 “Contractor Startup and Reporting”. These reports are to be submitted two weeks after the startup is completed.

I. Training Reports: Submit reports on training, documenting dates and attendance.

1.4 QUALITY ASSURANCE

A. Comply with the following testing and rating methods:

1. AMCA 300 and 301 for testing and rating airborne sound emissions of fans.
2. AMCA 500 for testing and rating of dampers and louvers.
3. AMCA 204 for testing and rating balance quality and vibration levels for fans.
4. ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for RTUs.
5. ARI 270 for testing and rating sound performance for RTUs.
6. ARI 430 for testing and rating equipment performance for RTU’s.
7. ARI 410 for testing and rating coil capacities.
8. Certify in accordance with ARI Certification Program.
9. ASHRAE 15 for refrigeration system safety.
10. ASHRAE 52.1 for filter efficiency.
11. ASHRAE/IESNA 90.1 for minimum efficiency of heating and cooling.

B. NFPA Compliance: Comply with NFPA 90A, NFPA 90B and NFPA 79.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Safety Standards:

1. Design, manufacture and installation of mechanical refrigeration equipment: ANSI B9.1
2. Machinery Guards: Provide guards as shown in AMCA 410 for belts, chains, couplings, pulleys, sheaves, shafts, gears and other moving parts regardless of height above the floor. Drive guards may be excluded where motors and drives are inside factory fabricated unit casings. Comply with the latest OSHA standard.
3. Comply with the Local Building Code requirement for smoke detection in supply air to shut down unit and notify unit status.

E. Corrosion Prevention: Unless specified otherwise, equipment fabricated from ferrous metals that do not have a zinc-coating conforming to ASTM A386 or a duplex coating of zinc and paint shall be treated for prevention of rust with a factory coating or paint system that shall withstand 125 hours in a salt-spray fog test, except that equipment located outdoors shall be tested for 2500 hours. The salt-spray fog test shall be in accordance with ASTM B117 using a 20 percent sodium chloride solution. Immediately after completion of the test, the coating shall show no signs of blistering, wrinkling or cracking, no loss of adhesion, and the specimen shall show no signs of rust creepage beyond 1/8 inch on either side of the scratch mark. The film thickness of the factory coating or paint system applied on the equipment shall be not less than film thickness used on the test specimen.

1.5 DELIVERY, STORAGE AND HANDLING

A. Follow manufacturer's instructions for unloading, rigging and storage of equipment.

B. Unit shall be shipped with door handles locked shut with door handle set screws and outside air hood closed to prevent damage during transport and temporary storage.

C. Maintain manufacturer's recommended temperature and humidity limits during storage and installation. Protect equipment from dirt, dust and other jobsite contaminants and conditions detrimental to the equipment.

1.6 COORDINATION

A. Verify dimensions of structural supports and roof openings duct connections.

B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with equipment provided.

C. Coordinate locations of connecting utilities including: electric, controls, and condensate with equipment provided

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: Two sets of filters for each unit.

1.8 WARRANTY

A. Warranty: Manufacturer shall replace components that fail within specified warranty period. Provide warranty on materials for 18 months starting from date of delivery, or one year from date of preliminary acceptance whichever is longer.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of preliminary acceptance. Warranty shall be on compressor exchange. Parts only warranty is not acceptable.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Trane – Basis of Design
2. Carrier
3. Johnson Controls - York

B. Comparable manufactured products to the basis of design equipment scheduled on the drawings meeting similar design performance, electrical power requirements, dimensions and weight, will be considered on a case-by-case basis by the Construction Manager and Engineer of Record. All submitted equipment must meet the warranty requirements as listed in this section.

2.2 GENERAL DESCRIPTION

A. Furnish and install rooftop unit of size, type and capacity as indicated on the Drawings. Cooling capacity ratings shall be based upon test in accordance with ARI Standard 360. Units shall consist of insulated weather tight casing, compressors, evaporator coil, electronic expansion valve, refrigerant reversing valve, air-cooled condenser coil, condenser fans, condensate drain pan, evaporator fan, auxiliary electric exhaust fans, motors and drives, and main control panel. Units shall also include filters, exhaust fans and controls as herein specified.

1. Units shall include DX cooling with heat pump heating, supply fan section, return, exhaust fan section, condensing unit section, filter section and control dampers for outside air, exhaust air and return air.
2. Capacities, characteristics, and accessories shall be as shown and/or scheduled on drawings.
3. Units shall be factory fabricated, assembled and factory finished.
4. Motors shall not be installed above any fans.
5. Max. operating weight shall not exceed equipment schedule weights shown on the design drawings including roof curb, if provided. Provide certified weights with submittals.
6. Unit should include outdoor air monitoring and controller.
7. BAS communication with BACnet over IP.

B. Units shall bear UL, CSA or ETL labels.

2.3 CAPACITIES AND CHARACTERISTICS:

A. Efficiency:

1. Air conditioners shall have a EER and IPLV better than ASHRAE Standard 90.1 – latest edition under ARI test procedures. When air conditioners with higher efficiencies than the Standard are scheduled on the drawings, the more efficient value shall be the minimum project requirement.

2.4 CABINET AND FRAME

A. All cabinet walls, access doors, and roof shall be fabricated of 2-inch double wall, impact resistant, foam injected panels.

B. Unit construction shall be double wall with and a thermal break so there is no path of continuous metal to metal conduction from the inner space to the outer space. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, prevents heat transfer through the panel, and prevents exterior condensation on the panel.

C. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.

D. Each panel shall be water and moisture tight to prevent water damage, electrical hazard and mold contamination within the unit.

E. All panels shall be fabricated from 22-gauge G90 galvanized steel or aluminum of equivalent strength.

F. Ceiling, walls, floors, doors shall be double wall as specified above with minimum of R-13 insulation. No exposed insulation shall be permitted. Single wall or un-insulated doors shall not be acceptable.

G. Panels shall be gasketed and secured to tubular steel or formed frame with zinc plated fasteners and neoprene washers. Fasteners shall be of design using double locknuts/locktite. Aluminum panels shall be isolated from steel frame with dielectric gaskets to prevent galvanic corrosion.

H. The unit framework shall be welded structural tubing or integrally formed steel around perimeter formed galvanized metal with integral curb flashing, electrically welded and painted with primer and one finish coat of paint for maximum protection from rust

I. Formed outer panels shall be secured to a framed galvanized steel base channel frame. Casings, panels, frame channels, and floors shall be constructed to withstand specified operating pressures including safety factors.

J. Roof and internal components shall be supported from the structural frame. Components supported from the side panels are not acceptable.

K. The roof of the unit shall be pitched to provide positive drainage. Top seams shall be covered with cap strips to prevent water leakage into the unit. All seams shall be sealed to prevent air and water leakage.

L. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors and electrical panels.

M. The base frame shall be constructed from structural steel tubing or formed members with integral curb flashing and structural steel cross members.

N. The base frame shall be installed in the factory and painted with industrial direct to metal (DTM) finish with built-in rust inhibitors.

O. Manufacturer's standard base shall be constructed of galvanized steel integral floor pan. Floor pan shall be insulated. Penetrations through the floor shall have a raised rib around each opening. Base shall have a overhang over the top of a roof curb to prevent water infiltration. Single walled floors with glued and pinned insulation are not acceptable. Formed metal base rails bolted or screwed together are not ac

ceptable.

P. Lifting lugs shall be provided on the base or top of the unit for rigging and shall accept cable or chain hooks.

2.5 AIR COOLED CONDENSING SECTION

A. Two condenser fans minimum shall be coated steel and have a steel hub locked on a 316-stainless steel motor shaft.

B. Condensing section shall be equipped with direct-drive condensing fans.

C. Condensing fan assembly shall be statically and dynamically balanced in accordance with AMCA Standard 204-05.

D. Condensing fan assembly shall consist of aluminum-bladed propeller fan wheel, formed-channel base, formed inlet venturi, and coated steel basket guard on the discharge.

E. Factory-supplied variable frequency drives, or modulating ECMs, shall be provided to modulate condensing fans to maintain refrigerant head pressure in the condensing section.

F. Condenser coils shall be an all-aluminum design. The aluminum tube shall be a micro channel SEP design with high efficiency aluminum fins. Fins shall be brazed to the tubing for a direct bond Each condenser coil shall be factory leak tested with high- pressure air under water Condenser coils shall be protected from incidental contact to coil ns by a coil guard Coil guard shall be constructed of cross wire welded steel with PVC coating. The mechanical refrigeration system shall be capable of operating at ambient conditions down to 35 degrees F.

G. The unit manufacturer shall provide the condensing section. Third party condensing sections bolted to the unit are not acceptable.

H. All refrigerant piping shall be installed and factory pressure tested prior to shipment of the unit.

I. Condenser fan motors shall have a shaft slinger to prevent liquid/ moisture from seeping into the motor.

J. Coil shall be hydrogen or helium leak tested.

2.6 COMPRESSORS

A. The RTU shall have a minimum of four compressors. Compressors shall be heavy duty suction cooled, hermetic scroll type, complete with forced feed lubrication, suction and discharge service valves, suction strainer, crankcase heater, and 3 phase solid state thermal motor protection. The compressors must be mounted on rubber in-shear isolators to prevent transmission of any noise and vibration to the space below. Minimum 50% of the compressors shall have modulating capability.

B. Each independent refrigeration circuit shall have an independent refrigeration circuit completely piped, tested, dehydrated, and fully charged with oil and refrigerant R-410A. The refrigerant circuit components shall include compressor, service isolation valves for servicing compressor, condenser with integral liquid sub cooler, liquid line service charging valve, filter drier, sight glass and relief valve. Suction piping shall be insulated.

C. Capacity reduction shall include modulating digital compressor or inverter scroll compressor technology. Hot gas bypass is not acceptable.

D. Compressors shall be mechanically air cooled, and shall be located so as to not allow leaking refrigerant to enter the airflow into occupied space.

E. Compressors shall be installed in a separate compartment, above the unit floor, and isolated from the surrounding environment by double wall foam injected panels and access doors.

F. Compressors shall be installed using manufacturer's recommended rubber vibration isolators.

G. Compressors shall be interlocked with Auxiliary heat so that compressors shall be locked out when heating is enabled.

H. Refrigerant Systems shall be provided with relief valve capability in compliance with the Local Building Code.

I. Controls shall include compressor anti-short cycle timers.

J. Provide low and high-pressure refrigerant safety shut offs.

2.7 EVAPORATOR COIL

A. Direct expansion coil shall be staggered seamless copper tubes expanded into aluminum fins and shall not be less than 4 rows in depth, nor have more than 14 fins per inch. Coil casings shall be constructed of galvanized steel. Headers shall be copper. Coil fins shall be constructed of aluminum. Coil shall be hydrogen or helium leak tested. Evaporator coils shall be provided with thermostatic expansion valves, adjustable superheat controls, and external equalizers. Expansion devices to be located out of airstream. Coil capacities and pressure drops are rated in accordance with ARI Standard 410.

B. The evaporator coil drain pan shall be stainless steel and coil shall be provided with vibration dampening stiffeners, thermal insulation and discharge pipe. This applies to each coil. Where coils are stacked, unit shall be equipped with intermediate drain pan and internal drain pipes to the lowest pan.

C. Drain pan shall extend a minimum of 8” past the evaporator coil to ensure condensate retention.

D. Provide a condensate drain connection on both sides of the unit fitted to allow field piping to nearest roof drain.

2.8 HEAT PUMP HEATING

A. The refrigerant circuit contains a 4-way reversing valve to provide heat.

B. The outdoor coil includes an electronic controlled expansion valve to control the refrigerant flow during heat pump operation.

C. The unit controller modulates the expansion valve to maintain compressor operation within the compressor operational envelope.

D. The refrigerant system includes a pump-down cycle for durable operation

2.9 FANS

A. Fan assemblies shall be plenum type direct-drive without the use of belts or adjustable sheaves.

B. A variable frequency drive (VFD) shall be provided for each fan. VFD shall be mounted, wired, and programmed by the equipment manufacturer. VFD shall be located in an enclosed compartment outside of the supply or exhaust air stream.

C. Fan wheels shall be constructed of a minimum of seven, stitch welded backward curved aluminum blades (APD) or welded aluminum with airfoil blades (APH).

D. Fan wheel shall be tested in accordance to AMCA 210. Fan speed shall not exceed 2400 RPM.

E. Fans may be full width or partial width. Fans modified to partial width through the use of banding or other blade reduction method are not acceptable.

F. Fans shall be mounted on vibration isolators.

G. Fan motor shall be VFD rated, ODP type, EPACT compliant, and shall be of premium efficiency (PE).

H. Provide grease lubricated fan bearings with grouped accessible fittings, located within one foot of a door for lubrication. Both bearings shall have the same bore, type and manufacturer

I. Variable frequency drives shall be factory wired and mounted in the unit for each fan. Fan motors shall be premium efficiency.

2.10 FAN MOTORS

A. The fan motor shall be heavy duty TEFC, three phase, 1200 or 1800 nominal rpm, NEMA Premium (per the latest NEMA standard). The motor and fan shall be mounted on the common isolated steel frame assembly.

B. Motors shall be selected so that they do not operate within the 1.15 service factor at total fan pressures +/-10% from design selection point.

2.11 FILTERS

A. Outdoor air filters

1. Outdoor air filter rack shall accommodate factory-provided 2" aluminum filters.
2. Filter sections shall be accessible through a 2" foam-injected, double-wall, hinged access door with quarter-turn latches.

B. Exhaust air filters

1. Exhaust air filter rack shall accommodate 2” MERV8 pleated filters.
2. Filter sections shall be accessible through a 2" foam-injected, double-wall, hinged access door with quarter-turn latches.

C. Supply air filters

1. Supply air filter rack shall accommodate factory-provided 4" MERV 13 filters.
2. Filter sections shall be accessible through a 2" thick, foam-injected, double-wall, hinged access door with quarter-turn latches.
3. Filter section shall include magnehelic gauge and/or dirty filter pressure switch.

2.12 OUTSIDE AIR AND RECICULATION AIR MOTORIZED DAMPERS

A. Blade seals shall be extruded vinyl permanently bonded to the appropriate blade edges.

B. Modulating actuators shall be provided by the factory, installed on the damper, and wired to the control center. Economizer damper shall have a dedicated actuator.

C. Dampers shall be low leak

D. All dampers shall be motorized. Damper motors/operators shall be provided and installed by unit manufacturer.

2.13 OUTSIDE AIR LOUVERS

A. Outside air louvers shall be of a storm proof design and provided with a ½ inch x ½ inch galvanized bird screen.

B. Outside air louvers and ductwork shall be sized for 100% unit outside air. Velocity shall not exceed 500 FPM over the net free area.

2.14 ACCESS DOORS

A. Access doors shall double wall construction with insulation between inner and outer wall to match the R-Value of the cabinet.

B. Access doors shall have handles outside of unit.

C. Access door frame shall have low-leakage air-bulb type seal. Seal shall be secured to the frame with rivets or weatherproof mastic or sealant.

D. Hinges shall be stainless steel, continuous (piano-type), heavy duty, and shall be riveted to the access door and frame.

E. Doors shall open against pressure or have latch catches on doors that open with pressure.

F. Provide hinged access doors on both sides of unit for fan, filter, control damper, and coil section. Also, provide doors for furnace and compressor access.

G. Control panel access doors shall have locking type door retainer to prevent wind damage when door is open.

H. Provide high compression single handle multiple closure type hatches/handles for quick access and positive air seal.

2.15 MAIN CONTROL PANEL

A. The main operating and control panel enclosure shall be a minimum 8 inches deep and equivalent to NEMA type 3R (rain-tight) and NEC compliant. The panel front shall be piano hinged at the top or have two outward swinging doors, key lockable at the bottom and have hold open devices for protection and safe maintenance in all weather conditions.

B. Panel shall have an insulated divider between power and control sections. Each section shall have terminal strips numbered to match wiring diagrams that identify field wiring and factory wiring. The control panel shall be structurally isolated from the unit curb so that conduits do not penetrate the curb.

C. The main panel shall accommodate an external electric service feeder consisting of four copper wires in an appropriately sized conduit to energize the unit.

D. Adjacent to the control panel provide a duplex GFI outlet for unit maintenance on the unit exterior and capable of receiving a ¾ inch IMC conduit and wiring. This is to provide maintenance capability with the control panel main switch de-energized.

E. Provide convenience outlet wired from a separate 120V circuit.

F. Provide control panel lights wired from a separate 120V circuit.

G. The circuit shall be extended through the exterior panel and terminated in a NEMA 3R junction box to allow others to field connect a separate lighting circuit to allow maintenance with unit main power switched off.

H. Panel access doors shall be equipped with gutters extending beyond sides of the door opening.

I. High voltage wiring shall be separated from low voltage wiring on the same panel.

J. Any external mounted disconnect switch shall be installed in a weather protected enclosure.

2.16 HEAT RECOVERY DEVICE: HEAT WHEEL – ALUMINUM SUBSTRATE

A. Energy recovery shall be an integral part of unit from the manufacturer. No field assembly, ducting, or wiring shall be required with the energy recovery option.

B. Energy recovery media shall be accessible through a 2" thick, foam-injected, double-wall, hinged access door with quarter-turn latches.

C. Energy recovery shall be provided through a total enthalpy wheel providing sensible and latent energy transfer per the scheduled performance.

D. Energy recovery wheel shall be constructed of aluminum substrate with permanently-bonded enthalpic coating

E. Energy recovery wheel cassette shall be mounted perpendicular (90°) to the base of the unit.

F. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours.

G. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.

H. Energy wheel cassette shall include seals, drive motor, and urethane drive belt.

I. Latent energy shall be transferred entirely in the vapor phase with no condensation.

J. The energy recovery cassette and wheel drive motor shall be an Underwriters Laboratories Recognized Component for electrical and fire safety.

K. Thermal performance shall be certified by the wheel manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment.

2.17 DDC TEMPERATURE CONTROL SYSTEM

A. General Description

1. Each unit shall be furnished complete with all operations controls compatible with the BAS via BACnet MSTP integration. These controls include the hardware and software required to operate the factory built rooftop unit (RTU) according to the sequence of operations specified in other Division 23 Sections and as shown on the drawings. Each of the RTU local DDC controllers shall be integrated into the temperature control system specified in other Division 23 Sections. The equipment manufacturer is responsible for all wiring in the RTU.
2. The RTU manufacturer shall supply and wire the local controller for the RTU. The RTU manufacturer shall factory install the controller in each RTU.
3. All input, output and DDC local devices are to be factory installed and wired, except the room thermostat/sensor, and supplied to the RTU manufacturer by the contractor supplying the local controller. All the devices in the RTU shall comply with the requirements of the temperature control specification in Division 23. Room temperature sensors shall be furnished and installed by the control contractor connected to the local controller at the RTU.
4. See drawings and Division 23 for control diagrams, points list and sequence of operation. Additional sensors shall be by temperature control contractor and shall be factory installed by the RTU manufacturer.
5. Outside airflow measuring stations shall be factory mounted and supplied by equipment manufacturer.
6. Factory-mounted and wired controls also include system on/off switches, lights and safety controls.

B. The above components are in addition to electrical components associated with other Sections, which shall be incorporated in the main control panel to facilitate maintenance and troubleshooting.

C. The following sensors shall be the minimum factory supplied, mounted, and wired inside the unit:

1. Outdoor air humidity sensor.
2. Outdoor air temperature sensor.
3. Supply air filter pressure monitoring switch and/or magnehelic gauge.
4. Energy wheel rotation sensor.
5. Condensate overflow switch

D. The following devices shall be the minimum factory-supplied for field installation and wiring:

1. Supply air temp temperature sensor.
2. Space static pressure sensor.
3. Supply duct static pressure sensor.

2.18 ADDITIONAL ITEMS

A. Provide GFI service outlets with separate transformers so that circuit is energized even when main disconnect is off.

B. All motors and electric devices shall be separately fused for over-current protection to minimize total unit out of service conditions. Fuses shall be integral to the unit.

C. Internal wiring for all electrical devices/controls shall be properly sized for ampacity and to match connections without damaging/stripping the conductor.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation, tolerances and other conditions affecting performance of RTUs.

B. Examine roughing-in for RTUs to verify actual locations of piping and duct connections before equipment installation.

C. Examine roof condition before RTUs are installed. Document any defects and deficiencies.

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

3.2 CONNECTIONS

A. Handle and install units and accessories in accordance with the manufacturer's printed instructions for the model.

B. Provide "P" trap at condensate drain sized to allow for units pressure and pipe over to nearest roof drain receptor.

C. Duct connection requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
3. Connect supply ducts to RTUs with flexible duct connectors specified in Division 23 Section "Air Duct Accessories". Make new connections to each individual zone duct with flexible ductwork connection.
4. Install return-air duct continuously through roof structure.

3.3 CLEANING

A. After completing installation, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes including chips, scratches, and abrasions.

B. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face; comb coil fins.

C. After completing system installation and testing, adjusting, and balancing RTU and air-distribution systems, clean filter housings and install new filters.

3.4 CONTRACTOR STARTUP AND REPORTING

A. Manufacturer's Field Service: Engage a factory-authorized service representative to observe unloading and placement of unit and inspect, test, and adjust components, assemblies, equipment installations, and connections including piping, ductwork and electrical connections. Report results in writing with recommendations for corrective action.

B. Perform tests and inspections and prepare test reports. All testing and inspection requirements identified in this document or required as part of the manufacturer’s startup shall be documented in writing.

C. Final Checks Before Start-Up: Perform the following operations and checks before start-up; document in writing.

1. Verify that shipping bolts, blocking, tie-down straps and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections for piping, ductwork, and electrical are complete.
3. Verify proper thermal overload protection is installed in motors, starters, and disconnects.
4. Perform cleaning and adjusting.
5. Disconnect fan drive from motor, verify proper motor rotation direction and verify fan wheel free rotation and smooth bearings operations. Reconnect fan drive system, align belts, and install belt guards.
6. Lubricate bearings, pulleys, belts, and other moving parts with factory-recommended lubricants.
7. Comb coil fins for parallel orientation.
8. Install clean filters.
9. Verify manual and automatic volume controls, and fire dampers in connected ductwork systems are in the full-open position.
10. Disable automatic temperature control operators.

D. Tests and Inspections:

1. After installing RTUs and after electrical circuitry has been energized, test units for compliance with requirements.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

    a. Energize motor, verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated RPM.
    b. Replace fan and motor pulleys as required to achieve design conditions.
    c. Measure and record motor electrical values for voltage and amperage

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
4. Shut unit down and reconnect automatic temperature control operators.

E. Remove and replace malfunctioning units and retest as specified above.

F. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for Procedures for air-handling-system testing, adjusting, and balancing

G. Engage a factory-authorized service representative to perform startup service.

H. Complete installation and startup checks according to manufacturer's written instructions and do the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to furnace combustion chamber.
3. Inspect for visible damage to compressor, coils, and fans.
4. Inspect internal insulation.
5. Verify that labels are clearly visible.
6. Verify that clearances have been provided for maintenance.
7. Verify that controls are connected and operable.
8. Verify that filters are installed.
9. Clean condenser coil and inspect for construction debris.
10. Clean furnace flue and inspect for construction debris.
11. Connect and purge gas line.

12. Remove packing from vibration isolators.
13. Verify lubrication on fan and motor bearings.
14. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
15. Adjust fan belts to proper alignment and tension.
16. Start unit according to manufacturer's written instructions.

    a. Start refrigeration system.
    b. Do not operate below recommended low-ambient temperature.
    c. Complete startup sheets and attach copy with Contractor's startup report.

17. Inspect and record performance of interlocks and protective devices; verify sequences.
18. Operate unit for an initial period as recommended or required by manufacturer.
19. Calibrate thermostats.
20. Adjust and inspect high-temperature limits.
21. Inspect dampers for proper stroke.
22. Start refrigeration system and measure and record the following when ambient is a minimum of 15 deg F above return-air temperature:

    a. Coil leaving-air, dry- and wet-bulb temperatures.
    b. Coil entering-air, dry- and wet-bulb temperatures.
    c. Outdoor-air, dry-bulb temperature.
    d. Outdoor-air-coil, discharge-air, dry-bulb temperature.

23. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown. (in conjunction with contractor supplying local controller)
24. Measure and record the following minimum and maximum airflows and plot fan volumes on fan curve. This is to be done by a Testing and Balance Certified Contractor according to Division 23 requirements.

    a. Supply-air volume.
    b. Exhaust-air volume.
    c. Relief-air volume.
    d. Outdoor-air intake volume.

25. Simulate maximum cooling demand and inspect the following:

    a. Compressor refrigerant suction and hot-gas pressures.
    b. Short circuiting of air through condenser coil or from condenser fans to outdoor-air intake.

26. Verify operation of remote panel including failure modes. Inspect the following:

    a. Low-temperature safety operation.
    b. Filter high-pressure differential alarm.
    c. Economizer to minimum outdoor-air changeover.
    d. Relief-air fan operation.
    e. Smoke and firestat alarms.

27. After startup and performance testing and prior to preliminary acceptance, contractor shall replace existing filters with new filters.

3.5 DEMONSTRATION AND COMMISSIONING

A. Arrange for a factory-authorized service representative to train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, maintenance,

preventative maintenance, and how to obtain replacement parts. The training will occur after the startup report has been provided to the Owner. The trainer shall provide four (4) Installation and Operations Manuals (IOM) for the use of the Owner's personnel during training. Training shall also follow the requirements of Division 01 Sections "Operation and Maintenance" and "Demonstration and Training."

B. Review data to familiarize Owner's personnel with contents of IOM and Operating and Maintenance Data specified in Division 01 Section "Project Closeout". All required and recommended maintenance shall be reviewed as well as operational troubleshooting. Provide a written troubleshooting guide if the IOM does not include one.

C. Schedule training with Owner, through AOR/EOR, with at least seven days' advance notice.

D. Demonstrate proper operation of equipment to commissioning agent or designated Owner's personnel. The scope of the demonstration shall include functional performance requirements under both local and building automation control as well as any commissioning requirements in Division 01 and 23. Manufacturer's representative shall participate in all commissioning activities related to the RTU, including demonstration by contractor supplying local controller.

END OF SECTION

SECTION 238126 - SPLIT-SYSTEM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes split-system air-conditioning units consisting of separate evaporator-fan and compressor-condenser components.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

1. Include documentation on refrigerants, including printed statement that refrigerants are free of HCFCs.

B. LEED Submittals:

1. Product Data for Credit EA 4: Refrigerants documentation including printed statement that refrigerants are free of HCFCs.

C. 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.

D. Field quality-control reports.

E. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

F. Recording(s) of training session(s).

G. Warranty: Sample of special warranty.

1.3 QUALITY ASSURANCE

A. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-most current version.

1.4 COORDINATION

A. Ground-Mounted Remote Condensing Units: Coordinate sizes and locations of concrete bases with actual equipment provided.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.

1. Warranty Period:

a. Compressor: Six years from date of Preliminary Acceptance or Substantial Completion.
b. Parts: One year from date of Preliminary Acceptance or Substantial Completion.

1.6 EXTRA MATERIALS

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

1. Filters: One set for each fan coil.

1.7 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 9100 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 9100 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Trane Mitsubishi Electric
2. Daikin

2.2 INDOOR UNITS (5 TONS OR LESS)

A. Wall-Mounted, Evaporator-Fan Components:

1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 210/240.
3. Fan: Direct drive, centrifugal.
4. Fan Motors:

a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Division 23.
b. Multi-tapped, multi-speed with internal thermal protection and permanent lubrication.
c. Enclosure Type: Totally enclosed, fan cooled.
d. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
e. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.
f. Mount unit-mounted disconnect switches on exterior or interior of unit.

5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-latest edition.
6. Condensate Drain Pans:

    a. Fabricated with one or two percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends), and to direct water toward drain connection.

        1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1-latest edition.
        2) Pan Depth: 1 inch, minimum.

    b. Single-wall, insulated or covered from room, non-corrosive non-condensing with moisture tight seal.
    c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.

        1) Minimum Connection Size: 3/4".

7. Air Filtration Section:

    a. Comply with NFPA 90A.
    b. Minimum Arrestance: According to ASHRAE 52.1 and MERV according to ASHRAE 52.2.
    c. 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.
    d. Disposable Panel Filters:

        1) Thickness: 1 inch.
        2) Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, and hinged; with pull and retaining handles.

2.3 OUTDOOR UNITS (5 TONS OR LESS)

A. Air-Cooled, Compressor-Condenser Components:

1. Casing: Steel, finished with baked enamel, in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.

    a. Compressor Type: Scroll.
    b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
    c. Refrigerant Charge: R-407C or R-410A as scheduled.
    d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid sub-cooler. Comply with ARI 210/240.

3. Fan: Aluminum-propeller type, directly connected to motor.
4. Motor: Permanently lubricated, with integral thermal-overload protection.
5. Low Ambient Kit: Permits operation down to -20 deg F.
6. Mounting Base: Polyethylene.

2.4 ACCESSORIES

A. Thermostat: Low voltage with sub-base to control compressor and evaporator fan.

1. Compressor time delay.
2. 24-hour time control of system stop and start.
3. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
4. Fan-speed selection including auto setting.

B. Automatic-reset timer to prevent rapid cycling of compressor.

C. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.

D. Drain Hose: For condensate.

E. Condensate Pump: If required to lift cooling coil condensate.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Install ground-mounted, compressor-condenser components on 4-inches thick, reinforced concrete base that is 4 inches larger, on each side, than unit, with cast-in anchor-bolt inserts. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-In-Place Concrete."

D. Install and connect pre-charged refrigerant pipes to component's fittings. Install pipes to allow access to unit.

E. Provide refrigerant valves, filters, and appurtenances, per manufacturer’s requirements for low ambient controls and section 23 23 00 refrigerant piping.

3.2 PIPE CONNECTIONS

A. Pipe installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Pipe installations shall allow space for service and maintenance of system components.

3.3 FIELD QUALITY CONTROL

A. 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. Leak Test: After installation, charge system and test for leaks. Repair leaks and repeat test until no leaks exist.

2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Controls and Safeties: Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

B. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 9100 Commissioning.

3.5 TRAINING AND DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain unit as specified below:

1. Train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining system components. The training will occur after the startup report has been provided to the Owner and the trainer will provide four Installation and Operation manuals for the use of the Owner's personnel during training.
2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational troubleshooting. If the IOM does not include a written troubleshooting guide, one will be provided.
3. Schedule training with Owner, through Architect, with at least seven days advance notice.

B. Demonstrate proper operation of equipment to commissioning agent, if one, and designated Owner's personnel. The scope of the demonstration shall include functional performance requirements under local control as well as any commissioning requirements in Division 01 and 23.

C. Video record the training session(s). The manufacturer may submit a standard training video or training CD for review as an alternate to recording of the training session. The standard video must be reviewed and accepted by the Owner and Commissioning Authority, if one, for the alternate to be acceptable.

D. Training of the Owner's operation and maintenance personnel is required in cooperation with the Commissioning Authority. The instruction shall be scheduled in coordination with the Commissioning Authority after submission and approval of formal training plans. Refer to Demonstration and Training, Section 01 7900, for contractor training requirements. Refer to Section 01 9100 and the Commissioning Plan for further contractor training requirements.

3.6 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 9100. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 238127 - VARIABLE REFRIGERANT FLOW SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes variable refrigerant flow systems consisting of remote air-cooled heat pump systems, heat recovery systems, fan coil units, and controllers.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

1. Include documentation on refrigerants, including printed statement that refrigerants are free of HCFCs.

B. Manufacturer shall provide a listing of all deviations from the designed system including equipment quantities, heating/cooling capacities, efficiency ratings, pipe routing, power requirements, accessories, refrigerant weights, etc. Provide a redline markup of this specification section identifying any additional deviations or exceptions from the contract documents

C. Refrigerant Verification Requirements

1. Manufacturer shall review the refrigerant quantities of their systems and confirm compliance with the latest editions of ASHRAE 15 and the local Mechanical Code. This includes verification that the refrigerant weights of each system do not exceed the maximum amount of refrigerant indicated in these codes and standards.
2. If a manufacturer's system exceeds the maximum amount of refrigerant then the manufacturer shall be responsible for the cost of all additional equipment and devices required to comply with the local code requirements of "Machinery Rooms". This room classification shall include, but is not limited to, a dedicated exhaust system and refrigerant monitoring devices.
3. Additional work as a result of a failure to review these requirements shall be the responsibility of the contractor and not result in additional costs to the Owner
4. Manufacturer review shall be conducted and submitted to the EOR at the time of bid.
5. Provide verification of refrigerant compliance of each system using the following table.

Refrigerant Compliance Table											
Refrigerant System Tag	Total Refrigerant Largest Refrigerant Circuit + Refrigerant in System (lbs)	Largest Refrigerant Circuit (lbs)	Refrigerant in System (lbs)	Refrigerant Type and Classification	Maximum Refrigerant Requirement (lbs per 1,000 CF)	Worst Case Room Name	Worst Case Room Name Room Volume (CF)	Actual Pounds of Refrigerant per Cubic Foot (lbs/CF)	Complies with ASHRAE 15	Complies with Local Code	Notes
HP-##	##.#	##.#	##.#	R-410A/ A1	26	MECH RM ###	###	##.#	Yes or No	Yes or No	1,2

Notes:

1. Refrigerant in System is the calculated refrigerant in the piping system and connected equipment.

2. Total Refrigerant in calculation includes the largest refrigerant circuit and the refrigerant in the system.

D. Delegated Design Submittal

1. For the design of a VRF system, including analysis data signed and sealed by the qualified professional engineer.
2. Design Calculations - Calculate requirements for selecting indoor and outdoor units and refrigerant piping sizing and refrigerant charging, as well as system controls components selections.
3. Unless otherwise noted, all fan coil units shall be selected for the following entering air conditions:

    a. Cooling: 72°F Dry-Bulb, 60°F Wet-Bulb
    b. Heating: 68°F Dry-Bulb

4. Product Data: Submit pipe materials and joining methods.
5. Design Criteria: Submit manufacturer's pipe design guidelines and installation instructions.
6. Shops Drawings: Contractor shall submit scaled drawings (¼" = 1') that include the refrigerant pipe layout including pipe sizes, joint construction, hangers and supports to comply with manufacturer's performance requirements and engineer's design criteria.

    a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

7. Wiring Diagrams: For power, signal, and control wiring.
8. Piping diagrams showing pipe sizes, riser locations, and total system refrigerant weight (lbs).
9. Manufacturer Review: Documents submitted shall be reviewed by the manufacturer for compliance with their guidelines and installation methods prior to being submitted. A written letter of compliance shall be submitted on the manufacturer's company letterhead.

E. Contractor Requirements

1. System shall be installed only by a contractor that has completed manufacturer authorized installation and service training. The representative shall provide proof of certification for training indicating successful completion within not more than two (2) years prior to system installation. The contractor shall have completed no less than five (5) projects of 50 tons or greater, submit references for each project. This certification shall be included as part of the equipment and/or controls submittals. On-site contractor training is not allowed.

F. LEED Submittals:

1. Product Data for Credit EA 4: Refrigerant documentation including printed statement that refrigerants are free of HCFCs.

G. Field quality-control reports.

H. Operation and Maintenance Data: Include emergency, operation, and maintenance manuals.

I. Video recording(s) of training session(s).

J. Warranty: Sample of equipment warranty.

1.3 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in National Electric Code, by a qualified testing agency, and marked for intended location and application. The units shall be listed by Electrical Testing Laboratories (ETL) and bear the ETL label

B. ASHRAE Compliance:

1. Applicable requirements in ASHRAE/IESNA 90.1 efficiency requirements for VRF systems. Efficiency shall be published in accordance with the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 1230.
2. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
3. Applicable requirements in ASHRAE 62.1-latest edition, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - " Procedures," and Section 7 - "Construction and System Start-Up."

C. All wiring shall be in accordance with the National Electrical Code (N.E.C.).

1.4 COORDINATION

A. Ground-Mounted Heat Pump Units: Coordinate sizes and locations of concrete bases with actual equipment provided.

1.5 WARRANTY

A. The equipment shall be covered by the manufacturer’s limited warranty on parts for a period of ten (10) years from the date of startup. Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within specified warranty period. Contractor shall additionally provide warranty as follows:

1. Parts and labor: One (1) year from date of Substantial Completion on the entire units and five (5) years on compressors.

1.6 EXTRA MATERIALS

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

B. Provide one extra air filter for each fan coil to be installed after construction.

1.7 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 9100 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 9100 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The design is based on the variable refrigerant flow (VRF) air conditioning systems as manufactured by *BASIS OF DESIGN MANUFACTURER,* Trane - Mitsubishi Electric as listed on drawing schedules

B. Approved Equal Acceptable Alternate Systems, assuming adherence to contract documents (drawings and specifications).

1. Comparable VRF Systems to the basis of design equipment scheduled on the drawings meeting similar design performances and efficiencies, electrical power requirements, dimensions, and weight, will be considered on a case-by-case basis by the Construction Manager and Engineer of Record. All submitted equipment must meet the warranty requirements as listed in this section.
2. Prior to submittal review and acceptance, alternate manufacturer's representative shall provide references for a minimum of five (5) projects of similar size or 50 tons and greater installed in the last two (2) years in the greater Philadelphia area.

C. Alternate equipment manufacturer shall provide the bidding mechanical contractor a complete equipment package. If an alternate manufacturer is selected, the contractor shall be responsible for all costs related to providing additional piping, accessories, devices, controls, etc. as required for a complete installation of the system.

1. Work as a result of additional equipment, different electrical requirements, alternate control wiring requirements, alternate piping arrangements shall not result in additional costs to the Owner for any of the following:
   a. Electrical Contractor.
   b. Controls.
   c. Space requirements.
   d. Piping arrangement,
   e. Rapid changeover: System shall allow automatic and alternating mode switching between heating and cooling mode during using agency-defined and adjustable ambient temperature ranges. Systems having changeover sequences which might result in more than one hour delay for the desired heating or cooling will not be accepted.

D. Additional Requirements for Heat Recovery Systems:

1. Systems must be capable of heat recovery (simultaneous heating and cooling).
2. Systems shall consist of a three-pipe refrigeration distribution system; a dedicated hot gas pipe shall be required to ensure optimum heating operation performance.
3. Two-pipe, heat recovery systems utilizing a lower temperature mixed liquid/gas refrigerant to perform heat recovery are acceptable provided that the systems are sized to meet the scheduled heating and cooling capacities.

2.2 AIR-COOLED HEAT PUMPS

A. General: Air-cooled heat pump modules shall be completely factory assembled, piped and wired and run tested at the factory. The casing(s) shall be fabricated of galvanized steel, bonderized and completely finished.

1. All units requiring a factory supplied twinning kits shall be piped together in the field, without the need for an equalizing line(s).
2. Heat pump unit shall have a sound rating no higher than 65 dB(A) individually.
3. Refrigerant lines from the heat pump to the indoor components shall be insulated in accordance with manufacturers installation manual or the local energy code whichever is more stringent.
4. The heat pump shall have an accumulator with refrigerant level sensors and controls.
5. The heat pump shall have a high-pressure safety switch, over-current protection, crankcase heater and DC bus protection.
6. Heat pumps located indoors and shall be ducted to the outdoors. The unit shall be capable of continuous operation and provide full heating capacity at the room's designs space temperature.
7. The heat pumps shall have a nominal heating operating down to -4°F ambient temperatures and cooling mode up to 122°F without additional restrictions on line length and vertical separation beyond those published in respective product catalogs. Models with capacity data for required temperature range published as "for reference only" are not considered capable of continuous operation and are not acceptable.
8. The outdoor unit shall have a high efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained. Provide hot gas defrost.
9. The condensing unit shall have the ability to connect an indoor unit evaporator capacity of up to 200% of the condensing unit capacity.
10. Operation of Heat Recovery Heat Pump systems shall permit either individual cooling or heating of each indoor unit simultaneously or all of the indoor units associated with each branch of the branch selector box.
11. Defrost Heating – Heat pump systems shall maintain continuous heating during defrost operation. Reverse cycle (cooling mode) defrost operation shall not be permitted due to the potential reduction in space temperature.

B. Fan: Each heat pump unit module shall be furnished with one direct drive, variable speed propeller type fan.

C. Ducted Units: The fan shall be set to operate at external static pressure required to accommodate the field connected ductwork and filters.

1. All fan motors shall have inherent protection, have permanently lubricated bearings, and be completely variable speed.
2. Night setback control of the fan motor for low noise operation by way of automatically limiting the maximum speed shall be a standard feature. Operation sound level shall be selectable from 3 steps.

D. Coil: The heat pump heat exchanger shall be of zinc coated aluminum construction with turbulating flat tube construction. The coil fins shall have a factory applied corrosion resistant blue-fin finish. Uncoated aluminum coils/fins are not allowed. The coil shall be protected with an integral metal guard.

1. Refrigerant flow from the outdoor unit shall be controlled by means of an inverter driven compressor. The outdoor coil shall include 4 circuits with two position valves for each circuit, except for the last stage.

E. Compressor: Each heat pump unit module shall be equipped with all inverter driven scroll hermetic compressors. Non inverter-driven compressors, which may cause inrush current (demand charges) are not permitted.

1. Crankcase heat shall be provided via induction-type heater utilizing eddy currents from motor windings. Energy-wasting “belly-band” type crankcase heaters are not allowed.
2. The outdoor unit compressor shall have an inverter to modulate capacity. The capacity shall be completely variable with a turndown of 15%-5% of rated capacity, depending upon unit size. The compressor shall be equipped with an internal thermal overload.
3. Compressors shall be spring mounted to prevent transmission of vibration.
4. In the event of compressor failure, the remaining compressors shall continue to operate and provide heating or cooling as required at a proportionally reduced capacity.

F. Piping: The piping system shall be connected with manufacturer provided engineered joints and headers to ensure correct refrigerant flow and balancing. T-style joints are not acceptable.

G. Refrigerant: Each unit shall be factory charged with R-410A refrigerant. Contractor shall provide additional refrigerant charge if required.

1. Polyol-ester (POE) oil shall be used in the units. If an alternate oil is used, submit material safety data sheets (MSDS) and comparison of hygroscopic properties with list of local suppliers stocking alternate oil for approval at least two weeks prior to bidding.

H. Electrical: The outdoor unit electrical power shall be capable of satisfactory operation within voltage limits.

2.3 BRANCH SELECTOR BOXES FOR HEAT RECOVERY HEAT PUMP SYSTEMS

A. General: Branch selector boxes shall be provided for use with heat recovery heat pump systems. These shall be factory assembled, wired, piped, and tested.

B. Install branch selector boxes indoors.

C. When simultaneously heating and cooling, the units in heating mode shall energize their sub-cooling electronic expansion valve.

D. These units shall have a galvanized steel plate casing.

E. The cabinet shall contain one sub cooling heat exchanger per branch.

F. The unit shall have sound absorption thermal insulation material made of flame and heat resistant foamed polyethylene.

G. Refrigerant Valves:

1. The unit shall be furnished with 3 electronic expansion valves per branch to control the direction of refrigerant flow. The use of solenoid valves for changeover and pressure equalization shall not be acceptable due to refrigerant noise.
2. The refrigerant connections must be of the braze type.
3. In multi-port units, each port shall have its own electronic expansion valves. If common expansion/solenoid valves are used, redundancy must be provided.

H. Condensate Removal: The unit shall not require provisions for condensate removal. A safety device or secondary drain pan shall be installed by the mechanical contractor. If manufacturer, requiring condensate removal is submitted, include provisions for condensate piped to nearest floor drain in a non-public space. Condensate piping in finished spaces is not acceptable and may require the contractor to provide a loose condensate pump.

I. Supplemental Connections: Each branch selector unit shall include at least one (1) unsused port for future connections.

2.4 WALL MOUNTED DUCTLESS FAN COIL UNITS

A. General: Fan coil units shall be wall mounted and shall have a modulating linear expansion device and a flat front. The indoor fan coil units shall be assembled, wired and run tested in the factory. All casings shall have the same white finish. Multi directional drain and refrigerant piping offering four (4) directions for refrigerant piping and two (2) directions for draining shall be standard. There shall be a separate back plate which secures the unit firmly to the wall

1. Each unit shall contain piping, electronic modulating linear expansion device, control circuit board and fan motor complete with all wiring. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

B. Fan: The fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.

1. A manual adjustable guide vane shall be provided with the ability to change the airflow from side to side (left to right).
2. A motorized air sweep louver shall provide an automatic change in airflow by directing the air up and down to provide uniform air distribution.

C. Coil: The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phos-copper or silver alloy. The coils shall be pressure tested at the factory.

1. A condensate pan and drain shall be provided under the coil. Both refrigerant lines and condensate drain line shall be insulated.

D. Filter: Return air shall be filtered by means of an easily removable, washable filter.

E. Condensate Pump: Each indoor fan coil unit shall be provided with a built-in condensate removal pump. Pump shall be factory wired and piped. If pump is not available by the manufacturer, the contractor shall provide a field installed condensate pump. Pump unit shall be wired from associated fan coil unit electrical circuit. Furnish line set cover for refrigerant piping, condensate piing, and condensate pump.

2.5 CEILING RECCESSED CASSETTE

A. General:

1. The ceiling cassette shall be a 24" x 24" or 36" x 36" ceiling cassette style indoor unit that recesses into the ceiling with a ceiling grille. The ceiling cassette shall be field configurable for directional air flow patterns per the installation requirements. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, an emergency operation function, a test run switch, and the ability to adjust airflow patterns for different ceiling heights. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

B. Unit Cabinet:

1. The cabinet shall be space-saving ceiling-recessed cassette.
2. The cabinet panel shall have provisions for a field installed filtered outside air intake.
3. Each decoration grilles shall be fixed to bottom of cabinet allowing field adjustable two-way, three-way, four-way blow.
4. The grille vane angles shall be individually adjustable from the wired remote controller to customize the airflow pattern for the conditioned space

C. Fan:

1. The indoor fan shall be an assembly with a turbo fan direct driven by a single motor.
2. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
3. The indoor fan shall consist of minimum three (3) speed settings, Low, Medium and High.
4. The fan shall have a selectable Auto fan setting that will adjust the fan speed based on the difference between controller set-point and space temperature.
5. The indoor unit shall have switches that can be set to provide optimum airflow based on ceiling height and number of outlets used.
6. The vanes shall have an Auto-Wave selectable option in the heating mode that shall randomly cycle the vanes up and down to evenly heat the space.

D. Filter:

1. Return air shall be filtered by means of a long life washable filter.

E. Coil:

1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
2. The tubing shall have inner grooves for high efficiency heat exchange.
3. All tube joints shall be brazed with phos-copper or silver alloy.
4. The coils shall be pressure tested at the factory.
5. A condensate pan and drain shall be provided under the coil.

F. The unit shall be provided with an integral condensate lift mechanism that will be able to raise drain water 33 inches above the condensate pan.

G. Electrical: The unit electrical power shall be as scheduled on the drawings. The system shall be capable of satisfactory operation within voltage limits.

2.6 SUSPENDED DUCTED FAN COIL UNIT

A. General:

1. The ducted fan coil units shall be a ceiling-concealed ducted indoor unit with integral 2” MERV 13 filter box. The indoor fan coil unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, an emergency operation function and a test run switch. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

B. Unit Cabinet:

1. The cabinet shall be located into the ceiling and ducted to the supply and return openings.
2. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

C. Fan:

1. The fan shall be direct-drive DC (ECM) type fan, statically and dynamically balanced impeller with three fan speeds available.
2. The unit shall be equipment with automatically adjusting external static pressure logic selectable during commissioning. This logic shall assure specified air flow is being delivered to the space according to as-built duct work static.
3. The airflow rate shall be available in three settings.
4. The fan motor shall be thermally protected.
5. The fan motor shall be equipped as standard with adjustable external static pressure (ESP) settings.
6. Fan motor external static pressure range for nominal airflow

D. Filter Box:

1. The unit manufacturer shall provide a shipped loose return air filter box to be rigidly coupled to the ducted fan coil units. The return air shall be filtered by means of a high efficiency disposable MERV 13 filters.

E. Coil:

1. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
3. The coil shall completely factory tested.
4. The refrigerant connections shall be braze connections and the condensate will be 1-1/4” outside diameter PVC.
5. A condensate pan shall be located under the coil.
6. A condensate pump with an 18-3/8” lift shall be located below the coil in the condensate pan with a built in safety alarm.
7. A thermistor will be located on the liquid and gas line.

2.7 CONTROLS

A. General: Provide manufacturer packaged master central controller (with touch-screen graphical interface) capable of supporting remote controllers, an integrated web based interface, graphical user workstation, and system integration to Building Management Systems via BACnet.

1. The outdoor unit shall be controlled by integral microprocessors. The control circuit between the indoor units and the outdoor unit shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.
2. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of compensation shall be possible for individual indoor units (to accommodate instances when compensation is not required).

    a. Provide a complete control package that shall consists of Centralized Controller, Expansion Controller and Advanced HVAC Controllers with instructions and wiring diagrams. These must be capable to supporting all the controllers in the project. Control power shall be provided by an integrated 100-240 VAC power supply.

3. The Controllers shall support system configuration, daily/weekly scheduling, monitoring of operation status, free contact interlock configuration and malfunction monitoring. Centralized Controller shall have basic operation control authority which can be applied to an individual indoor unit, a collection of indoor units (up to 50 indoor units), or all indoor units (collective batch operation); this basic set of operation controls for the Centralized Controller shall include on/off, operation mode selection (cool, heat, auto (heat recovery systems only), dry, and fan), temperature setting, fan speed setting, and airflow direction setting.
4. Controllers shall be able to enable or disable operation of local remote controllers. Centralized Controller shall allow the user to define both daily and weekly schedules (up to 24 scheduled events per day) with operations consisting of ON/OFF, mode selection, temperature setting, air flow (vane) direction, fan speed, and permit/prohibit of remote controllers.
5. Controllers shall be capable of performing/changing initial settings via the panels on the controllers themselves or via a PC browser using the initial settings. Include standard software functions for the building manager to securely log into each central controller via the pc's web browser to support operation monitoring, scheduling, error email, interlocking and online maintenance diagnostics.

B. Additional software function for tenant billing shall be included. The tenant billing function shall require specialized integrated system software in conjunction with the centralized controllers. Tenant billing "charge" calculates per tenant energy usage in kwh and uses user inputs monetary amount based on the energy consumption of the outdoor unit(s) divided among the associated indoor units requires software on local monitoring PC (PC furnished by using agency) connected to a local electric meter. Furnish watt hour meters as required for the intended electrical panel configuration and layout.

C. Additional software function for heat pump systems. Provide voting system that allows heat pump system to alternate between heating and cooling to satisfy the demand of heating and cooling in different zones.

D. Indoor Unit Remote Controllers: Backlit, wall-mount remote controllers shall be provided for each indoor unit. Controller shall be compact in size (approximately 3" x 5"), display temperature selection in Fahrenheit or Celsius, and allow the user to change temperature setting, and fan speed setting and airflow direction. Controller must be capable of sensing room temperature. The Backlit Remote Controller shall display a four-digit error code in the event of system abnormality/error.

E. Each indoor unit shall be able to provide set temperature independently via a local remote controller, an Intelligent Manager Controller

F. Wiring: The controls network shall operate at 24-30VDC. Controller power and communications shall be via a common non-polar communications bus. Control wiring shall be installed in a daisy chain configuration from indoor air conditioning units, to the condensing units and to the controllers. Control wiring to remote controllers shall be run from the indoor unit terminal block to the controller associated with that unit. Wiring shall be 2-conductor (16 AWG), twisted, stranded, shielded wire as defined by the Diamond System Builder output. Network wiring shall be CAT-5 with RJ-45 connection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install units level and plumb.

B. Install ground-mounted, compressor-condenser components on 4-inches thick, reinforced concrete base that is 4 inches larger, on each side, than unit, with cast-in anchor-bolt inserts. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-In-Place Concrete." Install units a minimum of 18 inches above the concrete base on equipment supports.

C. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

D. Install and connect pre-charged refrigerant pipes to component's quick-connect fittings. Install pipes to allow access to unit.

E. Provide manual shutoff valves at each fan coil unit.

3.2 PIPE CONNECTIONS

A. Follow manufacturer’s recommendations for piping installation. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Piping to use nitrogen purge prior to charging.

C. Pipe installations shall allow space for service and maintenance of system components.

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service Pre-Installation Meeting

1. The VRF manufacturer local representative’s certified VRF field supervisor/project manager shall hold a pre-installation coordination meeting with the mechanical contractor, electrical contractor, BAS contractor and general contractor/construction manager to review the final approved VRF system design submittals, wiring requirements, piping requirements, insulation requirements, project specific installation requirements and all installation procedures. Provide meting minutes to AE as a submittal prior to proceeding with installation.
2. The VRF manufacturer local representative’s certified VRF field supervisor/project manager shall visit the project site once per week (minimum) throughout the duration of the VRF system(s) installation to review contractor compliance with all VRF manufacturer installation requirements. Submit weekly reports to AE for review.

B. Manufacturer's Field Inspections

1. The VRF manufacturer local representative's certified VRF field supervisor/project manager shall visit the project site every two (2) weeks (minimum) throughout the duration of the VRF system(s) installation to review contractor compliance with all VRF manufacturer installation requirements. Provide filed report to AE for review.

C. Tests and Inspections:

1. Pressure/Leak Tests: After installation, pressure test system with nitrogen per manufacturer installation guidelines.
2. Vacuum Tests: Prior to charging, draw system into vacuum per manufacturer installation guidelines.
3. Charging: Refrigerant shall be precisely weighed during charging to ensure the correct system charge as required by the manufacturer.
4. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
5. Controls and Safeties: Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

3.4 VRF SYSTEM START-UP AND COMMISSIONING

A. General:
1. The VRF manufacturer local representative's certified VRF field supervisor/project manager shall oversee and assist the installing contractor with the startup and commissioning of VRF equipment as outlined below. This process will be completed in two phases. Phase one shall cover the Pre-Start-Up inspection process, Phase two shall cover the Physical Start-Up & Commissioning of Equipment.
2. All VRF System Commissioning activities shall be completed by an employee of the VRF manufacturer's local rep whose primary job responsibilities are to provide start up and commissioning of their products. Sales staff or in-house support staffs are not permitted to complete this scope of work.
3. A factory certified representative may assist the VRF manufacturer's local representative personnel in the completion of certain elements of work contained within this specification. Activities completed by a Factory Certified Representative shall be supervised onsite by the VRF manufacturer's local representative. Certified representatives shall not be used in lieu of the manufacturer's representative personnel.
4. The installing contractor shall have been certified by the manufacturer to install VRF systems, having attended a minimum 3- day VRF Service & Installation course at an approved training center. A copy of this certificate shall be presented as part of the VRF equipment submittal process.
5. The installing contractor shall assist the VRF manufacturer's local rep in their completion of the system review and have available a technician with appropriate diagnostic tools, materials and equipment, as required, for the duration of the inspection process. The technician shall be fully licensed and insured to complete necessary duties as directed under the supervision of the VRF manufacturer.
6. The manufacturer's local rep shall record a minimum of 24 hours of system operation. The operation shall be reviewed by the manufacturer's local rep and summary provided in formal summary report included with post start-up documentation.
7. Upon completion of the Equipment Start-Up & VRF Commissioning process, the VRF manufacturer's local rep shall provide a formal report outlining the status of the system, in electronic format only. Contained within this report shall be copies of all field inspection reports,

required action items and status, Manufacturer's design software As-Built, equipment model & serial numbers.

8. Completion of the Equipment Start-Up and VRF Commissioning process shall verify that the VRF system has been installed per the Engineer's design intent and complies with the VRF manufacturers engineering and installation specifications related to their equipment.
9. Compliance with federal, state and local codes as well as other authorities having jurisdictions are not part of this process and are the responsibility of the installing contractor.

B. Pre Start-Up Inspection:

1. Contractor shall employ the services of the VRF manufacturer's local rep to provide a comprehensive field review of the completed VRF system installation, prior to the physical start up and operation of equipment. Upon satisfaction that the system meets the VRF manufacturer's local rep installation requirements and specifications, the contractor shall be allowed to proceed with the physical start up and operation of equipment.

2. Prior to the pre-start-up inspection, all systems components shall be in a final state of readiness having been fully installed and awaiting inspection.

3. The installing contractor shall provide the VRF manufacturer's local rep a copy of the electronic design file used in the design and engineering process of the system being inspected. This electronic design file shall have been completed on software approved by the specified VRF manufacturer and shall have been updated to reflect as-built conditions.

4. The installing contractor shall have prepared the refrigeration piping systems per equipment installation and service manuals. All refrigerant piping systems, upon completion of assembly, shall have been pressurized to a minimum 600 psi, using dry nitrogen, and held for an uninterrupted 24HR period, with acceptable change due to atmospheric conditions.

    a. A record of the pressure check process shall be recorded and tagged at the outdoor unit. The tag shall contain the following information: date & time of pressure check start, fill pressure, outdoor temperature at start & stop, date & time of pressure check completion, and the person's full name & company information completing the pressure check.

    b. The installing contractor shall engage the General Contractor as a witness of the pressure check process, confirming that all steps and procedures related to the pressure check where properly followed and that the system held the holding pressure of 600PSI for a period of 24hr hours, with acceptable change due to atmospheric conditions. Witness information, including full name, company name, title, phone number and signature shall be recorded on same pressure tag used by installing contractor.

5. Upon completion of the 600 psi pressure check, the system shall be evacuated to a level of 500 microns, where it will be held for an uninterrupted 24 hour period with no deflection. The installing contractor shall utilize the triple evacuation method per the equipment install and service manuals.

    a. Evacuation start & stop dates, times, and persons involved shall be recorded and tagged at the outdoor equipment.

    b. Installing contractor shall digitally capture a photo of the micron gauge reading, at the conclusion of the 24 hour holding period, for each system and provide a copy to the VRF manufacturer. Each photo shall contain a tag providing the outdoor units Serial number.

c. VRF manufacturer local representative's certified VRF field supervisor/project manager shall verify system evacuation tests. Contractor shall provide written acceptance of all evacuation tests from the VRF manufacturer to the Architect/Engineer for review.

6. Upon the completion of the 500-micron hold, the calculated additional refrigerant charge can be added. The calculated refrigerant charge shall have been calculated using the VRF manufacturers design software.

   a. Total refrigerant charge of the system shall be recorded and displayed at the outdoor unit by permanent means.

7. A review of the equipment settings shall be completed, with recommendations provided to improve system performance, if applicable. Physical changes of system settings will be completed by the contractor. Electronic recording of final DIP switches shall be provided as part of the commissioning report.

8. A comprehensive review and visual inspection shall be completed for each piece of equipment following a detailed check list, specific to the equipment being reviewed. A copy of the inspection report shall be provided as part of the manufacturers close out documentation. Any deficiencies found during the inspection process shall be brought to the attention of the installing contractor for corrective action. Any system components that are not accessible for proper inspection shall be noted as such.

9. Indoor Equipment report shall contain the following:

   a. Model & Serial Number
   b. Equipment location
   c. Equipment Tag/Identification number
   d. Network Address & Port Assignment
   e. Digital recording of equipment settings
   f. Mounting/support method
   g. Seismic restraints used
   h. Proper service clearance provided
   i. Wiring and connection points are correct
   j. High voltage reading(s) within acceptable range
   k. Low voltage reading(s) within acceptable range
   l. Type of Remote Controller used and its location
   m. Occupied space temperature sensing location
   n. Air temperature readings within acceptable range
   o. Condensate pump interlock method
   p. Fan E.S.P. setting
   q. Air Filter condition
   r. Height differential setting in heat mode
   s. Noise level acceptable
   t. Refrigerant pipe connected and insulated properly
   u. Condensate pipe connected and insulated properly
   v. Condition of connected ductwork
   w. Fresh air connected
   x. Humidifier connected and checked
   y. Review of air balance report complete
   z. Other interlocked systems, i.e. baseboard heat, booster fan etc.

10. Outdoor Air Cooled equipment report shall contain the following:

a. Model & Serial Number
b. Equipment location
c. Equipment Tag/Identification number
d. Network Address & Port Assignment
e. Digital recording of equipment settings
f. Mounting/support method
g. High Wind Tethering method
h. Proper service clearance provided
i. Defrost Condensate removal addressed
j. Wiring and connection points are correct
k. High voltage reading(s) within acceptable range
l. Low voltage reading(s) within acceptable range
m. Control Network settings
n. Noise level setting
o. Refrigerant pipe installed and insulated properly
p. Low ambient operation settings

11. Physical Start-Up and Commissioning of Equipment:

    a. Upon proper equipment start up by the contractor, following the manufacturer's guidelines and specifications, an employee of the VRF manufacturer's local rep shall complete a review of the system performance and complete the following tasks:

        1) Check and confirm all communication addressing of system components.
        2) Check and confirm each indoor unit, individually, is properly piped and wired by commanding the indoor unit on, in either heat or cool mode and verifying proper response.
        3) This process shall be digitally recorded and included as part of the close out documentation.
        4) Electronically record a minimum of one-hour of operational data per refrigeration system.
        5) Electronically record selector switch positions on all indoor and outdoor equipment.
        6) The VRF manufacturer's local rep shall retain the electronically recorded data, collected during the start-up and equipment commissioning process, at a designated location within the US for future reference.

12. Close-Out Information:

    a. The VRF manufacturer local representative shall issue a System Performance report at the completion of all fieldwork. Contained within this report shall be an overview of the system performance, recommendations, field reports, all electronic data, and as-built design file.

C. Major equipment and system startup and operational tests shall be scheduled and documented in accordance with Section 01 9100 Commissioning.

3.5 TRAINING AND DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain unit as specified below:

1. Train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining system components. The training will occur

after the startup report has been provided to the Owner and the trainer will provide four Installation and Operation manuals for the use of the Owner's personnel during training.

2. Review data in maintenance manuals. Refer to Division 01 Section "Operation and Maintenance Data." All required and recommended maintenance will be reviewed as well as operational

troubleshooting. If the IOM does not include a written troubleshooting guide, one will be provided. Schedule training with Owner, through Architect, with at least (14) days advance notice.

B. Demonstrate proper operation of equipment to commissioning agent, if one, and designated Owner's personnel. The scope of the demonstration shall include functional performance requirements under local control as well as any commissioning requirements in Division 01 and 23.

C. Video record the training session(s). The manufacturer may submit a standard training video for review as an alternate to recording of the training session. The standard video must be reviewed and accepted by the Owner and Commissioning Authority, if one, for the alternate to be acceptable.

D. Training of the Owner's operation and maintenance personnel is required in cooperation with the Commissioning Authority. The instruction shall be scheduled in coordination with the Commissioning Authority after submission and approval of formal training plans. Refer to Demonstration and Training, Section 01 7900, for contractor training requirements. Refer to Section 01 9100 and the Commissioning Plan for further contractor training requirements.

3.6 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 9100. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 238239 - CABINET UNIT HEATERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes cabinet unit heaters with centrifugal fans and electric-resistance heating coils.

1.2 DEFINITIONS

A. CWP: Cold working pressure.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.

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. Plans, elevations, sections, and details.
2. Location and size of each field connection.
3. Location and arrangement of integral controls.
4. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which cabinet unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

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

6. Perimeter moldings for exposed or partially exposed cabinets.

D. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.

E. Samples for Verification: Finish colors for each type of cabinet unit heater indicated with factory-applied color finishes.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For cabinet unit heaters to include in operation and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5 DELIVERY, STORAGE AND HANDLING

A. Follow manufacturer's instructions for job site storage and protection of materials during construction.

1.6 COMMISSIONING

A. This section specifies a system or a component of a system being commissioned as defined in Section 01 9100 Commissioning. Testing of these systems is required, in cooperation with the Owner and the Commissioning Authority. Refer to Section 01 9100 Commissioning for detailed commissioning requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Electric Units:

a. Ouellet – Series OAC
b. Qmark
c. IndeecoMarley Electric Heating; a division of Marley Engineered Products
d.

2.2 CABINET UNIT HEATERS

A. Description: A factory-assembled and -tested unit complying with ARI 440.

1. Comply with UL 2021.

B. Coil Section Insulation: ASTM C 1071; surfaces exposed to airstream shall be aluminum-foil facing to prevent erosion of glass fibers.

1. Thickness: 1 inch .
2. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F mean temperature.
3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
4. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.

C. Cabinet: Steel with factory prime coating, ready for field painting.

1. Vertical Unit, Exposed Front Panels: Minimum 0.0677-inch thick, galvanized, sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
2. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0677-inch thick, galvanized, sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
3. Recessing Flanges: Steel, finished to match cabinet.
4. Control Access Door: Key operated.

5. Base: Minimum 0.0528-inch thick steel, finished to match cabinet, 6 inches high with leveling bolts.

D. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Pleated: 90 percent arrestance and 7 MERV.

E. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, embedded in magnesium oxide. Insulating refractory; and sealed in a high-mass steel or corrosion-resistant metallic sheath with fins a minimum of 0.16 inch apart. Provide 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. Fin surface temperature shall not exceed 550 deg. F at any point during normal operation.

F. Fan and Motor Board: Removable.

1. Fan: Forward curved, double width centrifugal; directly connected to motor. Provide thermoplastic or painted-steel wheels and galvanized-steel fan scrolls.
2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

G. Control devices and operational sequences are specified in Division 23 Sections "Building Automation System (BAS)" and "Building Automation System (BAS) - Sequence of Operation."

H. Basic Unit Controls:

1. Control voltage transformer.
2. Timer switch.
3. Safety-switch disconnect on cover of terminal box.
4. Mercury contactors.
5. Fan-delay relay.
6. Unit-mounted thermostat with the following features.

a. Heat-off switch.
b. Fan on-auto switch.
c. Manual fan speed switch.
d. Adjustable deadband.
e. Exposed set point.
f. Exposed indication.
g. Deg F indication.

I. Electrical Connection: Factory wire motors and controls for a single field connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for electrical connections to verify actual locations before cabinet unit heater installation.

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

3.2 INSTALLATION

A. Install wall boxes in finished wall assembly; seal and weatherproof.

B. Install cabinet unit heaters to comply with NFPA 90A.

C. Suspend cabinet unit heaters from structure with elastomeric hangers. Vibration isolators are specified in Division 23 Section " Vibration Controls for HVAC."

D. Install new filters in each unit within two weeks of Substantial Completion.

E. For suspended ceiling hung cabinet unit heaters, Install separate thermostats 5’ above finished floor.

3.3 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Conductors and Cables for Electrical Systems."

3.4 CLEANING

A. After construction and painting are completed, clean all exposed surfaces and vacuum interiors.

B. Retouch marred or scratched surfaces of cabinets. If units have factory-finished cabinets, use materials furnished by the manufacturer.

3.5 CONTRACTOR STARTUP AND REPORTING

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. 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.

C. Remove and replace malfunctioning units and retest as specified above.

D. Training of the Owner’s operation and maintenance personnel is required in cooperation with the Commissioning Authority. The instruction shall be scheduled in coordination with the Commissioning Authority after submission and approval of formal training plans. Refer to Demonstration and Training, Section 01 7900, for contractor training requirements. Refer to Section 01 9100 and the Commissioning Plan for further contractor training requirements.

3.6 DEMONSTRATION AND COMMISSIONING

A. Engage a factory-authorized service representative to train Owner’s maintenance personnel to adjust, operate, and maintain cabinet unit heaters. Refer to Division 01 Section "Demonstration and Training."

3.7 FUNCTIONAL PERFORMANCE TESTS

A. System functional performance testing is part of the Commissioning Process as specified in Section 01 9100. Functional performance testing shall be performed by the contractor and witnessed and documented by the Commissioning Authority.

END OF SECTION

SECTION 260503 - GENERAL REQUIREMENTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general administrative, material, and procedural requirements for electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 01.

1. Electrical product general requirements and accesses.
2. Substitutions.
3. Submittals.
4. Alternates.
5. Coordination drawings.
6. Record documents.
7. Maintenance manuals.
8. Rough-ins.
9. Electrical installations.
10. Cutting and patching.

1.2 DEFINITIONS

A. Definitions:

1. Listed: Equipment or materials included in a list published by an organization acceptable to the authority having jurisdiction and concerned with product evaluation, that maintain periodic inspection of production of listed equipment or materials, and whose listing states either that the equipment or material meets appropriate designated standards or has been tested and found suitable for use in a specified manner.
2. Labeled: Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.
3. General Explanation: A substantial amount of specification language consists of definitions of terms found in other Contract Documents, including Drawings. (Drawings are recognized as being diagrammatic in nature and not completely descriptive of the requirements indicated thereon). Certain terms used in Contract Documents are defined in this article. Definitions and explanations contained in this Section are not necessarily either complete or exclusive but are general for the Work to the extent that they are not stated more explicitly in another element of the Contract Documents.
4. General Requirements: The provisions or requirements of other Division 01 Sections apply to entire work of the Contract and where so indicated, to other elements which are included in the project.
5. Indicated: The term "indicated" is a cross-reference to graphic representations, notes or schedules on drawings, to other paragraphs or schedules in the specifications, and to similar means of recording requirements in the Contract Documents. Where terms such as "shown," "noted," "scheduled," and "specified" are used in lieu of "indicated," it is for purpose of helping the reader locate cross- references, and no limitation of location is intended except as specifically noted.
6. Directed, Requested, etc: Where not otherwise explained, terms such as "directed", "requested", "authorized", "selected", "reviewed", "required", "accepted", and "permitted" mean "directed by Architectural/Engineer", and similar phrases. However, no such implied meaning will be interpreted to extend the Architect/Engineer's responsibility into the Contractor's area of construction supervision.
7. Furnish: Except as otherwise defined in greater detail, the term "furnish" is used to mean supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, and similar operations, as applicable in each instance.

8. Install: Except as otherwise defined in greater detail, the term "install" is used to describe operations at the job site, including unloading, unpacking, assembly, erection, placing, anchoring, mounting, connecting, testing, protecting and cleaning, placing in working condition and similar operations, as applicable in each instance.
9. Provide: Except as otherwise defined in greater detail, the term "provide" means to furnish and install, complete and ready for intended use, as applicable in each instance.
10. Installer: The term "installer" is defined as the entity (person or firm) engaged by the contractor, its subcontractor or sub-subcontractor for performance of a particular unit of work at the project site. It is a general requirement that such entities (installers) be expert in the operation they are engaged to perform.
11. Connect: The term "connect" means to provide power sources, overcurrent devices, raceway, conductors, terminations, insulation and other materials required for the operation and control of the equipment noted by the term.
12. Wiring: The term wiring means all raceways, fittings, conductors, connectors, tape, junction and outlet boxes, connectors, splices, and all other items necessary and/or required in connection with such work.
13. Conduit: The term conduit means the inclusion of all fittings, hangers, supports, sleeves, etc.
14. Concealed: The term concealed means embedded in masonry or other construction, installed behind wall furring or within partitions, or installed within suspended ceilings.
15. Exposed: The term exposed means not installed underground or concealed as defined above.
16. Accessible: The term accessible means being capable of being reached without the use of ladders or without climbing or crawling under, through or over obstacles such as other mechanical or electrical equipment, building members or structure, piping, ductwork or going through doors.

1.3 SUBMITTALS

A. General: Follow the procedures specified in Division 01 Section “Submittal Procedures.” If submittals include any deviations from specified equipment/materials, these deviations must be clearly identified. The reason for the deviation must also be indicated.

B. Prepare shop drawings and obtain approvals from inspection authorities for power utility company, fire alarm and life systems, and other electrical installations requiring specific approval.

C. Submit coordination drawings for areas specified and those areas defined as “problem” coordination areas during construction.

D. Submit ¼” scaled coordination drawings in electronic PDF format of electrical equipment room layouts prior to issuing electrical switchboard and equipment submittals to engineer of record. Layout shall be based on equipment being submitted for approval. In addition to electrical equipment room layouts, contractor shall also include all major conduit raceway systems 2” conduit trade size and larger for both underground and overhead including all pull and junction boxes. The contractor’s electrical coordination drawings shall be fully coordinated with all trade contractor’s equipment and shall bear each trade contractor’s approval stamp and signature on each coordination plan drawing submittal.

E. Electronic drawing files in AutoCad 2013 of the electrical drawings for use in preparing submittals may be purchased from the engineer. These drawings will not be provided without charge to the contractor or any of the subcontractors.

F. Documents will not be accepted for review unless:

1. They comply as to number of copies and type of paper indicated in the General Requirements.
2. They include complete information pertaining to appurtenances and accessories.
3. They are submitted as a package where they pertain to related items.
4. Where they consist of standard catalog sheets displaying other items which are not applicable, they are properly marked with the electrical data, product identification and accessories as related to this specific project.
5. They indicate the project and address along with the Contractor's name, address and phone number.

6. Where they consist of standard factory assembly or field installation drawings, they are properly marked with external connection identification as related to this specific project.

G. Any materials, fixtures, apparatus, or equipment that are not in accordance with specification requirements can and will be rejected for use in this installation and construction.

H. Any materials, fixtures, apparatus or equipment installed without stamped or written review will be removed by the Contractor and replaced with specified equipment at the direction of the Architect/Engineer and without recourse for additional compensation.

I. Prepare and submit all shop drawings to governmental agencies and utility companies which are required by these agencies for their approval.

1.4 QUALITY ASSURANCE

A. Carefully examine the contract documents, visit the site, and become thoroughly familiar with the local conditions relating to the work. Failure to do so will not relieve the contractor of the obligations of the Contract.

B. Discovery of any conflicting design information or any design intentions which are not readily interpreted shall be referred to the Architect/Engineers for further description or illustration prior to any product selection or execution of work.

C. Discovery of any materials or equipment which are damaged, unsuitable, incompatible, or non-compliant with any applicable codes, laws, ordinances or other regulations shall be brought to the direct attention of the Architect/Engineer.

D. Should there be any discrepancies or question of intent, refer the matter to the Architect/Engineer for a final decision before ordering any equipment or materials and before starting any relating work.

1. In case of conflict between project specifications and drawings, the Contractor shall assume the more expensive method for purposes of bidding, unless the Architect/Engineer rules otherwise.

E. Manufacturers of equipment shall be firms regularly engaged in manufacturing factory fabricated systems and equipment whose products have been in satisfactory use in similar service for not less than 5 years.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Delivery product to the project properly identified with names, model numbers, types grades, compliance labels, and other information needed for identification.

1.6 RULES AND REGULATIONS

A. Work and materials shall conform to and be execute, inspected and tested in accordance with the latest edition of the National Electrical Code and the governing rules and regulations of Federal, State and Local governmental agencies.

B. Other codes which will apply to this installation include the current editions of:

1. ANSI C2 – National Electrical Safety Code.
2. ASME/ANSI A17.1 - Safety Code for Elevators and Escalators.
3. ASTM - American Society for Testing and Materials.
4. ICEA - Standards for Wire and Cable.
5. IEEE Standards.
6. IESNA Standards.

7. NEMA Standards.
8. NFPA 20 - Standards.
9. OSHA Regulations.
10. Underwriters Laboratories.

C. Where governing codes indicate the Drawings and Specifications do not comply with the minimum requirements of applicable codes, the Contractor shall either notify the Architect/Engineer in writing during the bidding period identifying the revisions required to meet code requirements or provide an installation which will comply with the code requirements.

D. Where regulations of electric utility and telephone companies apply, conformance with their regulations is mandatory and any costs involved shall be included in the Contract, with the exception of extra facility and other charges which are directly paid by the Owner.

E. Where any materials, equipment or installation is not in compliance with the more stringent of the applicable codes, laws, ordinances, regulations and contract documents, they shall be entirely removed, replaced, modified or otherwise corrected at no additional cost to the Owner.

1.7 SUBSTITUTIONS

A. The materials, products and equipment described in the Bidding Documents establish a standard of required functions, dimensions, appearance and quality to be met by any proposed substitutions.

B. No substitution will be considered prior to receipt of Bids unless written request for approval has been received by the Architect/Engineer at least ten (10) days prior to the date for receipt of Bids. Each such request shall include the name of the material or equipment for which it is to be substituted and a complete description of the proposed substitute including drawings, cuts, performance, test data and warranties, and any other information necessary for an evaluation. A statement setting forth any changes in other materials, equipment or other work than incorporation of the substitute would require shall be included. The burden of proof of the merit of the proposed substitute is upon the proposer. The Architect's decision of approval or disapproval of a proposed substitution shall be final.

C. If the Architect approved any proposed substitution prior to receipt of Bids, such approval will be set forth in an Addendum. This Addendum shall then be issued to all Bidders.

D. Requests for substitution shall be made only by a Bidder. Request for substitution received by the Architect from Sales representative, vendors, suppliers etc., are not acceptable.

E. Refer to Division 01 Section "Substitution Procedures" for additional instructions on substitution.

1.8 RELATED WORK SPECIFIED IN OTHER SECTIONS

A. Openings: Wall, floor, ceiling, and roof openings specifically shown and identified on the Architectural and Structural or Electrical Drawing shall be provided.

B. Roof Sleeves: Electrical Contractor shall provide all roof penetrations and sleeves for all conduits serving HVAC equipment and shall be incorporated into the finished roofing and made watertight according to the roof construction type manufacturer's reccommendations.

C. Painting: Painting of all exposed-to-view conduit, pipes, unfinished hangers, supports, and equipment, insulated or not, in finished and unfinished areas, shall be provided. Furnish all manufactured equipment in factory-finished baked enamel, unless otherwise specified.

1.9 WIRING AND CONTROLS

A. Wiring and controls associated with equipment shall be furnished, installed, and wired in accordance with the manufacturer's recommendations and applicable standards and codes. Provide installation instructions, locating dimensions, and wiring diagrams for the other trades. Supervise the installation and start-up and test the equipment unless otherwise specified.

B. Equipment Furnished by Other Divisions: Equipment specified in other Divisions and requiring electrical supply shall be erected, aligned, leveled, and prepared for operation. Provided required controls and accessories along with installation instructions, diagrams, dimensions and supervision of installation and start-up. Provide the required electrical rough-ins, and confirm the electrical controls and accessories furnished under the specifications for the other Divisions. Install those controls and accessories not located in the mechanical piping and ductwork. Provide additional electrical controls, accessories, fittings, and devices not specified under the equipment but required for a finished, operating job. Make final electrical connections. Participate in the start-up and test services.

1.10 PERMIT AND INSPECTIONS

A. Permits: Obtain and pay for all permits, bonds, licenses, tap-in fees, etc., required by the City, State, or other authority having jurisdiction over the work, as a part of the work of the affected Section.

B. Inspections: Arrange and pay for all inspections required by the above when they become due as part of the work of the Sections affected. Conceal no work until approved by these governing authorities. Present the Contractor, Architect/Engineer with properly signed certificate of final inspection.

1.11 REVIEW OF MATERIALS

A. Within 21 calendar days after award of this Contract, submit a typewritten list of all items of equipment and material proposed for installation on this Project to the Architect/Engineer for review for design conformance. Set forth the specification page number, manufacturer's name, model number, size, nonstandard accessories specified or required, and any other information required to identify each item.

1.12 PROJECT SITE CONDITIONS

A. Inspect and examine the site before submitting the proposal. Note the location of any existing facilities, existing services or interference with other trades. Immediately contact Architect/Engineer indicating discrepancies. Failure to do so will not relieve the Contractor of the obligations of the Contract.

B. Visit the site or premises in order to become familiar with job conditions. No extras will be allowed for work which could have been foreseen by an examination of the site or premises.

C. Adjust work to meet actual conditions existing at the job.

D. Inspect and examine the site to determine how equipment will be transported to final mounting locations. No extra charges will be allowed for moving, hoisting or otherwise transporting equipment to final mounting location.

E. The location and routing of power and communication utility service raceway systems shown on the site plan and associated plan drawings are diagrammatic only. The contractor shall coordinate with all new and existing overhead and underground utilities (power utility service company, communication utility service company, etc.). Contractor shall verify and confirm with power and communication service utility providers the exact location and routing of proposed underground and overhead conduits prior to rough-in. Contractor shall obtain an official sign-off from such utility service providers prior to performing any work. Failure to do so shall not relieve the contractor from providing what is required by the utility service providers and shall not result in an added cost to the contract.

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials, unless otherwise specified, shall be new and be the standard products of the manufacturer. Seconds, rejects, or damaged materials will be rejected.

B. The equipment to be provided under these Specifications shall be essentially the standard commercial grade product of the manufacturer. Where two or more units of the same class of equipment are required, these units shall be products of a single manufacturer.

C. The listing of a manufacturer for certain equipment and systems does not indicate acceptance of a standard or catalogued item of equipment. All equipment and systems shall conform to the Specifications.

2.2 U.L. LISTING & LABELING

A. All equipment shall bear the Underwriter's Laboratories (U.L.), or other approved agency, listing label.

B. Wherein an item of equipment is specified to be U.L. Listed, the entire assembly shall be listed by Underwriters laboratories, Inc. Any modifications to suit the intent of the Specifications, shall be performed in accordance with the National Electrical Code.

PART 3 - EXECUTION

3.1 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Divisions 02 through 14, 22, 23, and 26 for rough-in requirements.

3.2 ELECTRIAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:

1. The Architect shall control the placement of wall and ceiling mounted electrical devices, fixtures, and outlets. The intent is to aesthetically locate fixtures/outlets by providing rough-in hardware, boxes and/or mounting plates, as required, when stud or furring may not be readily available for direct mounting. When drawing details are not available, consult with Architect's representative for actual placement.
2. Coordinate electrical systems, equipment, and materials installation with other building components. Be responsible for any changes in openings and locations necessitated by the equipment installed.
3. Verify all dimensions by field measurements.
4. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.
5. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-concrete and other structural components, as they are constructed.
6. 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.
7. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
8. 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.

9. Switchgear/Switchboard/Motor Control Center Assembly Selection: The drawings indicate sizes, profiles, and dimensional requirements of assembly equipment. Equipment having equal performance characteristics and complying with indicated maximum dimensions and profiles may be considered, provided deviations do not change the design concept, intended performance, or code/future extension provision clearances. The burden of proof of equality is on the proposer a minimum of 10 days prior to bid.

10. Protect all equipment and materials from the elements, dirt and other damage from the time it is removed from the point of storage until final acceptance.

11. Equipment shall include the component parts thereof such as disconnect switches, motor starters, motors, drives, and guards necessary to the satisfactory and safe operation of the equipment.

12. Installation shall include setting equipment to accurate line and grade, leveling equipment, aligning equipment components, providing and installing couplings, bolts, guards and anchor bolts.

13. All tolerances in alignment and leveling, and the quality of workmanship for each class and stage of work shall be subject to manufacturer's installation instructions.

14. All manufacturers' finished equipment surfaces damaged during construction shall be brought to an "as new" condition by touch up or repairing. Any rust shall be completely removed and the surface primed prior to repainting.

15. Workmanship shall conform to the "Standard of Installation" published by the National Electrical Contractors Association.

16. Prior to start of utility trench work, notify the Architect of utilities that require excavations lower than the building foundations. Do not proceed with trench work without direction from the Architect to ensure the building foundations will not be compromised by the utility installation.

17. Provide all scaffolding, rigging, hoisting and services necessary for erection and delivery of equipment and apparatus furnished into the premises. These items shall be removed from the premises when no longer required.

18. No electrical equipment, raceways or other work of any kind shall be covered up or hidden from view before it has been examined and approved. Any unsatisfactory work or materials shall be removed and corrected immediately.

19. Install systems, materials, and equipment level and plumbing, parallel and perpendicular to other building systems and components.

20. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

21. Install access panels or doors where units are concealed behind finished surfaces. Access panels and doors are specified in Division 26 Section "Basic Electrical Materials and Methods."

22. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

3.3 MANUFACTURER'S DIRECTIONS AND SUPERVISION

A. Where supervision by a manufacturer is specified, follow all instructions, recommended manufacturer and specified field tests, and other recommendations of the manufacturer. The manufacturer shall supervise the installation, connection, start-up, testing, and adjustment, instruction of the Owner and final tests of such equipment or system. Where two or more manufacturer's equipment are interrelated, take responsibility to coordinate their work and provide supervision.

B. Have the manufacturer instruct the Owner in the proper operation and maintenance techniques of all equipment, systems, etc., at the time of completion of all work.

C. Prior to final acceptance by the Owner prepare and submit to the Architect for review 3 copies of operation and maintenance (O and M) instructions in printed form for each item of equipment or system installed in the building. Complete instructions for each system shall be assembled and bound in a brochure. Detailed contents of the O and M manuals are as hereinafter specified. Refer to appropriate Division 01 Sections for general requirements affecting this work.

3.4 PAINTING

A. Provide the prime painting of all equipment and materials furnished under Division 26 specifications, unless specifically stated otherwise. In general, all equipment except raceways and galvanized boxes that are not provided with a factory-applied final finish shall be delivered to the job site with a shop-applied prime coat of paint.

3.5 TEST AND INSPECTION

A. Upon completion of the work, notify the Architect in writing, that the entire electrical installation has been examined, inspected, tested, calibrated or adjusted as specified and that it is ready for final inspection. Work to be connected prior to final inspection and also to include all of the work specified for "Manufacturers' Directions and Supervision." Include documentation of specified testing and inspection.

B. Prior to each inspection, provide a written certification that each system or piece of equipment to be operated during that test has been tested and does meet design performance criteria of the Contract Documents.

C. On completion of work, obtain Certificates of Compliance, and approval or acceptance from all authorities having jurisdiction over the work, and deliver these certificates to the Architect. The work shall not be deemed to have reached a state of completion until the certificates have been delivered.

3.6 LOOSE EQUIPMENT

A. Provide four keys for every different piece of electrical equipment which is equipped with a lock.

B. Provide all other loose equipment specified/supplied for use with all systems.

3.7 SHOP DRAWINGS

A. Refer to Division 01 for quantities and types of shop drawings.

B. Required shop drawings shall be submitted in groups by systems. For example, all lighting fixtures, lamps, ballasts and accessories shall be submitted simultaneously in one package.

C. Refer to individual Division 26 Sections for required shop drawings.

D. Shop drawings submitted for other than those specifically required in the appropriate Specification Section will not be reviewed or returned.

3.8 OPERATION AND MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 01 Section "Operating and Maintenance Data". In addition to the requirements specified in Division 01, include specific Division 26 Section requirements, and the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
4. Servicing instructions and lubrication charts and schedules.

B. The minimum information that shall be furnished in the maintenance manual shall include the following:

1. Individual Characteristics for trouble shooting sequences for each item of:

    a. Branch circuit panel.
    b. Distribution panel.
    c. Fire alarm system.

d. Individual motor starter.
e. Switchboard.
f. Transformer.
g. UPS.
h. Battery Inverter System.
i. Lighting Inverter.

2. Catalog cut sheets for every item for which a shop drawing is required.
3. Schedule of loads served for each:

a. Branch circuit panel.
b. Distribution panel.
c. Switchboard.

4. On-hand spare parts list and complete parts list for each:

a. Distribution panel.
b. Individual motor starter.
c. Switchboard.

5. Tap setting schedule for each:

a. Transformer.

6. Overload element schedule for each motor starter whether individual or in a motor control center.
7. Bolt tightening torques and inspection intervals on each:

a. Bolted bus connection.
b. Cable connection.
c. Miscellaneous bolted electrical connections.

8. Manufacturers' recommended cleaning intervals and special procedures for each:

a. Cooling fins.
b. Dry-type transformer coil assembly.
c. Electrical equipment interior.
d. Electrical equipment ventilation opening.
e. Lighting fixture lenses, louvers and reflectors.

9. Main and arcing contact adjustment and replacement for each:

a. Contactor.
b. Circuit breaker.
c. Fused switch.
d. Interrupter switch.

e. Motor starter.

10. Calibration and exercise procedures and intervals for each:

a. Control system.
b. Emergency battery.
c. Molded case breaker.
d. Relay.

11. "As designed" and "as left" relay settings.
12. Testing interval and target values for ground fault protection circuit relays.
13. Testing and trouble shooting procedures unique to special systems.
14. Approved special construction details that differ from the details shown on Drawings.

3.9 COORDINATION DRAWINGS

A. Prepare coordination drawings to a scale of ¼" = 1'-0" or larger; detailing major elements, components, and systems of electrical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited to installation and access 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. Indicate the proposed locations of major raceway systems, equipment, and materials. Include the following:

a. Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
b. Exterior wall and foundation penetrations.
c. Fire-rated wall and floor penetrations.
d. Equipment connections and support details.
e. Sizes and location of required concrete pads and bases.

2. Coordination drawings shall be provided by Division 26 for the following:

a. Access door locations.
b. Communication rooms.
c. Electrical equipment rooms.
d. Mechanical equipment rooms.
e. Power factor correction capacitor locations.

3. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
4. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.

3.10 RECORD "AS-BUILT" DOCUMENTS

A. The Contractor shall be responsible for creating and providing accurate "As Built" drawings from field data collected during the course of the project. Field data is defined as information collected on site while constructing the project that is not available from the contract documents, addenda, change orders, or site instructions. It is of importance that the Contractor record on the "As Builts" all field information relating to concealed conditions.

B. The revisions from contractor markups and field inspection notes shall be transferred to the final as-built set of drawings. The final as-built drawings include modifications during construction, field requested changes, bulletins, shop drawing modifications, and contractor designs.

C. At the completion of construction all of the contractor's red-lined changes shall be transferred to electronic CAD drawings, typically using the engineer of record's original design drawing files as the starting point. These CAD drawings shall then be considered the final "as-builts" and shall be submitted to the engineer and owner in both electronic CAD format and PDF format as part of the project close out process. Hand marked-up as built drawings shall not be acceptable.

D. Prepare record "As-Built" documents/drawings in accordance with the requirements in Division 01 Section "Project Closeout." In addition to the requirements specified in Division 01, indicate installed conditions for:

1. Plan drawings indicating major raceway systems (100 amps and greater), conduit and wire sizes, routing and location, for both exterior and interior, locations of equipment, switchboards, panelboards, control devices; distribution and branch electrical circuitry; and fuse and circuit breaker size and arrangements.
2. Major equipment locations (exposed and concealed), dimensioned from prominent building lines.
3. Accurate electrical diagrams (electrical riser diagrams, wiring diagrams, etc.) reflective of all modifications during construction, field requested changes, bulletins, shop drawing modifications, and contractor designs.
4. Accurate record of all switchboard and panelboard branch circuit directories/schedules which reflect actual installed circuits.
5. Accurate branch circuit numbers and associated panelboard designations of all power receptacle outlet devices, electrical equipment, lighting fixtures and associated controls, etc.
6. Contract Modifications and actual equipment and materials installed.

E. Engage the services of a Land Surveyor or Professional Engineer registered in the State where the project is located in to record the locations and invert elevations of underground raceway installations.

END OF SECTION

SECTION 260505 - BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the limited scope construction materials and methods for application with electrical installations as follows:

1. Excavation for underground utilities and services, including underground raceways, vaults, and equipment.
2. Miscellaneous materials for support of electrical materials and equipment.
3. Concrete equipment bases.
4. Cutting and patching for electrical construction.
5. Touchup painting.
6. Mounting heights.
7. Electrical equipment coordination and installation.
8. Sleeves for raceways and cables.
9. Sleeve seals.
10. Common electrical installation requirements.

1.2 DEFINITIONS

A. The following definitions apply to excavation operations:

1. Additional Excavation: Where excavation has reached required subgrade elevations, if unsuitable bearing materials are encountered, continue excavation until suitable bearing materials are reached. The Contract Sum may be adjusted by an appropriate Contract Modification
2. Subbase: As used in this Section refers to the compacted soil layer used in pavement systems between subgrade and the pavement base course material.
3. Subgrade: As used in this Section refers to the compacted soil immediately below the slab or pavement system.
4. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction from the Architect.

1.3 SUBMITTALS

A. Shop drawings are not required for material and equipment specified under this Section of the specifications.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in National Electrical Code, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Installer Qualifications: Engage an experienced installer for the installation and application of joint sealers, access panels, and doors.

C. Qualify welding processes and welding operators in accordance with AWS D1.1 “Structural Welding Code – Steel.”

1. Certify that welder has satisfactorily passed AWS qualification tests for welding processes involved and, if pertinent, has undergone recertification.

1.5 PROJECT CONDITIONS

A. Conditions Affecting Excavations: The following project conditions apply:

1. Maintain and protect existing building services which transit the area affected by selective demolition.
2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation operations.
3. Site Information: Subsurface conditions were investigated during the design of the Project. Reports of these investigations are available for information only; data in the reports are not intended as representations or warranties of accuracy or continuity of conditions. The Owner will not be responsible for interpretations or conclusions drawn from this information.
4. Existing Utilities: Locate existing underground utilities in excavation areas. If utilities are indicated to remain, support and protect services during excavation operations.
5. Remove existing underground utilities indicated to be removed.

    a. Uncharted or Incorrectly Charted Utilities: Contact utility owner immediately for instructions.
    b. Provide temporary utility services to affected areas. Provide minimum of 48-hour notice to Architect prior to utility interruption.

6. Use of explosives is not permitted.

B. Environmental Conditions: Apply joint sealers under temperature and humidity conditions within the limits permitted by the joint sealer manufacturer. Do not apply joint sealers to wet substrates.

1.6 COORDINATION

A. Coordinate chases, slots, inserts, sleeves, and openings with general construction work and arrange in building structure during progress of construction to facilitate the electrical installations that follow.

1. Set inserts and sleeves in poured-in-place concrete, masonry work, and other structural components as they are constructed.

B. Sequence, coordinate, and integrate installing electrical materials and equipment for efficient flow of the Work. Coordinate installing large equipment requiring positioning before closing in the building.

1. Coordinate installation and connection to exterior underground and overhead utilities and services, including provision for electricity-metering components.
2. Comply with requirements of authorities having jurisdiction and of utility company providing electrical power and other services.

C. Coordinate location of access panels and doors for electrical items that are concealed by finished surfaces. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Manufacturers:

a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Metrafex Co.
d. Pipeline Seal and Insulator, Inc.

2.2 MISCELLANEOUS MATERIALS

A. Material: Cold-formed steel, with corrosion-resistant coating acceptable to authorities having jurisdiction.

B. Metal Items for Use Outdoors or in Damp Locations: Hot-dip galvanized steel.

C. Pipe Sleeves: ASTM A 53, Type E, Grade A, Schedule 40, galvanized steel, plain ends.

D. Expansion Anchors: Carbon-steel wedge or sleeve type.

E. Toggle Bolts: All-steel springhead type.

F. Powder-Driven Threaded Studs: Heat-treated steel.

2.3 CONCRETE BASES

A. Concrete Forms and Reinforcement Materials: As specified in Division 03 Section "Cast-in-Place Concrete."

B. Concrete: 3000 psi, 28 day compressive strength as specified in Division 03 Section "Cast-in-Place Concrete."

2.4 TOUCHUP PAINT

A. For Equipment: Equipment manufacturer's paint selected to match installed equipment finish.

B. Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

2.5 SLEEVES FOR RACEWAYS

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

B. Cast-Iron Pipe Sleeves: Cast or fabricated “wall pipe,” equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052 inch or 0.138 inch thickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section “Penetration Firestopping.”

2.6 SLEEVE

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

1. Sealing Elements: EPDM interlocking links shaped to fit surface of conduit. Include type and number required for material and size of raceway.
2. Pressure Plates: Carbon steel. Include two for each sealing element.
3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting installation and application of access panels. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 EXCAVATION

A. Slope sides of excavations to comply with local codes and ordinances. Shore and brace as required for stability of excavation.

B. Shoring and Bracing: Establish requirements for trench shoring and bracing to comply with local codes and authorities. Maintain shoring and bracing in excavations regardless of time period excavations will be open.

1. Remove shoring and bracing when no longer required. Where sheeting is allowed to remain, cut top of sheeting at an elevation of 30 inches below finished grade elevation.

C. Install sediment and erosion control measures in accordance with local codes and ordinances.

D. Dewatering: Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area.

1. Do not allow water to accumulate in excavations. Remove water to prevent softening of bearing materials. Provide and maintain dewatering system components necessary to convey water away from excavations.
2. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey surface water to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches.

E. Material Storage: Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade, and shape stockpiles for proper drainage.

1. Locate and retain soil materials away from edge of excavations. Do not store within drip-line of trees indicated to remain.
2. Remove and legally dispose of excess excavated materials and materials not acceptable for use as backfill or fill.

F. Excavation for Underground Vaults and Electrical Structures: Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 foot; plus a sufficient distance to permit placing and removal of concrete formwork, installation of services, other construction, and for inspection.

1. Excavate, by hand, areas within dri-line of large trees. Protect the root system from damage and dry-out. Maintain moist conditions for root system and cover exposed roots with burlap. Paint root cuts of 1 inch in diameter and larger with emulsified asphalt tree paint.
2. Take care not to disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is place.

G. Trenching: Excavate trenches for electrical installations as follows:

1. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of 6 to 9 inches clearance on both sides of raceways and equipment.
2. Excavate trenches to depth indicated or required.
3. Limit the length of open trench to that in which installations can be made and the trench backfilled within the same day.
4. Where rock is encountered, carry excavation below required elevation and backfill with a layer of crushed stone or gravel prior to installation of raceways and equipment. Provide a minimum of 6 inches of stone or gravel cushion between rock bearing surface and electrical installations.
5. Saw-cut existing concrete slabs, pavements, etc. due to new underground electrical conduit or conduit duct bank installation and patch to match existing construction and finish.

H. Cold Weather Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35 deg F.

I. Backfilling and Filling: Place soil materials in layers to required subgrade elevations for each area classification listed below, using materials specified in PART 2 of this Section.

1. Under walls and pavements, use a combination of subbase materials and excavated or borrowed materials.
2. Under building slabs, use drainage fill materials.
3. Under piping and equipment, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation.
4. For raceways less than 30 inches below surface of roadways, provide 4 inch thick concrete base slab support. After installation of raceways, provide a 4 inch thick concrete encasement (sides and top) prior to backfilling and placement of roadway subbase.
5. Other areas, use excavated or borrowed materials.

J. Backfill excavations as promptly as work permits, but not until completion of the following:

1. Inspection, testing, approval, and locations of underground utilities have been recorded.
2. Removal of concrete formwork.
3. Removal of shoring and bracing, and backfilling of voids.
4. Removal of trash and debris.

K. Placement and Compaction: Place backfill and fill materials in layers of not more than 8 inches in loose depth for material compacted by heavy equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

L. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification specified below. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

M. Place backfill and fill materials evenly adjacent to structures, piping, and equipment to required elevations. Prevent displacement of raceways and equipment by carrying material uniformly around them to approximately same elevation in each lift.

N. Compaction: Control soil compaction during construction, providing minimum percentage of density specified for each area classification indicated below.

1. Percentage of Maximum Density Requirements: Company soil to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture-density relationship (cohesive soils), determined in accordance with ASTM D 1557 and not less than the following percentages of relative density, determined in accordance with ASTM D 2049, for soils which will not exhibit a well-defined moisture-density relationship (cohesionless soils).

a. Areas Under Structures, Building Slabs and Steps, Pavements: Compact top 12 inches of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.
b. Areas Under Walkways: Compact top 6 inches of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.
c. Other Areas: Compact top 6 inches of subgrade and each layer of backfill or fill material to 85 percent maximum density for cohesive soils, and 90 percent relative density for cohesionless soils.

2. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water. Apply water in minimum quantity necessary to achieve required moisture content and to prevent water appearing on surface during, or subsequent to, compaction operations.

O. Subsidence: Where subsidence occurs at electrical installation excavations during the period 12 months after Substantial Completion, remove surface treatment (i.e., pavement, lawn, or other finish), add backfill material, compact to specified conditions, and replace surface treatment. Restore appearance, qualify, and condition of surface of finish to match adjacent areas.

3.3 ELECTRICAL EQUIPMENT INSTALLATION

A. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide the maximum possible headroom.

B. Materials and Components: Install level, plumb, and parallel and perpendicular to other building systems and components, unless otherwise indicated.

C. Equipment: Install to facilitate service, maintenance, and repair or replacement of components. Connect for ease of disconnecting, with minimum interference with other installations.

D. Right of Way: Give to raceways and piping systems installed at a required slope.

3.4 FIRESTOPPING

A. Apply firestopping to cable and raceway penetrations of fire-rated floor, ceiling and wall assemblies to achieve fire-resistance rating of the assembly. Provide 3M™ Fire Barrier Moldable Putty Pads. MPP+ shall be a one component, ready-to-use, intumescent elastomer capable of expanding a minimum of 3 times at 1000°F. The material shall be thixotropic and shall be applicable to overhead, vertical and horizontal firestops. Under normal conditions, 3M™ Fire Barrier Moldable Putty Pads MPP+ shall be noncorrosive to metal and compatible with synthetic cable jackets. The putty shall be listed by

independent test agencies such as UL, Intertek or FM. 3M™ Fire Barrier Moldable Putty Pads MPP+ shall be tested to and pass the criteria of ASTM E 814 (UL 1479) Standard Test Method for Fire Tests of Penetration Firestop Systems and CAN/ULC S115 Standard Method of Fire Tests of Firestop Systems. 3M™ Fire Barrier Moldable Putty Pads MPP+ meets the requirements of the IBC, NFPA 5000, NEC (NFPA 70), NFPA 101.

B. Additional firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

C. Provide Endothermic Mat where electrical boxes, panels and equipment are installed within fire rated floors, walls and ceilings using 3M™ Instream™ Endothermic Mat products to match fire ratings.

3.5 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 4 inches larger, in both directions, than supported unit. Follow supported equipment manufacturer's anchorage recommendations and setting templates for anchor-bolt and tie locations, unless otherwise indicated. Use 3000 psi, 28 day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-Place Concrete."

3.6 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section “Penetration Firestopping.”

C. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

D. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

E. Rectangular sleeve Minimum Metal Thickness:

1. For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
2. For sleeve cross-section rectangle perimeter equal to or greater than 50 inches, and 1 or more sides equal to or greater than 16 inches, thickness shall be 0.138 inch.

F. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

G. Cut sleeves to length for mounting flush with both surfaces of walls.

H. Extend sleeves installed in floors 2 inches above finished floor level.

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry with approved joint compound for gypsum board assemblies.

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section “Joint Sealants” for materials and installation.

K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway penetration sleeves with firestop materials. Comply with Division 07 Section "Penetration Firestopping."

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

M. Aboveground, Exterior-Wall 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.

N. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.7 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with Division 01 Section "Cutting and Patching." In addition to the requirements specified in Division 01, the following requirements apply:

1. Perform cutting, fitting, and patching of electrical equipment and materials required to:

   a. Uncover Work to provide for installation of ill-timed Work.
   b. Remove and replace defective Work.
   c. Remove and replace Work not conforming to requirements of the Contract Documents.
   d. Remove samples of installed Work as specified for testing.
   e. Upon written instructions for the Architect, uncover and restore Work to
   f. provide for Architect observation of concealed work.

2. Cut, remove, and legally dispose of electrical equipment, components, and materials as indicated, including but not limited to removal of electrical items indicated to be removed and items made obsolete by the new Work.
3. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.
4. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and direct to adjacent areas.
5. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.
6. Patch finished surfaces and building components using new materials matching materials and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

3.8 FIELD QUALITY CONTROL

A. Inspect installed components for damage and faulty work, including the following:

1. Excavation for underground utilities.
2. Concrete bases.
3. Cutting and patching for electrical construction.
4. Touchup painting.

B. Inspect installed sleeve and sleeve-seal installations and associated firestopping for damage and faulty work.

3.9 REFINISHING AND TOUCHUP PAINTING

A. Refinish and touch up paint. Paint materials and application requirements are specified in Division 09 Section "Painting."

1. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.
2. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.
3. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
4. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.10 MOUNTING HEIGHTS

A. Mounting heights of electrical items shall be as listed below, unless otherwise specified, or by the Architect/Engineer's field instructions. Dimensions are above finished floor, unless otherwise indicated. In areas where code requires different mount heights, as in hazardous areas, comply with code requirements.

1.	General Receptacles	-18" to C.L.
2.	Outdoor Receptacles	-24" to C.L.
3.	General Tele and Data Outlets	-18" to C.L.
4.	General Toggle Switches	-48" to C.L.
5.	Fire Alarm Pull Stations	-48" to C.L.
6.	Security Call Stations	-48" to C.L.
7.	General Television Outlets	-18" to C.L.
8.	Fire Alarm Audio Visual Devices	-80" to C.L.
9.	General Wall Mounted Lights	-90" to C.L.
10.	Corridor Wall Sconces (>4" deep)	-66" to C.L.
11.	Exit Signs	-90" to C.L.
12.	Individual Disconnects and Starters	-60" to C.L.
13.	Grouped Disconnects and Starters	>12" to C.L. >72" to C.L.
14.	Panelboard Overcurrent Devices	>12" to C.L. >72" to C.L.
15.	Grouped Utility Revenue Meters	>30" to C.L. >66" to C.L.

3.11 CLEANING AND PROTECTION

A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.

B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

END OF SECTION

SECTION 260506 - SELECTIVE DEMOLITION FOR ELECTRICAL

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Electrical demolition.

B. Telecommunication demolition.

1.02 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Sustainable Design Documentation: Submit certification of removal and appropriate disposal of abandoned cables containing lead stabilizers.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Materials and equipment for patching and extending work: As specified in individual sections.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify field measurements and circuiting arrangements are as indicated.

B. Verify that abandoned wiring and equipment serve only abandoned facilities.

C. Demolition drawings are based on casual field observation and existing record documents.

D. Report discrepancies to Architect/Engineer of Record before disturbing existing installation.

E. Beginning of demolition means installer accepts existing conditions.

3.02 PREPARATION

A. Disconnect electrical systems in walls, floors, and ceilings to be removed.

B. Coordinate utility service outages with utility company.

C. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.

D. Existing Electrical Service: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Minimize outage duration.
   1. Obtain permission from Owner at least 24 hours before partially or completely disabling system.

2. Make temporary connections to maintain service in areas adjacent to work area.

E. Existing Fire Alarm System: Maintain existing system in service until new system is accepted. Disable system only to make switchovers and connections. Minimize outage duration.
1. Notify Owner before partially or completely disabling system.
2. Notify local fire service.
3. Make notifications at least 24 hours in advance.
4. Make temporary connections to maintain service in areas adjacent to work area.

F. Existing Telephone System: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Minimize outage duration.
1. Notify Owner at least 24 hours before partially or completely disabling system.
2. Notify telephone utility company at least 24 hours before partially or completely disabling system.
3. Make temporary connections to maintain service in areas adjacent to work area.

3.03 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

A. Perform work for removal and disposal of equipment and materials containing toxic substances regulated under the Federal Toxic Substances Control Act (TSCA) in accordance with applicable federal, state, and local regulations. Applicable equipment and materials include, but are not limited to:
1. PCB-containing electrical equipment, including transformers, capacitors, and switches.
2. PCB- and DEHP-containing lighting ballasts.
3. Mercury-containing lamps and tubes, including fluorescent lamps, high intensity discharge (HID), arc lamps, ultra-violet, high pressure sodium, mercury vapor, ignitron tubes, neon, and incandescent.

B. Remove, relocate, and extend existing installations to accommodate new construction.

C. Remove abandoned wiring to source of supply.

D. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.

E. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets that are not removed.

F. Disconnect and remove abandoned panelboards and distribution equipment.

G. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.

H. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.

I. Repair adjacent construction and finishes damaged during demolition and extension work.

J. Maintain access to existing electrical installations that remain active. Modify installation or provide access panel as appropriate.

K. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified.

3.04 CLEANING AND REPAIR

A. See Section 01 74 19 - LEED Construction Waste Management and Disposal for additional requirements.

B. Clean and repair existing materials and equipment that remain or that are to be reused.

C. Panelboards: Clean exposed surfaces and check tightness of electrical connections. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.

D. Luminaires: Remove existing luminaires for cleaning. Use mild detergent to clean all exterior and interior surfaces; rinse with clean water and wipe dry. Replace lamps, ballasts and broken electrical parts.

END OF SECTION

SECTION 260507 - TEMPORARY POWER AND COMMUNICATION SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes requirements for temporary commercial AC power, telephone and security service utilities to Contractor's construction trailer and/or common construction support facilities.

1.2 USE CHARGES

A. General: Cost or use charges for temporary facilities shall be included in the Contract Sum. Allow other entities to use temporary services and facilities without cost, including, but not limited to, Owner's construction forces, Architect, occupants of Project, testing agencies, and authorities having jurisdiction.

1.3 SUBMITTALS

A. Site Plan: Show temporary construction trailer and/or building facilities, utility hookups, staging areas, and parking areas for construction personnel.

B. Electrical contractor shall complete and submit a temporary electrical service meter application (load letter) to the local power utility company indicating requested electrical service size, voltage, and all associated loads. Load letter shall also include service start and completion dates

1.4 QUALITY ASSURANCE

A. Electric Service: Comply with NECA, NEMA, and UL standards and regulations for temporary electric service. Install service to comply with NFPA 70, Local Building Code and Local Power utility service requirements.

B. Tests and Inspections: Arrange for authorities having jurisdiction to test and inspect each temporary utility before use. Obtain required certifications and permits.

1.5 PROJECT CONDITIONS

A. Temporary Use of Permanent Facilities: Installer of each permanent service shall assume responsibility for operation, maintenance, and protection of each permanent service during its use as a construction facility before Owner's acceptance, regardless of previously assigned responsibilities.

PART 2 - EXECUTION

2.1 INSTALLATION, GENERAL

A. Locate facilities where they will serve Project adequately and result in minimum interference with performance of the Work. Relocate and modify facilities as required by progress of the Work.

B. Provide each facility ready for use when needed to avoid delay. Do not remove until facilities are no longer needed or are replaced by authorized use of completed permanent facilities.

2.2 TEMPORARY UTILITY INSTALLATION

A. Temporary overhead/underground electric power utility service shall be coordinated with local power utility company. Provide all electrical equipment infrastructure, connections and extensions of utility services and distribution system of sufficient size, capacity, and power characteristics required for construction operations. Pay electric power service use charges for electricity used by all entities for construction operations.

1. Provide a temporary commercial AC electrical service rated not less than 800 amps at 277/480V, 3-phase, 4-wire, 60 Hz. For construction equipment and a separate temporary commercial AC electrical service rated not less than 100 amps at 120/208V, 3-phase, 4-wire, 60 Hz. For construction trailer(s).
2. Arrange with utility company, Owner, and existing users for time when service can be interrupted, if necessary, to make connections for temporary services.
3. Install electric power service overhead, unless otherwise indicated.
4. Connect temporary service to Owner's existing power source, as directed by Owner.

B. Lighting: Provide temporary lighting with local switching that provides adequate illumination for construction operations, observations, security, inspections, and traffic conditions.

1. Install and operate temporary lighting that fulfills security and protection requirements without operating entire system.
2. Install lighting for Project identification sign.

C. Telephone Service: Provide temporary telephone service in common-use facilities and/or contractor’s construction trailer for use by all construction personnel. Install three T1 telephone line(s) for each field office, weather it is in the contractor’s construction trailer or on-site building construction facility.

1. Provide additional telephone lines for the following:

    a. Provide a dedicated telephone line for each facsimile machine and computer in each field office.
    b. Provide one telephone line(s) for Owner's use.

2. At each telephone, post a list of important telephone numbers.

    a. Police and fire departments.
    b. Ambulance service.
    c. Contractor's home office.
    d. Architect's office.
    e. Engineers' offices.
    f. Owner's office.
    g. Principal subcontractors' field and home offices.

3. Provide superintendent with cellular telephone or portable two-way radio for use when away from field office.

D. Electronic Communication Service: Provide temporary electronic communication service, including electronic mail, video surveillance security systems in common-use facilities and site.

1. Provide one high speed DSL or T-1 line in primary field office.
2. Coordinate with telephone utility company a minimum of four (4) weeks prior to construction start date.

END OF SECTION

SECTION 260513 - MEDIUM-VOLTAGE CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes cables and related splices, terminations, and accessories for medium-voltage electrical distribution systems.

1.3 DEFINITIONS

A. NETA ATS: Acceptance Testing Specification.

1.4 SUBMITTALS

A. Product Data: For each type of cable indicated. Include splices and terminations for cables and cable accessories.

B. Samples: 16-inch lengths of each type of cable indicated.

C. Qualification Data: For Installer.

D. Material Certificates: For each cable and accessory type, signed by manufacturers.

E. Source quality-control test reports.

F. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Installer: Engage a cable splicer, trained and certified by splice material manufacturer, to install, splice, and terminate medium-voltage cable.

B. 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) as defined by OSHA in 29 CFR 1910.7, 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.

C. Source Limitations: Obtain cables and accessories through one source from a single manufacturer.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with IEEE C2 and NFPA 70.

1.6 PROJECT CONDITIONS

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

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

1. Cables:

a. American Insulated Wire Corp.; a Leviton Company.
b. General Cable Technologies Corporation.
c. Kerite Co. (The); Hubbell Incorporated.
d. Okonite Company (The).
e. Pirelli Cables & Systems NA.
f. Rome Cable Corporation.
g. Southwire Company.

2. Cable Splicing and Terminating Products and Accessories:

a. Engineered Products Company.
b. G&W Electric Company.
c. MPHusky.
d. Raychem Corp.; Telephone Energy and Industrial Division; Tyco International Ltd.
e. RTE Components; Cooper Power Systems, Inc.
f. Scott Fetzer Co. (The); Adalet.
g. Thomas & Betts Corporation.
h. Thomas & Betts Corporation/Elastimold.

i. 3M; Electrical Products Division.

2.2 CABLES

A. Cable Type: MV105.

B. Comply with UL 1072, AEIC CS 8[, ICEA S-93-639, and ICEA S-97-682] [, ICEA S-94-649].

C. Conductor: Copper.

D. Conductor Stranding: Compact round, concentric lay, Class B.

E. Strand Filling: Conductor interstices are filled with impermeable compound.

F. Conductor Insulation: Crosslinked polyethylene.

G. Conductor Insulation: Ethylene-propylene rubber.

1. Voltage Rating: 15kV.
2. Insulation Thickness: 133 percent insulation level.

H. Shielding: Copper tape, helically applied over semiconducting insulation shield.

I. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket.

J. Three-Conductor Cable Assembly: Three insulated, shielded conductors cabled together with ground conductors.

1. Circuit Identification: Color-coded tape (black, red, blue) under the metallic shielding.

K. Cable Armor: Interlocked aluminum applied over cable.

L. Cable Jacket: Sunlight-resistant PVC.

2.3 SPLICE KITS

A. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.

B. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.

1. Combination tape and cold-shrink-rubber sleeve kit with rejacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.
2. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.
3. Premolded, cold-shrink-rubber, in-line splicing kit.
4. Premolded EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.

2.4 SOLID TERMINATIONS

A. Multiconductor Cable Sheath Seals: Type recommended by seal manufacturer for type of cable and installation conditions, including orientation.

1. Compound-filled, cast-metal body, metal-clad cable terminator for metal-clad cable with external plastic jacket.
2. Cold-shrink sheath seal kit with preformed sleeve openings sized for cable and insulated conductors.
3. Heat-shrink sheath seal kit with phase- and ground-conductor rejacketing tubes, cable-end sealing boot, and sealing plugs for unused ground-wire openings in boot.
4. Cast-epoxy-resin sheath seal kit with wraparound mold and packaged, two-part, epoxy-resin casting material.

B. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.

1. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone rubber, insulator modules; shield ground strap; and compression-type connector.
2. Class 1 Terminations: Heat-shrink type with heat-shrink inner stress control and outer nontracking tubes; multiple, molded, nontracking skirt modules; and compression-type connector.
3. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief shield terminator; multiple-wet-process, porcelain, insulator modules; shield ground strap; and compression-type connector.
4. Class 1 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, compression-type connector, and end seal.
5. Class 2 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.
6. Class 3 Terminations: Kit with stress cone and compression-type connector.

C. Nonshielded-Cable Terminations: Kit with compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.

2.5 SEPARABLE INSULATED CONNECTORS

A. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.

B. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.

C. Load-Break Cable Terminators: Elbow-type units with 200-A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

D. Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

E. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.

1. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
2. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
3. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
4. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.

F. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.

G. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.

2.6 ARC-PROOFING MATERIALS

A. Tape for First Course on Metal Objects: 10-mil- thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.

B. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to 0.3 inch thick, compatible with cable jacket.

C. Glass-Cloth Tape: Pressure-sensitive adhesive type, 1/2 inch wide.

2.7 FAULT INDICATORS

A. Indicators: Automatically reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.

B. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.

2.8 SOURCE QUALITY CONTROL

A. Test and inspect cables according to ICEA S-97-682 before shipping.

B. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of 5 psig.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install cables according to IEEE 576.

B. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

1. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.
2. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.

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

D. Support cables according to Division 26 Section "Common Work Results for Electrical."

E. Install direct-buried cables on leveled and tamped bed of 3-inch- thick, clean sand. Separate cables crossing other cables or piping by a minimum of 4 inches of tamped earth. Install permanent markers at ends of cable runs, changes in direction, and buried splices.

F. Install "buried-cable" warning tape 12 inches above cables.

G. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag.

H. Install cable splices at pull points and elsewhere as indicated; use standard kits.

I. Install terminations at ends of conductors and seal multi-conductor cable ends with standard kits.

J. Install separable insulated-connector components as follows:

1. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
2. Portable Feed-Through Accessory: Three.
3. Standoff Insulator: Three.

K. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:

1. Clean cable sheath.
2. Wrap metallic cable components with 10-mil pipe-wrapping tape.
3. Smooth surface contours with electrical insulation putty.
4. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
5. Band arc-proofing tape with 1-inch- wide bands of half-lapped, adhesive, glass-cloth tape 2 inches o.c.

L. Seal around cables passing through fire-rated elements according to Division 07 Section "Penetration Firestopping."

M. Install fault indicators on each phase where indicated.

N. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.

O. Identify cables according to Division 26 Section "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

A. Testing: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

B. Testing: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

C. Perform the following field tests and inspections and prepare test reports:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
2. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.

D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 260513

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Single conductor building wire.

B. Service entrance cable.

C. Wiring connectors.

1.02 REFERENCE STANDARDS

A. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire; 2013.

B. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft; 2011 (Reapproved 2017).

C. ASTM B33 - Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes; 2010 (Reapproved 2014).

D. ASTM B787/B787M - Standard Specification for 19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation; 2004 (Reapproved 2014).

E. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

F. NEMA WC 70 - Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy; 2009.

G. NFPA 70 - National Electrical Code; 2017.

H. UL 44 - Thermoset-Insulated Wires and Cables; Current Edition, Including All Revisions.

I. UL 83 - Thermoplastic-Insulated Wires and Cables; Current Edition, Including All Revisions.

J. UL 486A-486B - Wire Connectors; Current Edition, Including All Revisions.

K. UL 486C - Splicing Wire Connectors; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate sizes of raceways, boxes, and equipment enclosures installed under other sections with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
   2. Coordinate with electrical equipment installed under other sections to provide terminations suitable for use with the conductors to be installed.
   3. Notify Architect/Engineer of Record of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. See Section 01 33 29 - LEED Sustainable Design Reporting, when required.

PART 2 - PRODUCTS

2.01 CONDUCTOR AND CABLE GENERAL REQUIREMENTS

A. Provide products that comply with requirements of NFPA 70.

B. Provide products listed, classified, and labeled as suitable for the purpose intended.

C. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, etc. as required for a complete operating system.

D. Comply with NEMA WC 70.

E. Thermoplastic-Insulated Conductors and Cables: Listed and labeled as complying with UL 83.

F. Thermoset-Insulated Conductors and Cables: Listed and labeled as complying with UL 44.

G. Conductor Material:
1. Copper Conductors: Soft drawn annealed, 98 percent conductivity, uncoated copper conductors complying with ASTM B3, ASTM B8, or ASTM B787/B787M unless otherwise indicated.
2. Tinned Copper Conductors: Comply with ASTM B33.

H. Conductor Color Coding:
1. Color code conductors as indicated unless otherwise required by the authority having jurisdiction. Maintain consistent color coding throughout project.
2. Color Coding Method: Integrally colored insulation.
3. Color Code:
   a. Equipment Ground, All Systems: Green.

2.02 SINGLE CONDUCTOR BUILDING WIRE

A. Description: Single conductor insulated wire.

B. Conductor Stranding:
1. Feeders and Branch Circuits:
   a. Size 8 AWG and Smaller: Solid.
   b. Size 6 AWG and Larger: Stranded.
   c. Minimum size: No. 14 for control wiring, No. 12 for all other unless otherwise noted.

C. Insulation Voltage Rating: 600 V.

D. Insulation:
1. Copper Building Wire: Type THHN/THWN or THHN/THWN-2, except as indicated below.

2.03 SERVICE ENTRANCE CABLE

A. Conductor Stranding: Stranded.

B. Insulation Voltage Rating: 600 V.

2.04 WIRING CONNECTORS

A. Description: Wiring connectors appropriate for the application, suitable for use with the conductors to be connected, and listed as complying with UL 486A-486B or UL 486C as applicable.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that interior of building has been protected from weather.

B. Verify that work likely to damage wire and cable has been completed.

C. Verify that raceways, boxes, and equipment enclosures are installed and are properly sized to accommodate conductors and cables in accordance with NFPA 70.

D. Verify that field measurements are as indicated.

E. Verify that conditions are satisfactory for installation prior to starting work.

3.02 PREPARATION

A. Clean raceways thoroughly to remove foreign materials before installing conductors and cables.

3.03 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Perform work in accordance with NECA 1 (general workmanship).

C. Installation in Raceway:
   1. Tape ends of conductors and cables to prevent infiltration of moisture and other contaminants.
   2. Pull all conductors and cables together into raceway at same time.
   3. Do not damage conductors and cables or exceed manufacturer's recommended maximum pulling tension and sidewall pressure.
   4. Use suitable wire pulling lubricant where necessary, except when lubricant is not recommended by the manufacturer.

D. Paralleled Conductors: Install conductors of the same length and terminate in the same manner.

E. Secure and support conductors and cables in accordance with NFPA 70 using suitable supports and methods approved by the authority having jurisdiction. Provide independent support from building structure. Do not provide support from raceways, piping, ductwork, or other systems.

F. Install conductors with a minimum of 12 inches of slack at each outlet.

G. Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.

H. Group or otherwise identify neutral/grounded conductors with associated ungrounded conductors inside enclosures in accordance with NFPA 70.

I. Make wiring connections using specified wiring connectors.

1. Make splices and taps only in accessible boxes. Do not pull splices into raceways or make splices in conduit bodies or wiring gutters.
2. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors.
3. Do not remove conductor strands to facilitate insertion into connector.
4. Clean contact surfaces on conductors and connectors to suitable remove corrosion, oxides, and other contaminates. Do not use wire brush on plated connector surfaces.

J. Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.

K. Insulate ends of spare conductors using vinyl insulating electrical tape.

L. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00 - Firestopping.

M. Unless specifically indicated to be excluded, provide final connections to all equipment and devices, including those furnished by others, as required for a complete operating system.

END OF SECTION

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Grounding and bonding requirements.
   1. Equipment grounding.
   2. Wiring device grounding.
   3. Panelboard grounding.
   4. Switchboard grounding.
   5. Telecommunication Grounding (TGB) including:
      a. Telecommunications Main Grounding Busbar (TMGB).
      b. Telecommunications Grounding Busbar (TGB).
      c. Telecommunications Bonding Backbone (TBB).

B. Conductors for grounding and bonding.

C. Connectors for grounding and bonding.

D. Ground bars.

E. Ground rod electrodes.

F. Ground loop.

1.02 REFERENCE STANDARDS

A. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire; 2013.

B. ASTM B33 - Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes; 2010 (Reapproved 2014).

C. National Electric Code.

D. IEEE 1100 - IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment; 2005.

E. IEEE 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System; 2012.

F. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

G. NEMA GR 1 - Grounding Rod Electrodes and Grounding Rod Electrode Couplings; 2007.

H. NFPA 780 - Standard for the Installation of Lightning Protection Systems; 2017.

I. TIA-607-C - Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises; Rev C, 2015.

J. TIA-942 - Telecommunications Infrastructure Standard for Data Centers; 2017.

K. UL 467 - Grounding and Bonding Equipment; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Verify exact locations of underground metal water service pipe entrances to building.
   2. Coordinate the work with other trades to provide steel reinforcement complying with specified requirements for concrete-encased electrode.
   3. Notify Architect/Engineer of Record of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

B. Sequencing:
   1. Do not install ground rod electrodes until final backfill and compaction is complete.

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements for submittals procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each type of component for grounding and bonding system(s).

C. Shop Drawings:
   1. Plans showing dimension as-built locations of grounding features, including the following:
      a. Ground rods.
      b. Grounding arrangements and connections for separately derived systems.
      c. Grounding for sensitive electronic equipment.
   2. Grounding rod and ground loop locations.
   3. Grounding arrangements and connections for separately derived systems.
   4. Grounding for sensitive electronic equipment.

D. Field quality control test reports with indication of overall resistance to ground.

E. Project Record Documents: Record actual locations of grounding electrode system components and connections.

F. Operation and Maintenance Data: For grounding to include the following in emergency, operation, and maintenance manuals:
   1. Instructions for periodic testing and inspection of grounding features at grounding connections for separately derived systems based on NETA MTS.
      a. Periodic testing and inspection shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
      b. Include recommended testing intervals.

1.05 QUALITY ASSURANCE

A. Product Listing Organization Qualifications: An organization recognized by OSHA regulation 1910.7 as a Nationally Recognized Testing Laboratory (NRTL) and as defined in the National Electrical Code, Article 100.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

C. Conform with UL 467 for grounding and bonding materials and equipment

D. Conform with National Electrical Code.

E. Installer Qualifications: Electrical contractor approved by the Owner for installation and termination of the main bonding conductor to the building service entrance ground.

F. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

G. Follow IEEE 1100 - Recommend Practice for Powering and Grounding Electronic Equipment (IEEE Emerald Book).

PART 2 - PRODUCTS

2.01 GROUNDING AND BONDING REQUIREMENTS

A. Existing Work: Where existing grounding and bonding system components are indicated to be reused, they may be reused only where they are free from corrosion, integrity and continuity are verified, and where acceptable to the authority having jurisdiction.

B. Do not use products for applications other than as permitted by the National Electrical Code and product listing.

C. Unless specifically indicated to be excluded, provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.

D. Where conductor size is not indicated, size to comply with the National Electrical Code but not less than applicable minimum size requirements specified.

E. Grounding System Resistance:
   1. Achieve specified grounding system resistance under normally dry conditions unless otherwise approved by Architect/Engineer of Record. Precipitation within the previous 48 hours does not constitute normally dry conditions.
   2. Grounding Electrode System: Not to exceed the values set forth to ground as indicated in part 3.03 of this specification, when tested according to IEEE 81 using the "fall-of-potential" method.
   3. Between Grounding Electrode System and Major Electrical Equipment Frames, System Neutral, and Derived Neutral Points: Not greater than 0.5 ohms, when tested using "point-to-point" methods.

F. Grounding Electrode System:
   1. Provide connection to required and supplemental grounding electrodes indicated to form grounding electrode system.
      a. Provide continuous grounding electrode conductors without splice or joint.
      b. Install grounding electrode conductors in raceway where exposed to physical damage. Bond grounding electrode conductor to metallic raceways at each end with bonding jumper.
   2. Metal Underground Water Pipe(s):
      a. Provide connection to underground metal domestic and fire protection (where present) water service pipe(s) that are in direct contact with earth for at least 10 feet at an accessible location not more than 5 feet from the point of entrance to the building.
      b. Provide bonding jumper(s) around insulating joints/pipes as required to make pipe electrically continuous.
      c. Provide bonding jumper around water meter of sufficient length to permit removal of meter without disconnecting jumper.
   3. Metal In-Ground Support Structure:

a. Provide connection to metal in-ground support structure that is in direct contact with earth in accordance with the National Electrical Code.

4. Ground Rod Electrode(s):
   a. Provide three electrodes in an equilateral triangle configuration unless otherwise indicated or required.
   b. Space electrodes not less than 10 feet from each other and any other ground electrode.
5. Provide additional ground electrode(s) as required to achieve specified grounding electrode system resistance.
6. Ground Bar: Provide ground bar, separate from service equipment enclosure, for common connection point of grounding electrode system bonding jumpers as permitted in the National Electrical Code. Connect grounding electrode conductor provided for service-supplied system grounding to this ground bar.
   a. Ground Bar Size: 1/4 by 2 by 12 inches unless otherwise indicated or required.
   b. Ground Bar Mounting Height: 18 inches above finished floor unless otherwise indicated.
7. Ground Riser: Provide common grounding electrode conductor not less than 3/0 AWG for tap connections to multiple separately derived systems as permitted in the National Electrical Code.

G. Service-Supplied System Grounding:
1. For each service disconnect, provide grounding electrode conductor to connect neutral (grounded) service conductor to grounding electrode system. Unless otherwise indicated, make connection at neutral (grounded) bus in service disconnect enclosure.
2. For each service disconnect, provide main bonding jumper to connect neutral (grounded) bus to equipment ground bus where not factory-installed. Do not make any other connections between neutral (grounded) conductors and ground on load side of service disconnect.

H. Grounding for Separate Building or Structure Supplied by Feeder(s) or Branch Circuits:
1. Provide grounding electrode system for each separate building or structure.
2. Provide equipment grounding conductor routed with supply conductors.
3. For each disconnecting means, provide grounding electrode conductor to connect equipment ground bus to grounding electrode system.
4. Do not make any connections and remove any factory-installed jumpers between neutral (grounded) conductors and ground.

I. Separately Derived System Grounding:
1. Separately derived systems include, but are not limited to:
   a. Transformers (except autotransformers such as buck-boost transformers).
   b. Uninterruptible power supplies (UPS), when configured as separately derived systems.
   c. Generators, when neutral is switched in the transfer switch.
2. Provide grounding electrode conductor to connect derived system grounded conductor to nearest effectively grounded metal building frame. Unless otherwise indicated, make connection at neutral (grounded) bus in source enclosure.
3. Provide bonding jumper to connect derived system grounded conductor to nearest metal building frame and nearest metal water piping in the area served by the derived system, where not already used as a grounding electrode for the derived system. Make connection at same location as grounding electrode conductor connection.
4. Outdoor Source: Where the source of the separately derived system is located outside the building or structure supplied, provide connection to grounding electrode at source in accordance with the National Electrical Code.
5. Provide system bonding jumper to connect system grounded conductor to equipment ground bus. Make connection at same location as grounding electrode conductor connection. Do not make any other connections between neutral (grounded) conductors and ground on load side of separately derived system disconnect.
6. Where the source and first disconnecting means are in separate enclosures, provide supply-side bonding jumper between source and first disconnecting means.

J. Bonding and Equipment Grounding:
   1. Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with the National Electrical Code.
   2. Provide insulated equipment grounding conductor in each feeder and branch circuit raceway. Do not use raceways as sole equipment grounding conductor.
   3. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with the National Electrical Code.
   4. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
   5. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on neutral (grounded) or isolated/insulated ground bus.
   6. Provide bonding jumper across expansion or expansion/deflection fittings provided to accommodate conduit movement.
   7. Provide bonding for interior metal piping systems in accordance with the National Electrical Code. This includes, but is not limited to:
      a. Metal water piping where not already effectively bonded to metal underground water pipe used as grounding electrode.
      b. Metal gas piping.
      c. Metal process piping.
   8. Provide bonding for interior metal air ducts.
   9. Provide bonding for metal building frame.
   10. Provide bonding for metal siding not effectively bonded through attachment to metal building frame.
   11. Provide bonding and equipment grounding for pools and fountains and associated equipment in accordance with the National Electrical Code.
   12. Metal 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.

K. Communications Systems Grounding and Bonding:
   1. Provide intersystem bonding termination at service equipment or metering equipment enclosure and at disconnecting means for any additional buildings or structures in accordance with the National Electrical Code.
   2. Communications grounding system shall adhere to the recommendations of the TIA-942 and TIA-607-C standards, and shall be installed in accordance with best industry practices.
   3. Utilize equipment manufacturer bonding terminals where provided.
   4. Thread-forming screws and paint piercing grounding washers will be used to ensure metal-to-metal contact.
   5. In MDF/IDF telecommunication rooms mount an electrostatic discharge (ESD) port kit, PANDUIT part number RGESD-1 (or OTS approved equal), directly to each side of the vertical mounting rail of the center most rack using thread-forming screws to form a bond to the rack. Mount at approximately 48 inches from the floor. Place the Electric Static Discharge (ESD) protection identification stickers directly above the ESD ports.
   6. Provide an equipment grounding conductor from the Telecommunications Grounding Busbar (TGB) to each MDF/IDF rack grounding bar and ladder tray.
   7. Each Concentrator Enclosure Telecommunications Grounding Busbar (TGB) will:
      a. Be terminated to the equipment ground terminal within the isolated ground receptacle outlet box.
      b. Have a ground conductor to the enclosure door.
   8. Two-hole lugs shall be used to resist loosening. All lugs shall be irreversible compression type.
   9. Provide bonding jumper in raceway from intersystem bonding termination to each communications room or backboard and provide ground bar for termination.

a. Bonding Jumper Size: 6 AWG, unless otherwise indicated or required.
b. Raceway Size: 3/4 inch trade size unless otherwise indicated or required.
c. Ground Bar Size: 1/4 by 2 by 12 inches unless otherwise indicated or required.
d. Ground Bar Mounting Height: 18 inches above finished floor unless otherwise indicated.

10. Grounding/Earthing System (in reference to Telecommunication Systems)
    a. Antioxidant shall be used when making bonding connections in the field.
    b. The Telecommunications Grounding Busbar (TGB) in each telecommunications space shall be grounded (earthed) to the Telecommunications Main Grounding Busbar (TMGB) located at the electrical service entrance. The gauge of the connecting ground cable, known as the Telecommunications Bonding Backbone (TBB) shall follow TIA-607-C and referenced in the table appendix for sizing the Telecommunications Bonding Backbone (TBB).
    c. The Telecommunications Main Grounding Busbar (TMGB) shall be bonded to the electrical service grounding according to the BICSI TDMM rev. 10 and TIA-607-C. Verify all requirements in The National Electric Code including all updates and addendum) as they may supersede the BICSI requirements. Where telecommunications spaces have only one rack, the jumper cables must be connected directly to the Telecommunications Grounding Busbar (TGB).
    d. Route the TBB to each TGB in straight pathways. The TBB shall be a continuous conductor. The TBB shall be bonded to the equipment ground bar in the IG Computer Panel to the TGB in the MDF and IDF's.
    e. In the event of more than one TBB, the contractor will bond them together at the TBD on the top floor with a Grounding Equalizer (GE). Reference the TIA-607-C standards for sizing TBB's for the GE.
    f. Building steel and metallic water piping must be bonded to the grounding system for safety, however neither may be utilized as the TBB.
    g. Equipment racks shall be bonded to the grounding system in accordance with TIA-942.
    h. To maintain continuity throughout each equipment rack where bonding to the grounding system paint or insulators must be ground away to expose bare, unpainted, and uncoated metal to insure metal to metal contact.
    i. Paint piercing grounding washers and hardware shall be used where rack sections join together. Paint piercing hardware will be used on both sides when and where the hardware passes through the rack.
    j. Any metallic components that part of the data equipment (equipment, racks, ladder racks, enclosures, cable runway, etc.) must be bonded to the grounding systems.
11. Each of the Communications surge protection devices shall be grounded in accordance with manufacturers recommendations as presented in product installation instructions to the TGB.

2.02 GROUNDING AND BONDING COMPONENTS

A. General Requirements:
1. Provide products listed, classified, and labeled as suitable for the purpose intended.
2. Provide products listed and labeled as complying with UL 467 where applicable.

B. Conductors for Grounding and Bonding, in Addition to Requirements of Section 26 05 26 - Grounding and Bonding for Electrical Systems.
1. Use insulated copper conductors unless otherwise indicated.
    a. Exceptions:
        1) Use bare copper conductors where installed underground in direct contact with earth.
        2) Use bare copper conductors where directly encased in concrete (not in raceway).
2. Equipment Grounding Conductors: Insulated with green color insulation.
3. Grounding-Electrode Conductors: Stranded cable.
4. Underground Conductors: Bare, tinned, stranded, except as otherwise indicated.

5. Insulated Conductors: Wire or cable insulated for 600V unless otherwise required by applicable code or authorities having jurisdiction.
6. Bare Copper Conductors:
    a. Solid Conductors: ASTM B3.
    b. Stranded Conductors: ASTM 8.
    c. Tinned Conductors: ASTM B33.
    d. Bonding Cable: 28kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
    e. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
    f. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
    g. Bonding Straps: Soft copper, 0.05 inch think and 2 inches wide, except as indicated.
    h. Cable assemblies shall be UL listed and CSA certified.

C. Connectors for Grounding and Bonding:
1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.
2. Unless otherwise indicated, use exothermic welded connections for underground, concealed and other inaccessible connections.
3. Unless otherwise indicated, use mechanical connectors or exothermic welded connections for accessible connections.
4. Mechanical Connectors: Copper or copper alloy, bolted pressure-type, with at least two bolts.
    a. Heavy Duty Pipe Clamps: Pipe clamps shall be high copper alloy or cast bronze with silicon bronze threaded fasteners; saddle type designed for the size of conductor indicated or required by Contract Documents.
    b. Beam Clamps: Beam clamps shall be compression type; heavy duty bronze construction; provide a minimum of 8 square inches of bonding surface; and designed for copper rope-lay cable.
    c. Grounding Bushing: Groundings bushings shall be malleable iron, threaded, with insulated liner and solderless lug.
5. Pressure Connectors: High-conductivity plated units.
6. Terminating Lugs: Exothermic weld or crimp compression type.
7. Manufacturers - Mechanical and Compression Connectors:
    a. Burndy LLC: www.burndy.com.
    b. Harger Lightning & Grounding: www.harger.com.
    c. Thomas & Betts Corporation: www.tnb.com.
    d. NSI Industries; www.nsiindustries.com.
8. Manufacturers - Exothermic Welded Connections:
    a. Burndy LLC: www.burndy.com.
    b. Cadweld, a brand of Erico International Corporation: www.erico.com.
    c. Cadweld, a brand of Erico International Corporation; www.erico.com.

D. Ground Bars:
1. Description: Rectangular bars of annealed copper, 1/4 by 2 inches in cross-section, unless otherwise indicated; with insulators.
2. Length: As indicated.
3. Holes for Connections: As indicated or as required for connections to be made.

E. Ground Rod Electrodes:
1. Comply with NEMA GR 1.
2. Material: Copper-bonded (copper-clad) steel.
3. Size: 3/4 inch diameter by 10 feet length, unless otherwise indicated.
4. Manufacturers:
    a. Harger Lightning & Grounding: www.harger.com.
    b. Burndy LLC; www.burndy.com
    c. NSI Industries; www.nsiindustries.com

d. Thomas and Betts Corporation; www.tnb.com

F. Ground Ring:
1. Material: Copper
2. Size: As indicated.
3. Manufacturers: Refer to "Grounding and Bonding Requirements".

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that work likely to damage grounding and bonding system components has been completed.

B. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions and the National Electrical Code.

B. Perform work in accordance with NECA 1 (general workmanship).

C. 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.

D. Ground Rod Electrodes: Unless otherwise indicated, install ground rod electrodes vertically. Where encountered rock prohibits vertical installation, provide ground plates.
1. Outdoor and Indoor Installations: Unless otherwise indicated, install with top of rod 2 inches below finished grade.
a. Verify all conditions prior to initiation of work.
b. Verify final backfill and compaction are complete before driving rod electrodes.
c. Do not expose steel or damage coating, if any, on interconnection of ground rods with grounding electrode conductors
d. Install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes and connect to service grounding electrode conductor.

E. Make grounding and bonding connections using specified connectors.
1. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors. Do not remove conductor strands to facilitate insertion into connector.
2. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.
3. Bond straps directory to structure without penetrating adjacent parts.
4. Install bonding to equipment mounted on vibration isolators so any vibration from equipment is not transmitted to any other equipment, devices, fixtures, and/or structure.
5. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer's recommendations.
6. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
7. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.
8. Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building.

a. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange.
b. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting.
c. Bond metal grounding conductor conduit or sleeve to conductor at each end.

9. Use braided-type bonding jumpers at water meter piping to electrically bypass water meters. Connect to pipe with a bolted connector.
10. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

F. Identify grounding and bonding system components in accordance with Section 26 05 53 - Identification for Electrical Systems.

G. 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 so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connector for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

H. See Section 01 40 00 - Quality Requirements, for additional requirements.

I. Restore surface features, including vegetation, at areas disturbed by work of this Section including but not limited to:
1. Re-establish original grades, except as otherwise indicated.
2. Where sod has been removed, replace it as soon as possible after backfilling has been completed.
3. Restore areas disturbed by trenching of dirt, cable laying, and other activities to their original condition.
a. Include trenching, storing of dirt, cable laying, and other areas to their original condition.
b. Include top soiling, fertilizing, liming, sodding, sprigging, and mulching.
4. Restore disturbed paving as indicated or to original condition prior to the initiation of work of this Section.

J. Perform the following tests and inspections:
1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells and at individual ground rods. make tests at ground rods before any conductors are connected.
a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
b. Perform ground electrode resistance tests under normally dry conditions. Precipitation within the previous 48 hours does not constitute normally dry conditions.
c. Perform tests by fall-of-potential method according to IEEE 81.

K. Investigate and correct deficiencies where measured ground resistances do not comply with specified requirements or exceed the following values:
1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10ohms.
2. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3ohms.
3. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).

4. Substations and Pad-Mounted Equipment: 5 ohms.

L. Submit detailed reports indicating inspection and testing results and corrective actions taken.

M. If resistance to exceeds specified values, notify Architect/Engineer of Record immediately with inclusion of recommendations to reduce ground resistance.

END OF SECTION

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Support and attachment components for equipment, conduit, cable, boxes, and other electrical systems and work.

B. Construction requirements for concrete bases.

1.02 REFERENCE STANDARDS

A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.

B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2016a.

C. ASTM A325 - Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength; 2014.

D. ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2014.

E. ASTM A780/A780M - Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings; 2009 (Reapproved 2015).

F. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; 2015.

G. AWS D1.1/D1.1M - Structural Welding Code - Steel; 2015, with Errata (2016).

H. National Electrical Code.

I. MFMA-4 - Metal Framing Standards Publication; 2004.

J. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2009.

K. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

L. NECA 101 - Standard for Installing Steel Conduits (Rigid, IMC, EMT); 2013.

M. NFPA 70 - National Electrical Code; 2017.

N. SSPC-PA 1 - Shop, Field, and Maintenance Painting of Steel; 2004.

O. UL 5B - Strut-Type Channel Raceways and Fittings; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
2. Coordinate the work with other trades to provide additional framing and materials required for installation.
3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
5. Install floor-mounted electrical equipment on a minimum of 4 inch concrete housekeeping pad, with a minimum of 4 inches of equipment inset on all sides. Concrete shall be in accordance with Section 03 30 00 - Cast-in-Place Concrete.
6. Provide steel supports, anchor bolts, inserts, etc., for all equipment specified under this section of the specifications.
7. Provide formed steel support channels extending from and solidly anchored to the floor and ceiling slabs and mount the designated equipment thereto.
8. Coordinate installation of roof curbs, equipment supports, and roof penetrations specified under Section 07 72 00 - Roof Accessories.
9. Notify Architect/Engineer of Record of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.
10. Provide concrete pads for:
    a. Switchboards.
    b. Transformers.
11. Provide steel support channels for:
    a. Communication and special systems cabinets.
    b. Disconnect switches.
    c. Fire alarm system cabinets.
    d. Individual motor starters.
    e. Individual circuit breakers.
    f. Panelboards.
    g. Wall mounted transformers.

B. Sequencing:
1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 03 30 00 - Cast-in-Place Concrete.

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for channel (strut) framing systems, non-penetrating rooftop supports, and post-installed concrete and masonry anchors.

C. Shop Drawings: Include details for fabricated hangers and supports where materials or methods other than those indicated are proposed for substitution.

D. Installer's Qualification Statement: Include evidence of compliance with specified requirements.

E. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.05 QUALITY ASSURANCE

A. Comply with the National Electrical Code.

B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

C. Installer Qualification for Field-Welding: Procedures and personnel according to AWS D1.1/D1.1M

D. Manufacturer's Qualifications: Company specializing in manufacturing products specified in this Section with a minimum three years' experience.

E. Listing and Labeling: Provide products specified in this section that are listed and labeled.

F. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.

G. Product Listing Organization Qualifications: An organization recognized by OSHA Regulation 1910.7 as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.06 DELIVERY, STORAGE, AND HANDLING

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

PART 2 - PRODUCTS

2.01 SUPPORT AND ATTACHMENT COMPONENTS

A. General Requirements:
   1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of electrical work.
   2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
   3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported. Include consideration for vibration, equipment operation, and shock loads where applicable.
   4. Do not use products for applications other than as permitted by NFPA 70 and product listing.
   5. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
      a. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
      b. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.

B. Conduit and Cable Supports: Straps, clamps, etc. suitable for the conduit or cable to be supported.
   1. Conduit Straps: One-hole or two-hole type; steel or malleable iron.
   2. Conduit Clamps: Bolted type unless otherwise indicated.

C. Outlet Box Supports: Hangers, brackets, etc. suitable for the boxes to be supported.

D. Metal Channel (Strut) Framing Systems: Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
   1. Comply with MFMA-4.
   2. Channel (Strut) Used as Raceway (only where specifically indicated): Listed and labeled as complying with UL 5B.
   3. Channel Material:
      a. Indoor Dry Locations: Use zinc coating or treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic.
      b. Outdoor and Damp or Wet Indoor Locations: Use hot-dip galvanized.
   4. Manufacturers:
      a. Cooper B-Line, a division of Eaton Corporation: www.cooperindustries.com.
      b. Thomas & Betts Corporation: www.tnb.com.
      c. Unistrut, a brand of Atkore International Inc.: www.unistrut.com.
      d. GS Metals Corporation; www.cmdgroup.com.
      e. Allied Tube & Conduit, part of Atkore International; www.alliedeg.us

E. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
   1. Minimum Size, Unless Otherwise Indicated or Required:

F. Anchors and Fasteners:
   1. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
   2. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
   3. Steel: Use beam clamps, machine bolts, or welded threaded studs.
   4. Plastic and lead anchors are not permitted.
   5. Powder-actuated fasteners are permitted only as follows:
      a. Use only threaded studs; do not use pins.
         1) Threaded-heat-treated 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..
   6. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
      a. Comply with MFMA-4 or MSS SP-58.
      b. Channel Material: Use Steel or malleable-iron, slotted support system units similar to MSS Type 18..
      c. Manufacturer: Same as manufacturer of metal channel (strut) framing system.
   7. Manufacturers - Mechanical Anchors:
      a. 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.
         1) Hilti, Inc.: www.us.hilti.com.
         2) ITW Red Head, a division of Illinois Tool Works, Inc.: www.itwredhead.com.
         3) Cooper B-Line, a division of Eaton Corporation; www.cooperindustries.com.
         4) Empire Tool and Manufacturing Company; www.empireindustries.com
         5) MKT Fastening, LLC; www.mktfastening.com
   8. Manufacturers - Powder-Actuated Fastening Systems:
      a. Hilti, Inc.: www.us.hilti.com.
      b. ITW Ramset, a division of Illinois Tool Works, Inc.: www.ramset.com.
      c. Simpson Strong-Tie Company Inc.: www.strongtie.com.
      d. MKT Fastening, LLC; www.mktfastening.com.

G. Clamps (attachment to steel structural elements):
   1. MSS SP-58, suitable for attached structural element.

H. Through Bolts:
   1. Structural type, hex head, and high strength.
   2. Comply with ASTM A325.

I. Toggle Bolts:
   1. All-steel springhead type.

J. Hanger Rods:
   1. Threaded steel.

2.02 VIBRATION ISOLATORS

A. General: Provide vibration isolators with either known undeflected heights or other markings so that, after adjustment, when carrying their load, the deflection under load can be verified, thus determining that the load is within the proper range of the device and that the correct degree of vibration isolation is being provided according to the design.
   1. Provide isolators that operate in the linear portion of their load versus deflection curve. Furnish load versus deflection curves from the manufacturer that are linear, over a deflection range 50% above the design deflection.

B. Manufacturers:
   1. California Dynamics Company; www.caldyn.com
   2. Mason Industries: www.mason-ind.com

C. Vibration Isolator Types:
   1. General Properties:
      a. The ratio of lateral to vertical stiffness shall be not less than 0.9 or greater than 1.5.
      b. The theoretical vertical natural frequency for each support point, based upon the load per isolator and isolator stiffness, shall not differ from the design objectives for the equipment as a whole by more than (+/-) 10%.
      c. Wave motion through the isolator shall be reduced to the following extent: Isolation above the primary vertical system resonance frequency shall follow the theoretically predicted isolation curve for single degree of freedom systems with 1- dB to 50 dB at all frequencies above the 150 Hz.
      d. All neoprene mountings shall have a shore hardness of 40 -65 after minimum aging of 30 days, or corresponding open-aging.
   2. Isolator Description:
      a. Type MS shall be spring type, without housings or snubbers, equipped with leveling bolts and with two layers of ribbed or waffled neoprene pads, separated by a 1/16” galvanized steel plate under the base plate. Neoprene sleeves and washer shall be installed at all anchor bolts.
      b. Type HS shall be suspension hangers having a steel frame and spring element, in series with a neoprene pad, cut or washer. The isolator shall be designed so that hanger rod may be misaligned 15 degrees in any direction relative to the vertical, without contacting hanger box frame.
      c. Type MN shall be neoprene isolator support type unit having a minimum static deflection of ¼”.
      d. Type HN shall be a suspension hanger type employing a neoprene isolator unit having a minimum static deflection of ¼”.

D. Equipment Frames
   1. Mounting frames and brackets shall be provided to carry the load of the equipment without causing mechanical distortion or stress to the equipment.
   2. The mounting frames shall consist of welded, wide flange or channel structural steel, with welder brackets to accept the isolators. The section depth of any frame member shall be not less than 1/10th of the length of the longest frame member, and not less than 1/10th of the greatest span between support points. All frame members shall have the same depth.

2.03 MANUFACTURERD SUPPORTING DEVICES

A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps as described in NECA 1 and NECA 101.

B. Conduit Sealing Bushings: Factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit, or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.

C. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for non-armored electrical cables in riser conduits. Plugs shall have number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish. Provide OZ/Gedney type “S” cable support or equal.

D. U-Channel Systems: 12-gauge steel channels, with 9/16 inch diameter holes, at a minimum of 2 inches on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacturer.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M, 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:

2.04 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 05 50 00 - Metal Fabrications for steel shapes and plates.

C. Pipe Sleeves: Provide pipe sleeves of one of the following:
   1. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate sleeves from the following gage metal for sleeve diameter noted:
      a. 3 inch and smaller: 2 gauge.
      b. 4 inch to 6 inch: 16 gauge.
      c. Over 6 inch: 14 gauge.
   2. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.
   3. Plastic Pipe: Fabricate from Schedule 80 PVC plastic pipe.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that mounting surfaces are ready to receive support and attachment components.

C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install support and attachment components in a neat and workmanlike manner in accordance with NECA 1 and .NECA 101

C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.

D. Unless specifically indicated or approved by Architect/Engineer of Record, do not provide support from suspended ceiling support system or ceiling grid.

E. Unless specifically indicated or approved by Architect/Engineer of Record, do not provide support from roof deck.

F. RMC, IMC, and EMT may be supported by openings through structure members, as permitted in the National Electrical Code.

G. Minimum static design load used for strength of support assemblies shall be weight of supported components plus 200 pounds.

H. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.

I. Equipment Support and Attachment:
   1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
   2. 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.
   3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations 1 inch off of wall or surface.
   4. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
   5. To Wood: Fasten with lag screws or through bolts.
   6. To New Concrete: Bolt to concrete inserts.
      a. Do not penetrate water proofing.
   7. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
   8. To Existing Concrete: Expansion anchor fasteners.
      a. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or

greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.

9. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts Spring-tension clamps.
    a. Welding to steel structure may be used only for threaded studs, not for conduits, pipe straps, or other items.
10. To Light Steel: Sheet metal screws.
11. Fasteners: Select so the load applied to each fastener does not of its proof test load.
12. 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.
13. Provide weight-distributing facilities, where required, so as not to exceed the load-bearing capabilities of floors or walls that bear the weight of, or support, electrical systems.
14. Exposed part of hangers and supports shall be painted with one coat of rust-inhibiting primer.
15. Equipment shall not be held in place by its own dead weight. Provide base anchor fasteners in each case.
16. Miscellaneous Supports: Support miscellaneous electrical components as required to provide the same structural safety factors as specified for raceway supports. Install metal channel or angle iron racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.

J. Conduit Support and Attachment: Also comply with Section 26 05 33.13 - Conduit for Electrical Systems.

K. Box Support and Attachment: Also comply with Section 26 05 33.16 - Boxes for Electrical Systems.

L. Interior Luminaire Support and Attachment: Also comply with Section 26 51 00 - Interior Lighting.

M. Exterior Luminaire Support and Attachment: Also comply with Section 26 56 00 - Exterior Lighting.

N. Preset Concrete Inserts: Use manufacturer provided closure strips to inhibit concrete seepage during concrete pour.

O. Overhead boxes shall be supported independently of associated raceways.

P. Secure fasteners according to manufacturer's recommended torque settings.

Q. Remove temporary supports.

R. Concrete Bases:
1. 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.
2. Concrete materials, reinforcement, and placement requirements are specified in Section 03 30 00 - Cast-in-Place Concrete.
3. Anchor equipment to concrete base.
    a. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
    b. Install anchor bolts to elevations required for proper attachment to supported equipment.
    c. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

S. Installation of Fabricated metal Supports:

1. Install metal channel racks for mounting cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices unless components are mounted directly to structural elements of adequate strength.
2. Comply with installation requirements in Section 05 50 00 - Metal Fabrications for site-fabricated metal supports.
3. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
4. Field Welding: Comply with AWS D1.1/D1.1M.

3.03 SCHEDULE, TABLE 1: SPACING FOR RACEWAY SUPPORTS:

*** Maximum spacing for IMC above apply to straight runs only. Otherwise the maximums for EMT appl**

RACEWAY SIZE (INCHS)	NO. OF CONDUCTORS IN RUN		MAXIMUM SPACING OF SUPPORTS (FEET) FOR RGS AND IMC	MAXIMUM SPACING OF SUPPORTS (FEET) FOR EMT
HORIZONTAL RUNS				
1/2, 3/4	1 or 2	Flat ceiling or wall	5	5
1/2, 3/4	1 OR 2	Where limited to support by building construction.	7	7
1/2, 3/4	3 or more	Any location	7	7
1/2-1	3 or more	Any location	7	7
1 and larger	1 or 2	Flat ceiling or wall	6	6
1 and larger	1 or 2	Where limited to support by building construction.	10	10
1 and larger	3 or more	Any location	10	10
Any	-	Concealed	10	10
VERTICAL RUNS				
1/2, 3/4	-	Exposed	7	7
1, 1 1/4	-	Exposed	8	8
1 1/2 and larger	-	Exposed	10	10
Up to 2	-	Shaftway	14	10
2 1/2	-	Shaftway	16	10
3 and larger	-	Shaftway	20	10
Any	-	Concealed	10	10

*** Maximum spacing for IMC above apply to straight runs only. Otherwise the maximums for EMT apply.**

A. Abbreviations:
   1. EMT:
   2. IMC:
   3. RGS:

3.04 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Inspect support and attachment components for damage and defects.

C. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.

D. Correct deficiencies and replace damaged or defective support and attachment components.

3.05 CLEANING AND PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
   1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A780/A780M.

END OF SECTION

SECTION 260533.13 - CONDUIT FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Galvanized steel rigid metal conduit (RMC).

B. Aluminum rigid metal conduit (RMC).

C. Intermediate metal conduit (IMC).

D. Flexible metal conduit (FMC).

E. Liquidtight flexible metal conduit (LFMC).

F. Electrical metallic tubing (EMT).

G. Rigid polyvinyl chloride (PVC) conduit.

H. Conduit fittings.

I. Accessories.

1.02 REFERENCE STANDARDS

A. ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC); 2015.

B. ANSI C80.3 - American National Standard for Electrical Metallic Tubing -- Steel (EMT-S); 2015.

C. ANSI C80.6 - American National Standard for Electrical Intermediate Metal Conduit (EIMC); 2005.

D. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

E. NECA 101 - Standard for Installing Steel Conduits (Rigid, IMC, EMT); 2013.

F. NECA 102 - Standard for Installing Aluminum Rigid Metal Conduit; 2004.

~~G. NECA 111 - Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC); 2003.~~

H. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; 2014.

I. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit; 2013.

J. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing; 2016.

K. NFPA 70 - National Electrical Code; 2017.

L. TIA-569-D - Telecommunications Pathways and Spaces; Rev D, 2015.

M. UL 1 - Flexible Metal Conduit; Current Edition, Including All Revisions.

N. UL 6 - Electrical Rigid Metal Conduit-Steel; Current Edition, Including All Revisions.

O. UL 360 - Liquid-Tight Flexible Steel Conduit; Current Edition, Including All Revisions.

P. UL 514B - Conduit, Tubing, and Cable Fittings; Current Edition, Including All Revisions.

Q. UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings; Current Edition, Including All Revisions.

R. UL 797 - Electrical Metallic Tubing-Steel; Current Edition, Including All Revisions.

S. UL 1242 - Electrical Intermediate Metal Conduit-Steel; Current Edition, Including All Revisions.

T. UL 1660 - Liquid-Tight Flexible Nonmetallic Conduit; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate minimum sizes of conduits with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
   2. Coordinate the arrangement of conduits with structural members, ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
   3. Verify exact conduit termination locations required for boxes, enclosures, and equipment installed under other sections or by others.
   4. Coordinate the work with other trades to provide roof penetrations that preserve the integrity of the roofing system and do not void the roof warranty.
   5. Notify Architect/Engineer of Record of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

B. Sequencing:
   1. Do not begin installation of conductors and cables until installation of conduit is complete between outlet, junction and splicing points.

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements for submittals procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conduits and fittings.
   1. Indicate each type and size of conduit to be utilized within project.
   2. Indicate each type and size of conduit fitting to be utilized within project.

C. Shop Drawings:
   1. Indicate proposed arrangement for conduits to be installed within structural concrete slabs, where permitted.
   2. Include proposed locations of roof penetrations and proposed methods for sealing.

D. Project Record Documents: Record actual routing for conduits installed underground, conduits embedded within concrete slabs, and conduits 2 inch trade size and larger.

1.05 QUALITY ASSURANCE

A. Comply with NECA's "Standard of Installation".

B. Comply with the National Electrical Code.

C. Product Listing Organization Qualifications: An organization recognized by OSHA Regulation 1910.7 as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store conduit and fittings in accordance with manufacturer's instructions.

B. Effectively protect all materials, accessories, and components from any damage or injury from the time of fabrication until final Board acceptance.

C. Store equipment in spaces with environments controlled within manufacturer's ambient temperature and humidity tolerances for non-operating equipment.

PART 2 - PRODUCTS

2.01 CONDUIT APPLICATIONS

A. Do not use conduit and associated fittings for applications other than as permitted by the National Electrical Code and product listing.

B. Unless otherwise indicated and where not otherwise restricted, use the conduit types indicated for the specified applications. Where more than one listed application applies, comply with the most restrictive requirements. Where conduit type for a particular application is not specified, use galvanized steel rigid metal conduit.

C. Underground:
1. Under Slab on Grade: Use galvanized steel rigid metal conduit.
2. Exterior, Direct-Buried: Use rigid PVC conduit where permitted by the National Electrical Code.
3. Service Entrance: Use galvanized steel rigid metal conduit.
4. Exterior, Embedded Within Concrete: Use galvanized steel rigid metal conduit.
5. Where rigid polyvinyl (PVC) conduit is provided, transition to galvanized steel rigid metal conduit where emerging from underground.
6. Where rigid polyvinyl (PVC) conduit larger than 2 inch trade size is provided, use galvanized steel rigid metal conduit elbows for bends.
7. Where steel conduit is installed in direct contact with earth where soil has a resistivity of less than 2000 ohm-centimeters or is characterized as severely corrosive based on soils report or local experience, use corrosion protection tape to provide supplementary corrosion protection.
8. Where steel conduit emerges from concrete into soil, use corrosion protection tape to provide supplementary corrosion protection for a minimum of 4 inches on either side of where conduit emerges.

D. Embedded Within Concrete:
1. Within Slab on Grade (within structural slabs only where approved by Structural Engineer): Use galvanized steel rigid metal conduit.

2. Within Slab Above Ground (within structural slabs only where approved by Structural Engineer): Use galvanized steel rigid metal conduit.
3. Within Concrete Walls Above Ground: Use galvanized steel rigid metal conduit.

E. Concealed Within Masonry Walls: Use electrical metallic tubing (EMT).

F. Concealed Within Hollow Stud Walls: Use electrical metallic tubing (EMT).

G. Concealed Above Accessible Ceilings: Use electrical metallic tubing (EMT).

H. Exposed, Interior, Damp or Wet Locations: Use galvanized steel rigid metal conduit.

I. Exposed, Interior, Not Subject to Physical Damage: Use electrical metallic tubing (EMT).

J. Exposed, Interior, Subject to Physical Damage: Use galvanized steel rigid metal conduit.
1. Locations subject to physical damage include, but are not limited to:
a. Where exposed below 8 feet, except within electrical and communication rooms or closets.
b. Loading dock.
c. Mechanical rooms.

K. Exposed, Exterior: Use intermediate metal conduit (IMC).

L. Concealed, Exterior, Not Embedded in Concrete or in Contact With Earth: Use intermediate metal conduit (IMC).

M. Hazardous (Classified) Locations: Use galvanized steel rigid metal conduit.

N. Connections to Luminaires Above Accessible Ceilings: Use flexible metal conduit.
1. Maximum Length: 6 feet.

O. Connections to Vibrating Equipment:
1. Dry Locations: Use flexible metal conduit.
2. Damp, Wet, or Corrosive Locations: Use liquidtight flexible metal conduit.
3. Maximum Length: 6 feet unless otherwise indicated.

2.02 CONDUIT REQUIREMENTS

A. Electrical Service Conduits: Also comply with Section 26 21 00 - Low-Voltage Electrical Service Entrance.

B. Communications Systems Conduits: Also comply with Section 27 10 00 - Structured Cabling.

C. Fittings for Grounding and Bonding: Also comply with Section 26 05 26 - Grounding and Bonding for Electrical Systems.

D. Provide all conduit, fittings, supports, and accessories required for a complete raceway system.

E. Provide products listed, classified, and labeled as suitable for the purpose intended.

F. Minimum Conduit Size, Unless Otherwise Indicated:
1. 3/4-inch trade size.

G. Where conduit size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

H. Where conduit size is not indicated, size to comply with the National Electrical Code but not less than applicable minimum size requirements specified.

I. Conduit finishes - Manufacturer's standard enamel color coded finish for each system type as follows:
1. Lighting and power receptacle circuits – Natural metallic enamel finish.
2. Grounding system – Green.
3. Fire alarm system – Red.
4. Low voltage (voice, data, signal, temperature control) system – Blue
5. Isolated ground system – Orange.
6. Video surveillance Security and access control systems – Yellow

2.03 GALVANIZED STEEL RIGID METAL CONDUIT (RMC)

A. Manufacturers:
1. Triangle
2. Spang
3. Youngstown
4. Jones & Laughlin

B. Description: The National Electrical Code, Type RMC galvanized steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6.

C. Fittings:
1. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
2. Hazardous (Classified) Locations: Use fittings listed and labeled as complying with UL 1203 for the classification of the installed location.
3. Material: Use steel only.
a. Do not use die cast zinc fittings.
4. Connectors and Couplings: Use threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

2.04 INTERMEDIATE METAL CONDUIT (IMC)

A. Manufacturers:

1. Triangle
2. Spang
3. Youngstown

B. Description: The National Electrical Code, Type IMC galvanized steel intermediate metal conduit complying with ANSI C80.6 and listed and labeled as complying with UL 1242.

C. Fittings:
1. Non-Hazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
2. Hazardous (Classified) Locations: Use fittings listed and labeled as complying with UL 1203 for the classification of the installed location.

3. Material: Steel only, intermediate wall thickness, hot dipped galvanized.
4. Connectors and Couplings: Use standard threaded type fittings only. Threadless set screw and compression (gland) type fittings are not permitted.

2.05 FLEXIBLE METAL CONDUIT (FMC)

A. Manufacturers:

1. Triangle
2. Spang
3. Youngstown
4. Jones & Laughlin

B. Description: The National Electrical Code, Type FMC standard wall steel, hot dipped galvanized, flexible metal conduit listed and labeled as complying with UL 1, and listed for use in classified firestop systems to be used.

C. Minimum Size: 1/2", and 3/8" where permitted by NEC.

D. Fittings:
1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
2. Material: Use steel fitting only.
   a. Do not use die cast zinc fittings.

2.06 LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

A. Manufacturers:
1. Allied Tube & Conduit; www.alliedeg.com.
2. Wheatland Tube Company; www.wheatland.com.
3. O-Z/Gedney, a brand of Emerson Industrial Automation; www.emersonindustrial.com.
4. Tenaris (formerly Maverick Tube Corporation); www.tenaris.com

B. Description: The National Electrical Code, type LFMC polyvinyl chloride (PVC) jacketed steel flexible metal conduit listed and labeled as complying with UL 360.

C. Fittings:
1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
2. Material: Use steel or malleable iron.
   a. Do not use die cast zinc fittings.

2.07 ELECTRICAL METALLIC TUBING (EMT)

A. Manufacturers:

1. Triangle
2. Spang
3. Youngstown
4. Jones & Laughlin

B. Description: NFPA 70, Type EMT steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.

C. Description: The National Electrical Code, Type EMT steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.

D. Fittings:
1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
2. Material: Use steel or malleable iron.
   a. Do not use die cast zinc fittings.
3. Connectors and Couplings: Use compression (gland) type with insulated throat.
   a. Do not use indenter type connectors and couplings.
   b. Do not use set-screw type connectors and couplings.
4. Damp or Wet Locations (where permitted): Use fittings listed for use in wet locations.

2.08 RIGID POLYVINYL CHLORIDE (PVC) CONDUIT

A. Manufacturers:

1. CANTEX
2. CARLON
3. Atkore - Allied Tube

B. Description: The National Electrical Code, Type PVC rigid polyvinyl chloride conduit complying with NEMA TC 2 and listed and labeled as complying with UL 651; Schedule 40 unless otherwise indicated, Schedule 80 where subject to physical damage including underground installations routed through roadways and parking lots; rated for use with conductors rated 90 degrees C.

C. Fittings:
1. Manufacturer: Same as manufacturer of conduit to be connected.
2. Description: Fittings complying with NEMA TC 3 and listed and labeled as complying with UL 651; material to match conduit.

~~2.09 LIQUIDTIGHT FLEXIBLE NONMETALLIC CONDUIT (LFNC)~~

~~A. Manufacturers:~~
~~1. Electri-Flex Company: www.electriflex.com/#sle.~~
~~2. Hubbell Company, RACO products; www.hubbell-rtb.com.~~
~~3. CertainTeed Pipe and Plastics; www.certainteed.com~~

~~B. Description: The National Electrical Code, Type LFNC liquidtight flexible nonmetallic conduit listed and labeled as complying with UL 1660.~~

~~C. Fittings:~~
~~1. Manufacturer: Same as manufacturer of conduit to be connected.~~
~~2. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B; suitable for the type of conduit to be connected.~~

2.10 ACCESSORIES

A. Corrosion Protection Tape: PVC-based, minimum thickness of 20 mil.

B. Conduit Joint Compound: Corrosion-resistant, electrically conductive; suitable for use with the conduit to be installed.

C. Solvent Cement for PVC Conduit and Fittings: Watertight and pressured to 25 PSI.

D. Pull Strings: Use nylon cord with average breaking strength of not less than 200 pound-force.

E. Sealing Compound for Sealing Fittings: Listed for use with the particular fittings to be installed.

F. Modular Seals for Conduit Penetrations: Rated for minimum of 40 psig; Suitable for the conduits to be installed.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that mounting surfaces are ready to receive conduits.

C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Perform work in accordance with NECA 1 (general workmanship).

C. Install galvanized steel rigid metal conduit (RMC) in accordance with NECA 101.

D. Install aluminum rigid metal conduit (RMC) in accordance with NECA 102.

E. Install intermediate metal conduit (IMC) in accordance with NECA 101.

F. Install PVC-coated galvanized steel rigid metal conduit (RMC) using only tools approved by the manufacturer.

G. Install rigid polyvinyl chloride (PVC) conduit in accordance with NECA 111.

H. Install liquidtight flexible nonmetallic conduit (LFNC) in accordance with NECA 111.

I. Conduit Routing:
   1. Unless dimensioned, any conduit routing indicated is diagrammatic.
   2. When conduit destination is indicated without specific routing, determine exact routing required.
   3. Conceal all conduits unless specifically indicated to be exposed.
   4. Conduits in the following areas may be exposed, unless otherwise indicated:
      a. Electrical rooms.
      b. Mechanical equipment rooms.
      c. Within joists in areas with no ceiling.
   5. Unless otherwise approved, do not route conduits exposed:
      a. Across floors.

b. Across roofs.
c. Across top of parapet walls.
d. Across building exterior surfaces.

6. Conduits installed underground or embedded in concrete may be routed in the shortest possible manner unless otherwise indicated. Route all other conduits parallel or perpendicular to building structure and surfaces, following surface contours where practical.
7. Arrange conduit to maintain adequate headroom, clearances, and access.
8. Protect stub-ups from damage where conduits rise through floor slabs. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
9. Arrange conduit to provide no more than the equivalent of three 90 degree bends between pull points.
   a. For Telecommunications conduit, fewer bends are allowed.
10. Arrange conduit to provide no more than 150 feet between pull points.
    a. For Telecommunications conduit, install pull boxes every 100 feet.
11. Make bends and offsets so ID is not reduced. Keep legs of bends in the same plan and straight legs of offsets parallel, unless otherwise indicated.
    a. Use raceway fittings compatible with raceways and suitable for use and location.
    b. Run concealed raceways, with a minimum of bends, in the shortest practical distance considering the type of building construction and obstructions, unless otherwise indicated.
12. Route conduits above water and drain piping where possible.
13. Arrange conduit to prevent moisture traps. Provide drain fittings at low points and at sealing fittings where moisture may collect.
14. Maintain minimum clearance of 6 inches between conduits and piping for other systems.
15. Maintain minimum clearance of 6 inches between conduits and hot surfaces. This includes, but is not limited to:
    a. Heaters.
    b. Hot water piping.
    c. Flues.
16. Group parallel conduits in the same area together on a common rack.
17. **Rigid steel conduit shall be used for all exposed exterior raceways.**

J. Conduit Support:
1. Secure and support conduits in accordance with the National Electrical Code and Section 26 05 29 - Hangers and Supports for Electrical Systems, using suitable supports and methods approved by the authority having jurisdiction.
2. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
3. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conduits to lay on ceiling tiles.
4. Use conduit strap to support single surface-mounted conduit.
   a. Use clamp back spacer with conduit strap for damp and wet locations to provide space between conduit and mounting surface.
5. Use metal channel (strut) with accessory conduit clamps to support multiple parallel surface-mounted conduits.
6. Use conduit clamp to support single conduit 1 1/2 inch and smaller from beam clamp or threaded rod and for fastening raceways to trapeze supports.
7. Use trapeze hangers assembled from threaded rods and metal channel (strut) with accessory conduit clamps to support multiple parallel suspended conduits.
   a. Sized so capacity can be increased by 25 percent in future without exceeding specified design load limits.
   b. Secure raceways and cables to supports with single-bolt conduit clamps.

8. Use of spring steel conduit clips for support of conduits is not permitted.
9. Use of wire for support of conduits is not permitted.

K. Connections and Terminations:
1. Use approved zinc-rich paint or conduit joint compound on field-cut threads of galvanized steel conduits prior to making connections.
2. Where two threaded conduits must be joined and neither can be rotated, use three-piece couplings or split couplings. Do not use running threads.
3. Use suitable adapters where required to transition from one type of conduit to another.
4. Provide drip loops for liquidtight flexible conduit connections to prevent drainage of liquid into connectors.
5. Terminate threaded conduits in boxes and enclosures using threaded hubs or double lock nuts for dry locations and raintight hubs for wet locations.
6. Where spare conduits stub up through concrete floors and are not terminated in a box or enclosure, provide threaded couplings equipped with threaded plugs set flush with finished floor.
7. Provide insulating bushings or insulated throats at all conduit terminations to protect conductors.
8. Secure joints and connections to provide maximum mechanical strength and electrical continuity.

L. Penetrations:
1. Do not penetrate or otherwise notch or cut structural members, including footings and grade beams, without approval of Structural Engineer.
2. Make penetrations perpendicular to surfaces unless otherwise indicated.
3. Provide sleeves for penetrations as indicated or as required to facilitate installation. Set sleeves flush with exposed surfaces unless otherwise indicated or required.
4. Conceal bends for conduit risers emerging above ground.
5. Seal interior of conduits entering the building from underground at first accessible point to prevent entry of moisture and gases.
6. Provide suitable modular seal where conduits penetrate exterior wall below grade.
7. Where conduits penetrate waterproof membrane, seal as required to maintain integrity of membrane.
8. Make penetrations for roof-mounted equipment within associated equipment openings and curbs where possible to minimize roofing system penetrations. Where penetrations are necessary, seal as indicated or as required to preserve integrity of roofing system and maintain roof warranty. Include proposed locations of penetrations and methods for sealing with submittals.
9. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00 - Firestopping.
10. Install sealing fittings in suitable, approved, and accessible locations.
    a. Install in flush steel box with blank cover plate.
        1) Finish similar to adjacent plates or surfaces.
    b. Install at the following locations:
        1) Where conduits pass from warm to cold locations.
        2) Where required by the National Electrical Code.

M. Underground Installation:
1. Provide trenching and backfilling in accordance with Section 31 23 16 - Excavation and Section 31 23 23 - Fill.
2. Minimum Cover, Unless Otherwise Indicated or Required:
    a. Underground, Exterior: 24 inches.
    b. Under Slab on Grade: 12 inches to bottom of slab.

3. Provide underground warning tape in accordance with Section 26 05 53 - Identification for Electrical Systems along entire conduit length.

N. Embedment Within Structural Concrete Slabs (only where approved by Structural Engineer):
1. Include proposed conduit arrangement with submittals.
2. Maximum Conduit Size: 1 inch (27 mm) unless otherwise approved.
3. Install conduits within middle one third of slab thickness.
4. Secure conduits to prevent floating or movement during pouring of concrete.

O. Concrete Encasement: Where conduits not otherwise embedded within concrete are indicated to be concrete-encased, provide concrete in accordance with Section 03 30 00 - Cast-in-Place Concrete with minimum concrete cover of 3 inches on all sides unless otherwise indicated.

P. Hazardous (Classified) Locations: Where conduits cross boundaries of hazardous (classified) locations, provide sealing fittings located as indicated or in accordance with the National Electrical Code.

Q. Conduit Movement Provisions: Where conduits are subject to movement, provide expansion and expansion/deflection fittings to prevent damage to enclosed conductors or connected equipment. This includes, but is not limited to:
1. Where conduits cross structural joints intended for expansion, contraction, or deflection.
2. Where calculated in accordance with NFPA 70 for rigid polyvinyl chloride (PVC) conduit installed above ground to compensate for thermal expansion and contraction.
3. Where conduits are subject to earth movement by settlement or frost.

R. Condensation Prevention: Where conduits cross barriers between areas of potential substantial temperature differential, provide sealing fitting or approved sealing compound at an accessible point near the penetration to prevent condensation. This includes, but is not limited to:
1. Where conduits pass from outdoors into conditioned interior spaces.
2. Where conduits pass from unconditioned interior spaces into conditioned interior spaces.
3. Where conduits penetrate coolers or freezers.

S. Provide pull string in all empty conduits and in conduits where conductors and cables are to be installed by others. Use No. 14 AWG zinc-coated steel or monofilament plastic line with not less than 200-lb tensile strength. Leave minimum slack of 12 inches at each end.

T. Provide grounding and bonding in accordance with Section 26 05 26 - Grounding and Bonding for Electrical Systems.

U. Voice and Data System Raceways, 2-Inch Trade Size and Smaller: In addition to the above requirements, install raceways in maximum lengths of 100 feet and with a maximum of two 90-degree bends or equivalent. Separate lengths with pull or junction boxes where necessary to comply with these requirements. Provide insulating bushings at all terminations. Comply with EIA/TIA-569-D.
1. Conduit to be color coded for Voice and Data systems in accordance with Section 26 05 53 - Identification for Electrical Systems.

3.03 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.

C. Where coating of PVC-coated galvanized steel rigid metal conduit (RMC) contains cuts or abrasions, repair in accordance with manufacturer's instructions.

D. Correct deficiencies and replace damaged or defective conduits.

3.04 CLEANING

A. Clean interior of conduits to remove moisture and foreign matter.

B. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

C. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.05 PROTECTION

A. Immediately after installation of conduit, use suitable manufactured plugs to provide protection from entry of moisture and foreign material and do not remove until ready for installation of conductors.

END OF SECTION

SECTION 260533.16 - BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Outlet and device boxes up to 100 cubic inches, including those used as junction and pull boxes.

B. Cabinets and enclosures, including junction and pull boxes larger than 100 cubic inches.

C. Boxes for hazardous (classified) locations.

D. Floor boxes.

1.02 REFERENCE STANDARDS

A. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

B. NECA 130 - Standard for Installing and Maintaining Wiring Devices; 2010.

C. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; 2014.

D. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports; 2013.

E. NEMA OS 2 - Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports; 2013.

F. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2014.

G. NFPA 70 - National Electrical Code; 2017.

H. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.

I. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations; Current Edition, Including All Revisions.

J. UL 508A - Industrial Control Panels; 2013.

K. UL 514A - Metallic Outlet Boxes; Current Edition, Including All Revisions.

L. UL 514C - Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers; Current Edition, Including All Revisions.

M. UL 1203 - Explosion-Proof and Dust-Ignition-Proof Electrical Equipment for Use in Hazardous (Classified) Locations; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by the National Electrical Code.

2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to the National Electrical Code.
4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to the National Electrical Code.
5. Coordinate the placement of boxes with millwork, furniture, devices, equipment, etc. installed under other sections or by others.
6. Coordinate the work with other trades to preserve insulation integrity.
7. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted boxes where indicated.
8. Notify Architect/Engineer of Record of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for cabinets and enclosures, boxes for hazardous (classified) locations, floor boxes, and underground boxes/enclosures.

C. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

D. Project Record Documents: Record actual locations for junction boxes, pull boxes, cabinets and enclosures, and floor boxes.

1.05 QUALITY ASSURANCE

A. Comply with the National Electrical Code.

B. Comply with NECA's "Standard of Installation".

C. Product Listing Organization Qualifications: An organization recognized by OSHA Regulation 1910.7 as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.06 DELIVERY, STORAGE, AND HANDLING

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

PART 2 - PRODUCTS

2.01 BOXES

A. General Requirements:
1. Do not use boxes and associated accessories for applications other than as permitted by the National Electrical Code.
2. Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
3. Provide products listed, classified, and labeled as suitable for the purpose intended.
4. here box size is not indicated, size to comply with the National Electrical Code but not less than applicable minimum size requirements specified.

5. Provide grounding terminals within boxes where equipment grounding conductors terminate.

B. Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:
1. Use sheet-steel boxes for dry locations unless otherwise indicated or required.
2. Use cast iron boxes or cast aluminum boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
3. Use cast iron boxes or cast aluminum boxes where exposed galvanized steel rigid metal conduit or exposed intermediate metal conduit (IMC) is used.
4. Use cast aluminum boxes where aluminum rigid metal conduit is used.
5. Use nonmetallic boxes where exposed rigid PVC conduit is used.
6. Use suitable concrete type boxes where flush-mounted in concrete.
7. Use suitable masonry type boxes where flush-mounted in masonry walls.
8. Use raised covers suitable for the type of wall construction and device configuration where required.
9. Use shallow boxes where required by the type of wall construction.
10. Do not use "through-wall" boxes designed for access from both sides of wall.
11. Sheet-Steel Boxes: Comply with NEMA OS 1, and list and label as complying with UL 514A.
12. Cast Metal Boxes: Comply with NEMA FB 1, and list and label as complying with UL 514A; furnish with threaded hubs.
13. Nonmetallic Boxes: Comply with NEMA OS 2, and list and label as complying with UL 514C.
14. Boxes for Supporting Luminaires and Ceiling Fans: Listed as suitable for the type and weight of load to be supported; furnished with fixture stud to accommodate mounting of luminaire where required.
15. Boxes for Ganged Devices: Use multigang boxes of single-piece construction. Do not use field-connected gangable boxes unless specifically indicated or permitted.
16. Wall Plates: Comply with Section 26 27 26 - Wiring Devices.
17. Manufacturers:
    a. Steel City
    b. Hubbell Incorporated; RACO Products: www.hubbell-rtb.com.
    c. Appleton Electric, a brand of Emerson Corporation; www.emersonindustrial.com

C. Cabinets and Enclosures, Including Junction and Pull Boxes Larger Than 100 cubic inches:
1. Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E, or UL 508A.
2. NEMA 250 Environment Type, Unless Otherwise Indicated:
3. Junction and Pull Boxes Larger Than 100 cubic inches:
    a. Provide hinged-cover enclosures unless otherwise indicated.
4. Cabinets and Hinged-Cover Enclosures, Other Than Junction and Pull Boxes:
    a. Removable interior panel and removable front.
    b. Hinged door in front cover with flush latch and concealed hinge.
    c. Keyed latch to match panelboards.
    d. Metal barriers to separate wiring of different systems and voltages.
    e. Accessory feet where required for freestanding equipment.
5. Finish for Painted Steel Enclosures: Finished inside and out with manufacturer's standard enamel. unless otherwise indicated.
6. Manufacturers:
    a. Hoffman
    b. Keystone
    c. Burns

D. Floor Boxes:
1. Description: Floor boxes compatible with floor box service fittings provided in accordance with Section 26 27 26 - Wiring Devices; with partitions to separate multiple services; furnished with all components, adapters, and trims required for complete installation.

2. Use cast iron floor boxes within slab on grade.
3. Use sheet-steel or cast iron floor boxes within slab above grade.
4. Metallic Floor Boxes: Fully adjustable (with integral means for leveling adjustment prior to and after concrete pour).
5. Manufacturer: Same as manufacturer of floor box service fittings, comply with Section 26 27 26 - Wiring Devices.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that mounting surfaces are ready to receive boxes.

B. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install boxes in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards where mounting heights are not indicated.

C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and the National Electrical Code.

D. Unless otherwise indicated, provide separate boxes for line voltage and low voltage systems.

E. Flush-mount boxes in finished areas unless specifically indicated to be surface-mounted.
1. In masonry walls, saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

F. Unless otherwise indicated, boxes may be surface-mounted where exposed conduits are indicated or permitted.

G. Box Locations:
1. Locate boxes to be accessible. Provide access panels in accordance with Section 08 31 00 - Access Doors and Panels as required where approved by the Architect/Engineer of Record.
2. Unless dimensioned, box locations indicated are approximate.
3. Locate boxes as required for devices installed under other sections or by others.
   a. Switches, Receptacles, and Other Wiring Devices: Comply with Section 26 27 26 - Wiring Devices.
   b. Communications Systems Outlets: Comply with Section 27 10 00 - Structured Cabling.
4. Locate boxes so that wall plates do not span different building finishes.
5. Locate boxes so that wall plates do not cross masonry joints.
6. Unless otherwise indicated, where multiple outlet boxes are installed at the same location at different mounting heights, install along a common vertical center line.
7. Unless otherwise indicated, where multiple outlet boxes are installed at the same location and at the same mounting height, install devices in multi-gang barriered box appropriate for the device types.
   a. Multi-ganged devices shall have a common, multi-device faceplate.
8. Do not install flush-mounted boxes on opposite sides of walls back-to-back. Provide minimum 6 inches horizontal separation unless otherwise indicated.

9. Acoustic-Rated Walls: Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches horizontal separation.
10. Fire Resistance Rated Walls: Install flush-mounted boxes such that the required fire resistance will not be reduced.
    a. Do not install flush-mounted boxes on opposite sides of walls back-to-back; provide minimum 24 inches separation where wall is constructed with individual noncommunicating stud cavities or protect both boxes with listed putty pads.
    b. Do not install flush-mounted boxes with area larger than 16 square inches or such that the total aggregate area of openings exceeds 100 square inches for any 100 square feet of wall area.
11. Locate junction and pull boxes in the following areas, unless otherwise indicated or approved by the Architect/Engineer of Record:
    a. Concealed above accessible suspended ceilings.
    b. Within joists in areas with no ceiling.
    c. Electrical rooms.
    d. Mechanical equipment rooms.
12. Install hinged-cover enclosures and cabinets plumb. Support at each corner.
13. Installation of Combination Device Wall Enclosures:
    a. In each instance where two or more device boxes are generally located in the same vicinity and at the same mounting height, mount those devices in a common multi-gang barriered box appropriate for the device types.
    b. Combination receptacle and communications devices (i.e. television, data and receptacle shall be installed in minimum 2 gang boxes with barriers to segregate the systems.
    c. Combination devices (i.e. data/voice outlet and normal and IG receptacle) installed in minimum 3 gang box under common wall plate. Provide barriers to segregate systems.

H. Box Supports:
1. Secure and support boxes in accordance with NFPA 70 and Section 26 05 29 - Hangers and Supports for Electrical Systems using suitable supports and methods approved by the authority having jurisdiction.
2. Provide independent support from building structure except for cast metal boxes (other than boxes used for fixture support) supported by threaded conduit connections in accordance with NFPA 70. Do not provide support from piping, ductwork, or other systems.
3. Installation Above Suspended Ceilings: Do not provide support from ceiling grid or ceiling support system.
4. Install hinged-cover enclosures and cabinets plumb. Support each corner.

I. Install boxes plumb and level.

J. Flush-Mounted Boxes:
1. Install boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that front edge of box or associated raised cover is not set back from finished surface more than 1/4 inch or does not project beyond finished surface.
2. Install boxes in combustible materials such as wood so that front edge of box or associated raised cover is flush with finished surface.
3. Repair rough openings around boxes in noncombustible materials such as concrete, tile, gypsum, plaster, etc. so that there are no gaps or open spaces greater than 1/8 inch at the edge of the box.

K. Floor-Mounted Cabinets: Mount on properly sized 4 inch high concrete pad constructed in accordance with Section 03 30 00 - Cast-in-Place Concrete.

L. Install boxes as required to preserve insulation integrity.

M. Metallic Floor Boxes: Install box level at the proper elevation to be flush with finished floor.

N. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.

O. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 84 00 - Firestopping.

P. Close unused box openings.

Q. Install blank wall plates on junction boxes and on outlet boxes with no devices or equipment installed or designated for future use.

R. Provide minimum 2-gang box with barriers for combination receptacle and data locations for specialty equipment (i.e. televisions, monitors).

S. Combination devices (i.e. data/voice outlet and normal and isolated ground receptacle) installed in minimum 3-gang box with barriers.

T. Provide grounding and bonding in accordance with Section 26 05 26 - Grounding and Bonding for Electrical Systems.

U. Identify boxes in accordance with Section 26 05 53 - Identification for Electrical Systems.

3.03 CLEANING

A. Clean interior of boxes to remove dirt, debris, plaster and other foreign material.

B. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

C. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

3.04 PROTECTION

A. Immediately after installation, protect boxes from entry of moisture and foreign material until ready for installation of conductors.

END OF SECTION

SECTION 260533.23 - SURFACE RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Surface raceway systems.

B. Wireways.

1.02 REFERENCE STANDARDS

A. National Electrical Code and all applicable local code amendments.

B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

C. NFPA 70 - National Electrical Code.

D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2014.

E. UL 5 - Surface Metal Raceways and Fittings; Current Edition, Including All Revisions.

F. UL 111 - Outline of Investigation for Multioutlet Assemblies; Current Edition, Including All Revisions.

G. UL 870 - Wireways, Auxiliary Gutters, and Associated Fittings; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Coordinate the placement of raceways with millwork, furniture, equipment, etc. installed under other sections or by others.
2. Coordinate rough-in locations of outlet boxes provided under Section 26 05 33.16 - Boxes for Electrical Systems and conduit provided under Section 26 05 33.13 - Conduit for Electrical Systems as required for installation of raceways provided under this section.
3. Verify minimum sizes of raceways with the actual conductors and components to be installed.
4. Wall Duct: Coordinate the work with other trades to provide walls suitable for installation of flush-mounted wall duct where indicated.
5. Notify Architect/Engineer of Record of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

B. Sequencing:
1. Do not install raceways until final surface finishes and painting are complete.
2. Do not begin installation of conductors and cables until installation of raceways is complete between outlet, junction and splicing points.

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets including dimensions, knockout sizes and locations, materials, fabrication details, finishes, service condition requirements, and accessories.
   1. Surface Raceway Systems: Include information on fill capacities for conductors and cables.

C. Shop Drawings:
   1. Wireways: Provide dimensioned plan and elevation views including adjacent equipment with all required clearances indicated.

D. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.05 QUALITY ASSURANCE

A. Comply with the Chicago Electrical Code.

B. Product Listing Organization Qualifications: An organization recognized by OSHA Regulation 1910.7 as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.06 DELIVERY, STORAGE, AND HANDLING

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

PART 2 - PRODUCTS

2.01 RACEWAY REQUIREMENTS

A. Provide all components, fittings, supports, and accessories required for a complete raceway system.

B. Provide products listed, classified, and labeled as suitable for the purpose intended.

C. Do not use raceways for applications other than as permitted by the City of Chicago Electrical Code and product listing.

2.02 SURFACE RACEWAY SYSTEMS

A. Manufacturers:
   1. Hubbell Incorporated: www.hubbell-wiring.com.
   2. Wiremold, a brand of Legrand North America, Inc.: www.legrand.us.

B. Surface Metal Raceways: Listed and labeled as complying with UL 5.
   1. Galvanized steel with snap-on cover.
   2. Manufacturer's standard enamel finish in color selected by the Architect/Engineer of Record.

C. Multi-outlet Assemblies: Listed and labeled as complying with UL 111.

2.03 WIREWAYS

A. Manufacturers:
   1. Cooper B-Line, a division of Cooper Industries: www.cooperindustries.com.

2. Hoffman, a brand of Pentair Technical Products: www.hoffmanonline.com.
3. Schneider Electric; Square D Products: www.schneider-electric.us.

B. Description: Lay-in wireways and wiring troughs with removable covers; listed and labeled as complying with UL 870.

C. Wireway Type, Unless Otherwise Indicated:
1. Indoor Clean, Dry Locations: NEMA 250, Type 1, painted steel with screw-cover.
2. Outdoor Locations: NEMA 250, Type 3R, painted steel with screw-cover; include provision for padlocking.
3. Hazardous Locations: NEMA 250, Type 12, painted steal with screw-cover. Sealed and gasketed.

D. Finish for Painted Steel Wireways: Manufacturer's standard enamel finish unless otherwise indicated.

E. Where wireway size is not indicated, size to comply with the City of Chicago Electrical Code but not less than applicable minimum size requirements specified.

2.04 SOURCE QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that outlet boxes and conduit terminations are installed in proper locations and are properly sized in accordance with the City of Chicago Electrical Code to accommodate raceways.

C. Verify that mounting surfaces are ready to receive raceways and that final surface finishes are complete, including painting.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Perform work in accordance with NECA 1 (general workmanship).

C. Install raceways plumb and level.

D. Arrange wireways and associated raceway connections to comply with the National Electrical Code, including but not limited to requirements for deflected conductors and wireways used as pullboxes. Increase size of wireway where necessary.

E. Secure and support raceways in accordance with Section 26 05 29 - Hangers and Supports for Electrical Systems at intervals complying with the National Electrical Code.

F. Close unused raceway openings.

G. Provide grounding and bonding in accordance with Section 26 05 26 - Grounding and Bonding for Electrical Systems.

H. Identify raceways in accordance with Section 26 05 53 - Identification for Electrical Systems.

3.03 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Inspect raceways for damage and defects.

C. Correct wiring deficiencies and replace damaged or defective raceways.

3.04 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.05 PROTECTION

A. Protect installed raceways from subsequent construction operations.

END OF SECTION

SECTION 260534 – ELECTRIC HEAT TRACING FOR PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes plumbing piping heat tracing for freeze prevention, and snow and ice melting on roofs and in gutters and downspouts with the following electric heating cables:

1. Plastic insulated, series resistance.
2. Self-regulating, parallel resistance.

B. Related Sections include the following:

1. Division 23 Section "Heat Tracing for HVAC and Plumbing Piping."

1.3 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.

1. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.

B. Shop Drawings: For electric heating cable. Include plans, sections, details, and attachments to other work.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.

E. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: 15 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PLASTIC-INSULATED, SERIES-RESISTANCE HEATING CABLES

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

1. Delta-Therm Corporation.
2. Easy Heat Inc.
3. NUHEAT.
4. Orbit Manufacturing.
5. Pyrotenax; a division of Tyco Thermal Controls.
6. Raychem; a division of Tyco Thermal Controls.
7. WarmlyYours.com Inc.
8. Watts Radiant Inc.

B. Comply with IEEE 515.1.

C. Heating Element: Single- or dual-stranded resistor wire. Terminate with waterproof, factory-assembled nonheating leads with connectors at both ends.

D. Electrical Insulating Jacket: Minimum 4.0-mil Kapton with silicone jacket or Tefzel.

E. Cable Cover: Aluminum braid and silicone outer jacket.

F. Maximum Operating Temperature: 300 deg F.

G. Capacities and Characteristics:

1. Maximum Heat Output: 7.5 W/ft.
2. Volts: 120 208 240 277 480 or as indicated on the drawings.
3. Phase: single phase or as indicated on the drawings.
4. Hertz: 60.

2.2 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

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

1. BH Thermal Corporation.
2. Chromalox, Inc.; Wiegard Industrial Division; Emerson Electric Company.
3. Delta-Therm Corporation.
4. Easy Heat Inc.
5. Nelson Heat Trace.
6. Pyrotenax; a division of Tyco Thermal Controls.
7. Raychem; a division of Tyco Thermal Controls.

8. Thermon Manufacturing Co.
9. Trasor Corp.

B. Heating Element: Pair of parallel No. 12 AWG, tinned stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

C. Electrical Insulating Jacket: Flame-retardant polyolefin.

D. Cable Cover: Stainless-steel braid, and polyolefin outer jacket with UV inhibitor.

E. Maximum Operating Temperature (Power On): 150 deg F.

F. Maximum Exposure Temperature (Power Off): 185 deg F.

G. Maximum Operating Temperature: 300 deg F.

H. Capacities and Characteristics:

1. Maximum Heat Output: 12 W/ft.
2. Volts: 120 208 240 277 480 or as indicated on the drawings.
3. Phase: single phase or as indicated on the drawings.
4. Hertz: 60.

2.3 CONTROLS

A. Pipe-Mounting Thermostats for Freeze Protection:

1. Remote bulb unit with adjustable temperature range from 30 to 50 deg F.
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.
3. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.
4. Corrosion-resistant, waterproof control enclosure.

B. Precipitation and Temperature Sensor for Snow Melting on Roofs and in Gutters:

1. Automatic control with manual on, automatic, and standby/reset switch.
2. Precipitation and temperature sensors shall sense the surface conditions of roof and gutters and shall be programmed to energize the cable as follows:

    a. Temperature Span: 34 to 44 deg F.
    b. Adjustable Delay Off Span: 30 to 90 minutes.
    c. Energize Cables: Following two-minute delay if ambient temperature is below set point and precipitation is detected.
    d. De-Energize Cables: On detection of a dry surface plus time delay.

3. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
4. Minimum 30-A contactor to energize cable or close other contactors.
5. Precipitation sensor shall be freestanding.

6. Provide relay with contacts to indicate operational status, on or off, for interface with central HVAC control system workstation.

2.4 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: Refer to Division 22 Section "Identification for Plumbing Piping and Equipment."

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Install the following types of electric heating cable for the applications described:
1. Snow and Ice Melting on Roofs and in Gutters and Downspouts: Plastic-insulated, series-resistance heating cable.
2. Temperature Maintenance for Domestic Hot Water: Self-regulating, parallel-resistance heating cable.

3.3 INSTALLATION

A. Install electric heating cable across expansion, construction, and control joints according to manufacturer's written recommendations using cable protection conduit and slack cable to allow movement without damage to cable.

B. Electric Heating Cable Installation for Snow and Ice Melting on Roofs and in Gutters and Downspouts: Install on roof and in gutters and downspouts with clips furnished by manufacturer that are compatible with roof, gutters, and downspouts.

C. Electric Heating Cable Installation for Freeze Protection for Piping:

1. Install electric heating cables after piping has been tested and before insulation is installed.
2. Install electric heating cables according to IEEE 515.1.
3. Install insulation over piping with electric cables according to Division 22 Section "Plumbing Insulation."
4. Install warning tape on piping insulation where piping is equipped with electric heating cables.

D. Set field-adjustable switches and circuit-breaker trip ranges.

E. Protect installed heating cables, including nonheating leads, from damage.

3.4 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Testing: Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.

1. Test cables for electrical continuity and insulation integrity before energizing.
2. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

B. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounting cables.

C. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

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.

B. Contractor shall provide separate hand holes for both power and low voltage systems.

C. Where a single hand hole is indicated on the drawings which serve both power and low voltage utilities, the hand hole shall be provided with a UL listed divider in order to provide physical separation of such utilities.

1.2 SUMMARY

A. This Section includes the following:

1. Conduit, ducts, and duct accessories for direct-buried and concrete-encased duct banks, and in single duct runs.
2. Handholes and boxes.

1.3 DEFINITION

A. PVC: Rigid nonmetallic conduit - Poly-Vinyl Chloride conduit.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Duct-bank materials, including separators and miscellaneous components.
2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Accessories for manholes, handholes, boxes, and other utility structures.
4. Warning tape.
5. Warning planks.

B. Shop Drawings for Precast Underground boxes: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:

1. Duct entry provisions, including locations and duct sizes.

C. 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.

D. Product Certificates: For concrete and steel used in precast concrete handholes, as required by ASTM C 858.

E. Qualification Data: For professional engineer and testing agency.

F. Source quality-control test reports.

G. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

B. Comply with ANSI C2.

C. Comply with NFPA 70.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

B. Store precast concrete and other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

C. Lift and support precast concrete units only at designated lifting or supporting points.

1.7 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 no fewer than two days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Construction Manager's written permission.

1.8 COORDINATION

A. Coordinate layout and installation of ducts, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field.

B. Coordinate elevations of ducts and duct-bank entrances into 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 from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Furnish cable-support stanchions, arms, insulators, and associated fasteners in quantities equal to 5 percent of quantity of each item installed.

PART 2 - PRODUCTS

2.1 CONDUIT

A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.
1. All ninety degree conduit elbows and conduit stub-ups shall be Rigid Steel Conduit, no exceptions.

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.

2.2 NON-METALLIC DUCTS AND DUCT ACCESSORIES

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

1. CANTEX
2. CARLON
3. Atkore - Allied Tube

B. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type EB-20-PVC, ASTM F 512, UL 651A, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.

C. Duct Accessories:

1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling (Underground Devices Incorporated (847) 205-9000, www.udevices.com).
   a. Duct bank shall be encased in concrete with at least three inches of concrete at the top and bottom and two inches on each side.
   b. A horizontal and vertical separation between the ducts of two inches shall be maintained by installing Underground Devices High Impact Polystyrene Wunpeece Spacers.
   c. Spacers shall be interlocked horizontally only. Along the length of the duct run spacers shall be staggered at least 6 inches vertically and shall be placed at an interval of five spacers per 20 feet or per manufacturer's recommendations.
2. Warning Tape: Underground-line warning tape specified in Division 26 Section "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.

2.3 PRECAST CONCRETE HANDHOLES AND BOXES

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

1. Quazite or equal.

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. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
3. Cover Legend: Molded lettering, "ELECTRIC.", "TELEPHONE." Or as indicated on the drawings for each service.
4. Configuration: Units shall be designed for flush burial and have closed bottom, unless otherwise indicated.
5. 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.

6. Where power and communication service conduits are routed in parallel to a common piece of equipment or device, the handhole shall be provided with an FHR divider panel and separate access covers in order to maintain code required physical separation of conduits and associated cabling.

2.4 PRECAST MANHOLES

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

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

1. Quazite or Equal

C. Comply with ASTM C 858, with structural design loading as specified in Part 3 "Underground Enclosure Application" Article and with interlocking mating sections, complete with accessories, hardware, and features.

1. 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 roofs of manholes, 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. 4 steel reinforcing bars in concrete around each opening.

2. Duct Entrances in Manhole 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 manholes to facilitate racking of cable.

D. Concrete Knockout Panels: 1-1/2 to 2 inches thick, for future conduit entrance and sleeve for ground rod.

E. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.5 SOURCE QUALITY CONTROL

A. Test and inspect precast concrete utility structures according to ASTM C 1037.

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

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

PART 3 - EXECUTION

3.1 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Cables Over 600 V: 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 concrete-encased duct bank, unless otherwise indicated.

C. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank, unless otherwise indicated.

D. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank, unless otherwise indicated.

E. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank, unless otherwise indicated.

F. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC, installed in direct-buried duct bank, unless otherwise indicated.

G. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank, unless otherwise indicated.

H. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EB-20-PVC, in concrete-encased duct bank, unless otherwise indicated.

I. Underground Ducts Crossing Paved Paths, Walks and Driveways/Roadways: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

3.2 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less, Including Telephone, Communications, and Data Wiring:

1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-10 structural load rating.
2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Non-deliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 structural load rating.
3. Units in Sidewalk and Similar Applications with a Safety Factor for Non-deliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 structural load rating.
4. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with 3000-lbf vertical loading.

3.3 EARTHWORK

A. Excavation and Backfill: Comply with Division 31 Section "Earth Moving," but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation and reestablish 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 Division 32 Sections "Turf and Grasses" and "Plants."

D. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 01 Section "Cutting and Patching."

3.4 DUCT INSTALLATION

A. 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.

B. 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.

C. 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.

D. 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.
3. Grout end bells into structure walls from both sides to provide watertight entrances.

E. 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 Division 26 Section "Common Work Results for Electrical."

F. Sealing and Waterproofing: Provide temporary mechanical waterproof closure/plug at all terminations of ducts that have cables pulled. Provide mechanical waterproof plug on all spare empty ducts at each duct/conduit end. Sealing and waterproofing mechanical plugs shall withstand at least 15-psig hydrostatic pressure. Sealing and waterproofing system shall be capable of adding and removing cables. Provide the following products for sealing and waterproofing conduits and ducts:
1. Tyco Electronics Corporation – Jackmoon Series Duct Plugs.

G. Pulling Cord: Install 100-lbf- test nylon cord in ducts, including spares.

H. Cleaning: Underground conduit duct shall completely dry and free from water and debris prior to installation of cables and nylon pull ropes. Clean entire length of all underground electrical conduit ducts with compressed air. Temporarily cover all ends of conduit ducts in order to prevent water and debris infiltration during the entire length of construction.

I. Concrete-Encased Ducts: Support ducts on duct separators.

1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 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.
2. 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 18 inches into concrete on both sides of joint near corners of envelope.

3. Pouring Concrete: Spade 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. Use a plank to direct concrete down sides of bank assembly to trench bottom. 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.

4. 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.
5. 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.
6. 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.
7. 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.
8. Stub-Ups: Use manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Extend concrete encasement throughout the length of the elbow.
9. Stub-Ups: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

    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. 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 the 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.

J. Direct-Buried Duct Banks:

1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 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.
3. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 Section "Earth Moving" for pipes less than 6 inches in nominal diameter.
4. Install backfill as specified in Division 31 Section "Earth Moving."
5. 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 as specified in Division 31 Section "Earth Moving."
6. Install ducts with a minimum of 3 inches between ducts for like services and 6 inches between power and signal ducts.
7. Depth: Install top of duct bank at least 36 inches below finished grade, unless otherwise indicated.
8. Set elevation of bottom of duct bank below the frost line.

9. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
10. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

    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.

11. 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.

3.5 INSTALLATION OF CONCRETE HANDHOLES, AND BOXES

A. 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.

B. Elevations:
1. Install handholes with bottom below the frost line, 36 inches below grade.
2. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes 1 inch above finished grade.
3. Where indicated, cast handhole cover frame integrally with handhole structure.

C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

D. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Division 07 Section "Elastomeric Sheet Waterproofing." After ducts have been connected and grouted, and before backfilling, waterproof joints and connections and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.

E. Damp proofing: Apply damp proofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Damp proofing materials and installation are specified in Division 07 Section "Bituminous Damp proofing." After ducts have been connected and grouted, and before backfilling, dampproof joints and connections and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.

F. Field-Installed Bolting Anchors in 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.

G. Warning Sign: Install "Confined Space Hazard" warning sign on the inside surface of each manhole cover.

3.6 GROUNDING

A. Ground underground ducts and utility structures according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.7 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 aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide 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 Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.8 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

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Electrical identification requirements.

B. Identification nameplates and labels.

C. Identification signs.

D. Wire and cable markers.

E. Voltage markers.

F. Underground warning tape.

G. Floor marking tape.

H. Warning signs and labels.

1.02 REFERENCE STANDARDS

A. 29 CFR 1910.145 - Accident Prevention Signs and Tags current edition.

B. ASME A13.1 - Scheme for the Identification of Piping Systems 2020.

C. National Electrical Code.

D. NFPA 70E - Standard for Electrical Safety in the Workplace 2018.

E. UL 969 - Marking and Labeling Systems Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Verify final designations for equipment, systems, and components to be identified prior to fabrication of identification products.

B. Sequencing:

1. Do not conceal items to be identified, in locations such as above suspended ceilings, until identification products have been installed.

2. Do not install identification products until final surface finishes and painting are complete.

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements for submittals procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product.

C. Samples:

1. For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features.

D. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation and installation of product.

1.05 QUALITY ASSURANCE

A. Comply with ASME A13.1.

B. Comply with ANSI/IEEE 802.7.

C. Comply with 29 CFR 1910.145.

1.06 FIELD CONDITIONS

A. Do not install adhesive products when ambient temperature is lower than recommended by manufacturer.

1.07 COORDINATION

A. Coordinate all names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Designations and labeling shall be consistent throughout the project.

B. Coordinate installation with coverings and painting of surfaces.

C. Coordinate installation with location of access panels and doors.

D. Install identifying devices before installation of acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.01 IDENTIFICATION REQUIREMENTS

A. Identification for Equipment:

1. Use identification nameplate to identify each piece of electrical distribution and control equipment and associated sections, compartments, and components.

a. Switchboards:

1) Identify ampere rating.

2) Identify voltage and phase.

3) Identify power source and circuit number. Include location when not within sight of equipment.

4) Use identification nameplate to identify main overcurrent protective device.

5) Use identification nameplate to identify load(s) served for each branch device. Do not identify spares and spaces.

b. Panelboards:

1) Identify ampere rating.

2) Identify voltage and phase.

3) Identify power source and circuit number. Include location when not within sight of equipment.

4) Use typewritten circuit directory to identify load(s) served for panelboards with a door. Identify spares and spaces.

5) For power panelboards without a door, use identification nameplate to identify load(s) served for each branch device. Do not identify spares and spaces.

c. Transformers:

1) Identify kVA rating.

2) Identify voltage and phase for primary and secondary.

3) Identify power source and circuit number. Include location when not within sight of equipment.

4) Identify load(s) served. Include location when not within sight of equipment.

d. Enclosed switches, circuit breakers, and motor controllers:

1) Identify voltage and phase.

2) Identify power source and circuit number. Include location when not within sight of equipment.

3) Identify load(s) served. Include location when not within sight of equipment.

e. Electricity Meters:

1) Identify load(s) metered.

f. UPS:

1) Identify kVA rating.

2) Identify voltage and phase for primary and secondary.

3) Identify power source and circuit number. Include location when not within sight of equipment.

4) Identify load(s) served. Include location when not within sight of equipment

2. Service Equipment:

   a. Use identification nameplate to identify each service disconnecting means.

   b. For buildings or structures supplied by more than one service, or any combination of branch circuits, feeders, and services, use identification nameplate or means of identification acceptable to authority having jurisdiction at each service disconnecting means to identify all other services, feeders, and branch circuits supplying that building or structure. Verify format and descriptions with authority having jurisdiction.

3. Use voltage marker to identify highest voltage present for each piece of electrical equipment.

4. Use identification nameplate to identify equipment utilizing series ratings, where permitted, in accordance with the National Electrical Code.

5. Use identification nameplate to identify switchboards and panelboards utilizing a high leg delta system in accordance with the National Electrical Code.

6. Use identification nameplate to identify disconnect location for equipment with remote disconnecting means.

7. Use identification label or handwritten text using indelible marker on inside of door at each fused switch to identify required NEMA fuse class and size.

8. Use identification label or handwritten text using indelible marker on inside of door at each motor controller to identify nameplate horsepower, full load amperes, code letter, service factor, voltage, and phase of motor(s) controlled.

9. Use identification label to identify overcurrent protective devices for branch circuits serving fire alarm circuits. Identify with text "FIRE ALARM CIRCUIT".

10. Use field-painted floor markings, floor marking tape, or warning labels to identify required equipment working clearances.

    a. Field-Painted Floor Markings: Alternating black and white stripes, 3 inches wide, painted in accordance with Section 09 91 23 - Interior Painting and 09 91 13 - Exterior Painting.

11. Available Fault Current Documentation: Use identification label to identify the available fault current and date calculations were performed at locations requiring documentation by the National Electrical Code, including but not limited to the following..

    a. Service equipment.

    b. Industrial control panels.

    c. Motor control centers.

d. Elevator control panels.

e. Industrial machinery.

12. Arc Flash Hazard Warning Labels: Use warning labels to identify arc flash hazards for electrical equipment, such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are likely to require examination, adjustment, servicing, or maintenance while energized.

a. Comply with NFPA 70E

b. Minimum Size: 3.5 by 5 inches.

c. Legend: Include orange header that reads "WARNING", followed by the word message "Arc Flash and Shock Hazard; Appropriate PPE Required; Do not operate controls or open covers without appropriate personal protection equipment; Failure to comply may result in injury or death; Refer to NFPA 70E for minimum PPE requirements" or approved equivalent.

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

e. Service Equipment: Include the following information in accordance with the National Electrical Code.

1) Nominal system voltage.

2) Available fault current.

3) Clearing time of service overcurrent protective device(s).

4) Date label applied.

13. Within all switchboard rooms, electrical closets, and other spaces containing electrical equipment provide the following:

a. Vitreous enameled metal sign, red on white, reading "Electrical Equipment Room - No Storage Permitted."

b. Mounted in clearly visible locations within rooms.

1) If wall space in room does not permit mounting, mount to door on inside of room.

14. In all switchboard rooms:

a. Install up-to-date black-lined print of feeder diagram of building completed with feeder schedules.

1) Print shall be installed in frame, behind glass.

2) Print to include up-to-date field record information.

3) Print to be on mylar.

4) Print to have lettering no smaller than 1/8 inch.

B. Identification for Conductors and Cables:

1. Color Coding for Power Conductors 600 V and Less: Comply with Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.

2. Use identification nameplate or identification label to identify color code for ungrounded and grounded power conductors inside door or enclosure at each piece of feeder or branch-circuit distribution equipment when premises has feeders or branch circuits served by more than one nominal voltage system.

3. Use wire and cable markers to identify circuit number or other designation indicated for power, control, and instrumentation conductors and cables at the following locations:

a. At each source and load connection.

b. Within boxes where there are more than three branch circuits, provide metal tags. Provide source and circuit number for each ungrounded conductor.

c. Within equipment enclosures when conductors and cables enter or leave the enclosure.

d. Provide write-on tags to conductors and list source and circuit number for conductors to be extended in the future.

4. Use wire and cable markers to identify connected grounding electrode system components for grounding electrode conductors.

5. Use underground warning tape to identify direct buried cables and cables buried in raceway for the following systems:

a. Power

b. Lighting

c. Communications

d. Control wiring

e. Optical Fiber

f. Connection to City OEMC network

C. Identification for Raceways:

1. Comply with ASME A13.1 for size of letters for legend and minimum length of color field for each raceway.

2. Use voltage markers to identify highest voltage present for accessible conduits at maximum intervals of 20 feet.

3. Use voltage markers or color-coded bands to identify systems other than normal power system for accessible conduits at maximum intervals of 20 feet.

    a. Color-Coded Bands: Use field-painting or vinyl color coding electrical tape to mark bands 3 inches wide.

        1) Color Code:

            (a) Emergency Power System: Red.

            (b) Fire Alarm System: Red.

            (c) Control Wiring: Green and red.

            (d) Telecommunication Systems:

                (1) Provide blue colored conduit for telecommunication system raceway. Conduit to be in accordance with Section 26 05 33.13 - Conduit for Electrical Systems.

            (e) Mechanical and Electrical Supervisory System: Green and blue.

            (f) Security System: Blue and yellow.

            (g) Fire-Suppression Supervisory and Control System: Red and yellow.

        2) Field-Painting: Comply with Section 09 91 23 - Interior Painting and 09 91 13 - Exterior Painting.

        3) Vinyl Color Coding Electrical Tape: Comply with Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.

4. Use identification labels, handwritten text using indelible marker, or plastic marker tags to identify circuits enclosed for accessible conduits at wall penetrations, at floor penetrations, at roof penetrations, and at equipment terminations when source is not within sight.

    a. Provide one label or marker at each end of the pathway and at any exposed pints (i.e., screw cover boxes, pull points, etc.)

5. Exposed raceways shall be labeled at transitions into and out of inaccessible spaces.

6. Provide alphanumeric identifiers to designate locations for origin and the end of the pathway.

    a. Type of pathways shall be identified:

        1) CN-conduit

        2) TCN-telecommunications conduit

3) RK-rack

4) W-workstation

b. Numbered from each origin point in series starting from 1.

7. Use underground warning tape to identify underground raceways.

8. Use voltage markers to identify highest voltage present for wireways at maximum intervals of 20 feet.

D. Identification for Boxes:

1. Use voltage markers to identify highest voltage present.

2. Use voltage markers or color coded boxes to identify systems other than normal power system.

a. Color-Coded Boxes: Field-painted in accordance with Section 09 91 23 - Interior Painting and 09 91 13 - Exterior Painting per the same color code used for raceways.

b. For exposed boxes in public areas, do not color code.

3. Use identification labels or handwritten text using indelible marker to identify circuits enclosed.

a. For exposed boxes in public areas, use only identification labels.

E. Identification for Devices:

1. Wiring Device and Wallplate Finishes: Comply with Section 26 27 26 - Wiring Devices.

2. Use identification label to identify fire alarm system devices.

a. For devices concealed above suspended ceilings, provide additional identification on ceiling tile below device location.

3. Use identification label to identify load controlled for wall-mounted control devices controlling loads that are not visible from the control location and for multiple wall-mounted control devices installed at one location.

2.02 IDENTIFICATION NAMEPLATES AND LABELS

A. Identification Nameplates:

1. Manufacturers:

a. Seton Identification Products: www.seton.com/#sle.

b. Quentin D. Schwab.

c. Joe Halm Building Specialties

d. Mechanical Tag Systems

e. N&E Specialty Company

2. Materials:

a. Indoor Clean, Dry Locations: Use plastic nameplates.

b. Outdoor Locations: Use plastic nameplates suitable for exterior use.

1) With non-corroding screws.

3. Plastic Nameplates: Two-layer or three-layer laminated acrylic or melamine with beveled edges; minimum thickness of 1/16 inch; engraved text.

4. Text:

a. Text to be 1/2 inch high letters on 1-1/2 inch label for single line.

b. Text to be 1/2 inch high letters on 2 inch label for 2 line text applications.

c. Increase sizes of labels and letters to be viewed from floor in elevated applications.

5. Mounting Holes for Mechanical Fasteners: Two, centered on sides for sizes up to 1 inch high; Four, located at corners for larger sizes.

B. Identification Labels:

1. Materials: Use self-adhesive laminated plastic labels; UV, chemical, water, heat, and abrasion resistant.

2. Text: Use factory pre-printed or machine-printed text. Do not use handwritten text unless otherwise indicated.

C. Format for Equipment Identification:

1. Minimum Size: 1.5 inches by 2.5 inches.

2. Legend:

a. System designation where applicable:

b. Equipment designation or other approved description.

3. Text: All capitalized unless otherwise indicated.

4. Minimum Text Height:

a. System Designation: 1/2 inch.

b. Equipment Designation: 1/2 inch.

5. Color:

a. Normal Power System: White text on black background.

b. Emergency Power System: White text on red background.

c. Fire Alarm System: White text on red background.

D. Format for General Information and Operating Instructions:

1. Minimum Size: 1 inch by 2.5 inches.

2. Legend: Include information or instructions indicated or as required for proper and safe operation and maintenance.

3. Text: All capitalized unless otherwise indicated.

4. Minimum Text Height: 1/4 inch.

5. Color: Black text on white background unless otherwise indicated.

E. Format for Caution and Warning Messages:

1. Minimum Size: 2 inches by 4 inches.

2. Legend: Include information or instructions indicated or as required for proper and safe operation and maintenance.

3. Text: All capitalized unless otherwise indicated.

4. Minimum Text Height: 1/2 inch.

5. Color: Black text on yellow background unless otherwise indicated.

F. Format for Control Device Identification:

1. Minimum Size: 3/8 inch by 1.5 inches.

2. Legend: Load controlled or other designation indicated.

3. Text: All capitalized unless otherwise indicated.

4. Minimum Text Height: 3/16 inch.

5. Color: Black text on clear background.

G. Format for Fire Alarm Device Identification:

1. Minimum Size: 3/8 inch by 1.5 inches.

2. Legend: Designation indicated and device zone or address.

3. Text: All capitalized unless otherwise indicated.

4. Minimum Text Height: 3/16 inch.

5. Color: Red text on white background.

2.03 IDENTIFICATION SIGNS

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-fourths the size of principal lettering.

G. Fasteners: Stainless-steel 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. Provide additional information as required by the Owner's representative.

2.04 WIRE AND CABLE MARKERS

A. Markers for Conductors and Cables: Use wrap-around self-adhesive vinyl cloth, wrap-around self-adhesive vinyl self-laminating, heat-shrink sleeve, plastic sleeve, plastic clip-on, vinyl split sleeve, or metal tag type markers suitable for the conductor or cable to be identified.

B. Markers for Conductor and Cable Bundles: Use plastic marker tags or metal tags secured by nylon cable ties.

C. Legend: Power source and circuit number or other designation indicated.

D. Text: Use factory pre-printed or machine-printed text, all capitalized unless otherwise indicated.

E. Text Height: Comply with ANSI A13.1.

F. Color: Black text on orange background unless otherwise indicated.

2.05 VOLTAGE MARKERS

A. Markers for Conduits: Use factory pre-printed self-adhesive vinyl, self-adhesive vinyl cloth, or vinyl snap-around type markers.

B. Markers for Boxes and Equipment Enclosures: Use factory pre-printed self-adhesive vinyl or self-adhesive vinyl cloth type markers.

C. Minimum Size:

1. Markers for Equipment: 1 1/8 by 4 1/2 inches.

2. Markers for Conduits: As recommended by manufacturer for conduit size to be identified.

3. Markers for Pull Boxes: 1 1/8 by 4 1/2 inches.

4. Markers for Junction Boxes: 1/2 by 2 1/4 inches.

D. Legend:

1. Markers for Voltage Identification: Highest voltage present.

2. Markers for System Identification:

a. Emergency Power System: Text "EMERGENCY".

b. Other Systems: Type of service.

E. Color: Black text on orange background unless otherwise indicated.

2.06 UNDERGROUND WARNING TAPE

A. Materials: Use non-detectable type polyethylene tape suitable for direct burial, unless otherwise indicated.

B. Non-detectable Type Tape: 6 inches wide, with minimum thickness of 4 mil.

C. Legend: Type of service, continuously repeated over full length of tape.

1. Legend shall be factory printed.

D. Color:

1. Tape for Buried Power Lines: Black text on red background.

2.07 FLOOR MARKING TAPE

A. Floor Marking Tape for Equipment Working Clearance Identification: Self-adhesive vinyl or polyester tape with over laminate, 3 inches wide, with alternating black and white stripes.

2.08 WARNING SIGNS AND LABELS

A. Comply with the National Electrical Code and 29 CFR 1910.145.

B. Warning Signs:

1. Materials:

a. Indoor Dry, Clean Locations: Use factory pre-printed rigid plastic or self-adhesive vinyl signs.

b. Outdoor Locations: Use factory pre-printed rigid aluminum signs.

2. Rigid Signs: Provide four mounting holes at corners for mechanical fasteners.

3. Minimum Size: 7 by 10 inches unless otherwise indicated.

C. Warning Labels:

1. Materials: Use factory pre-printed or machine-printed self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969.

a. Do not use labels designed to be completed using handwritten text.

2. Machine-Printed Labels: Use thermal transfer process printing machines and accessories recommended by label manufacturer.

3. Minimum Size: 2 by 4 inches unless otherwise indicated.

D. Shall include, but not limited to, the following legends:

1. Multiple power source warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace clearance warning: " WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

PART 3 - EXECUTION

3.01 PREPARATION

A. Clean surfaces to receive adhesive products according to manufacturer's instructions.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install identification products to be plainly visible for examination, adjustment, servicing, and maintenance. Unless otherwise indicated, locate products as follows:

1. Surface-Mounted Equipment: Enclosure front.

2. Flush-Mounted Equipment: Inside of equipment door.

3. Free-Standing Equipment: Enclosure front; also enclosure rear for equipment with rear access.

4. Elevated Equipment: Legible from the floor or working platform.

5. Branch Devices: Adjacent to device.

6. Interior Components: Legible from the point of access.

7. Conduits: Legible from the floor.

8. Boxes: Outside face of cover.

9. Conductors and Cables: Legible from the point of access.

10. Devices: Outside face of cover.

C. Install identification products centered, level, and parallel with lines of item being identified.

D. Secure nameplates to exterior surfaces of enclosures using stainless steel screws and to interior surfaces using self-adhesive backing or epoxy cement.

E. Install self-adhesive labels and markers to achieve maximum adhesion, with no bubbles or wrinkles and edges properly sealed.

F. Install underground warning tape above buried lines with one tape per trench at 3 inches below finished grade.

G. Secure rigid signs using stainless steel screws.

H. Mark all handwritten text, where permitted, to be neat and legible.

I. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:

1. Power transfer switches.

2. Controls with external control power connections.

3.03 PATHWAY IDENTIFICATION

A. Conduit labels shall be made adhesive and a minimum of ¾ inch wide, embossed with the designations in 5/16-inch high letters (numbers placed in 2 locations for all spaces and on all pathways at both ends) and legibly written with a permanent marker.

B. Minimum of two (2) labels, one at each end of the pathway and any exposed points (i.e., screw cover boxes, pull points, etc.).

C. Exposed raceways do not need to be labeled unless transitioning into or out of an inaccessible space. When necessary, raceway designation will be (RW).

D. All pathways shall be identified with an alphanumeric identifier to designate locations for the origin and the end of the pathway.

E. Pathways shall follow the hierarchy.

F. Final identification shall be required at the beginning and the end of the pathway and at all accessible points along the pathway (i.e. Pull boxes).

3.04 IDENTIFICATION SIGN INSTALLATION

A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

B. Electronic shut off valves are to be identified with signs at the activating switch or button, including:

1. Gas Shut Off

2. Emergency Boiler Shut Off

3.05 WARNING SIGN INSTALLATION

A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.

B. Warning Signs are required for the following elements:

C. Warning Lights are to have an accompanying sign identifying the light meaning, including:

D. “Gas Usage in Space” for Science Labs and Prep Rooms

E. “Do Not Enter – Photo Developing” for Photography Dark Rooms

F. “Refrigerant Alarm” at Chiller Room

3.06 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Replace self-adhesive labels and markers that exhibit bubbles, wrinkles, curling or other signs of improper adhesion.

END OF SECTION

SECTION 260573 - POWER SYSTEM STUDIES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Short-circuit study.

B. Protective device coordination study.

C. Arc flash and shock hazard assessment.
   1. Includes arc flash hazard warning labels.

D. Criteria for the selection and adjustment of equipment and associated protective devices not specified in this section, as determined by studies to be performed.

1.02 REFERENCE STANDARDS

A. ANSI Z535.4 - American National Standard for Product Safety Signs and Labels; 2011.

B. IEEE 141 - IEEE Recommended Practice for Electrical Power Distribution for Industrial Plants; 1993 (Reaffirmed 1999).

C. IEEE 242 - IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems; 2001, with Errata (2003).

D. IEEE 399 - IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis; 1997.

E. IEEE 551 - IEEE Recommended Practice for Calculating Short-Circuit Currents in Industrial and Commercial Power Systems; 2006.

F. IEEE 1584 - IEEE Guide for Performing Arc Flash Hazard Calculations - Includes 1584, 1584A and 1584B; 2002 (Amended 2011).

G. NEMA MG 1 - Motors and Generators; 2017.

H. NFPA 70E - Standard for Electrical Safety in the Workplace; 2017.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work to provide equipment and associated protective devices complying with criteria for selection and adjustment, as determined by studies to be performed.
   2. Notify Architect/Engineer of Record of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

B. Pre-Study Meeting: Conduct meeting with Owner to discuss system operating modes and conditions to be considered in studies.

C. Sequencing:
   1. Submit study reports prior to or concurrent with product submittals.
   2. Do not order equipment until matching study reports and product submittals have both been evaluated by Architect/Engineer of Record.

3. Verify naming convention for equipment identification prior to creation of final drawings, reports, and arc flash hazard warning labels (where applicable).

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Study preparer's qualifications.
1. For coordination-study specialist, submit name and references for at least five actual Arc-Flash Hazard Analysis performed in the past year.

C. Field testing agency's qualifications.

D. Study reports, stamped or sealed and signed by study preparer.

E. Product Data:
1. In addition to submittal requirements specified in other sections, include manufacturer's standard catalog pages and data sheets for equipment and protective devices indicating information relevant to studies.
   a. Include characteristic time-current trip curves for protective devices.
   b. Include impedance data for busway.
   c. Include impedance data for engine generators.
   d. Clearly indicate that proposed short circuit current ratings are fully rated.
   e. Identify modifications made in accordance with studies that:
      1) Can be made at no additional cost to Owner.
      2) As submitted will involve a change to the contract sum.
2. Provide product data and information for software program to be used for studies.

F. Arc Flash and Shock Hazard Warning Label Samples: One of each type and legend specified.

G. Field quality control reports.

H. Certification that field adjustable protective devices have been set in accordance with requirements of studies.

I. Project Record Documents: Revise studies as required to reflect as-built conditions.
1. Include hard copies with operation and maintenance data submittals.
2. Include computer software files used to prepare studies with file name(s) cross-referenced to specific pieces of equipment and systems, including but not limited to:
   a. Coordination study input data (including program input data sheets).
   b. Study and Equipment Evaluation Reports.
   c. Coordination Study Report.
   d. Arc Flash Study Report.
   e. Shock Hazard Report

1.05 POWER SYSTEM STUDIES

A. Scope of Studies:
1. Section includes computer-based, fault-current and overcurrent protective device coordination studies. Protective devices shall be set based on results of the protective device coordination study performed by a licensed professional engineer hired by the electrical contractor. The contractor shall provide preliminary and post-construction fault-current and overcurrent protective device coordination studies.

2. Section includes computer-based arc flash hazard analysis study. Recommendations for reducing Arc Flash Incident Energy levels and enhancing worker safety shall be issued based on the results of the study. The contractor shall provide preliminary and post-construction arc flash hazard analysis studies.
3. Except where study descriptions below indicate exclusions, analyze system at each bus from primary protective devices of utility source down to each piece of equipment involved, including parts of system affecting calculations being performed (e.g. fault current contribution from motors).
4. Include in analysis alternate sources and operating modes (including known future configurations) to determine worst case conditions.
    a. Known Operating Modes:
        1) Utility as source.
        2) Generator as source.
        3) Utility/generator in parallel.
        4) Maintenance settings.

B. General Study Requirements:
1. Comply with the National Electrical Code.
2. Perform studies utilizing computer software complying with specified requirements; manual calculations are not permitted.
3. The studies shall be performed for As-Built condition reflecting all changes that occurred during construction and actual installed length of all the feeders.
4. The studies shall be based on actual equipment submitted and reviewed by EOR.
5. Include all power sources rated 50 V and greater.

C. Data Collection:
1. Compile information on project-specific characteristics of actual installed equipment, protective devices, feeders, etc. as necessary to develop single-line diagram of electrical distribution system and associated input data for use in system modeling.
    a. Utility Source Data: Include primary voltage, maximum and minimum three-phase and line-to-ground fault currents, impedance, X/R ratio, and primary protective device information.
        1) Obtain up-to-date information from Owner.
    b. Generators: Include manufacturer/model, kW and voltage ratings, and impedance.
    c. Motors: Include manufacturer/model, type (e.g. induction, synchronous), horsepower rating, voltage rating, full load amps, and locked rotor current or NEMA MG 1 code letter designation.
    d. Transformers: Include primary and secondary voltage ratings, kVA rating, winding configuration, percent impedance, and X/R ratio.
    e. Protective Devices:
        1) Circuit Breakers: Include manufacturer/model, type (e.g. thermal magnetic, electronic trip), frame size, trip rating, voltage rating, interrupting rating, available field-adjustable trip response settings, and features (e.g. zone selective interlocking).
        2) Fuses: Include manufacturer/model, type/class (e.g. Class J), size/rating, and speed (e.g. time delay, fast acting).
    f. Protective Relays: Include manufacturer/model, type, settings, current/potential transformer ratio, and associated protective device.
    g. Conductors: Include feeder size, material (e.g. copper, aluminum), insulation type, voltage rating, number per phase, raceway type, and actual length.

D. Short-Circuit Study:
1. Comply with IEEE 551 and applicable portions of IEEE 141, IEEE 242, and IEEE 399.

2. For purposes of determining equipment short circuit current ratings, consider conditions that may result in maximum available fault current, including but not limited to:
    a. Maximum utility fault currents.
    b. Maximum motor contribution.
    c. Known operating modes (e.g. utility as source, generator as source, utility/generator in parallel, bus tie breaker open/close positions).
3. For each bus location, calculate the maximum available three-phase bolted symmetrical and asymmetrical fault currents. For grounded systems, also calculate the maximum available line-to-ground bolted fault currents.

E. Protective Device Coordination Study:
1. Comply with applicable portions of IEEE 242 and IEEE 399.
2. Analyze alternate scenarios considering known operating modes (e.g. utility as source, generator as source, utility/generator in parallel, bus tie breaker open/close positions).
3. Analyze protective devices and associated settings for suitable margins between time-current curves to achieve full selective coordination while providing adequate protection for equipment and conductors.

F. Arc Flash and Shock Hazard Assessment:
1. Comply with NFPA 70E.
2. Perform incident energy and arc flash boundary calculations in accordance with IEEE 1584 (as referenced in NFPA 70E Annex D), where applicable.
    a. To clarify IEEE 1584 statement that "equipment below 240 V need not be considered unless it involves at least one 125 kVA or larger low-impedance transformer in its immediate power supply" for purposes of studies, study preparer to include equipment rated less than 240 V fed by transformers less than 125 kVA in calculations.
    b. Where reasonable, study preparer may assume a maximum clearing time of two seconds in accordance with IEEE 1584, provided that the conditions are such that a worker's egress from an arc flash event would not be inhibited.
    c. For single-phase systems, study preparer to perform calculations assuming three-phase system in accordance with IEEE 1584, yielding conservative results.
3. For equipment with main devices mounted in separate compartmentalized sections, perform calculations on both the line and load side of the main device.
4. Analyze alternate scenarios considering conditions that may result in maximum incident energy, including but not limited to:
    a. Maximum and minimum utility fault currents.
    b. Maximum and minimum motor contribution.
    c. Known operating modes (e.g. utility as source, generator as source, utility/generator in parallel, bus tie breaker open/close positions).

G. Study Reports:
1. General Requirements:
    a. Identify date of study and study preparer.
    b. Identify study methodology and software product(s) used.
    c. Identify scope of studies, assumptions made, implications of possible alternate scenarios, and any exclusions from studies.
    d. Identify base used for per unit values.
    e. Include single-line diagram and associated input data used for studies; identify buses on single-line diagram as referenced in reports and indicate bus voltage.
    f. Include conclusions and recommendations.
2. Short-Circuit Study:
    a. For each scenario, identify at each bus location:
        1) Calculated maximum available symmetrical and asymmetrical fault currents (both three-phase and line-to-ground where applicable).

2) Fault point X/R ratio.
3) Associated equipment short circuit current ratings.

b. Identify locations where the available fault current exceeds the equipment short circuit current rating, along with recommendations.

3. Protective Device Coordination Study:
   a. For each scenario, include time-current coordination curves plotted on log-log scale graphs.
   b. For each graph include (where applicable):
      1) Partial single-line diagram identifying the portion of the system illustrated.
      2) Protective Devices: Time-current curves with applicable tolerance bands for each protective device in series back to the source, plotted up to the maximum available fault current at the associated bus.
      3) Conductors: Damage curves.
      4) Transformers: Inrush points and damage curves.
      5) Generators: Full load current, overload curves, decrement curves, and short circuit withstand points.
      6) Motors: Full load current, starting curves, and damage curves.
      7) Capacitors: Full load current and damage curves.
   c. For each protective device, identify fixed and adjustable characteristics with available ranges and recommended settings.
      1) Circuit Breakers: Include long time pickup and delay, short time pickup and delay, and instantaneous pickup.
      2) Include ground fault pickup and delay.
      3) Include fuse ratings.
      4) Protective Relays: Include current/potential transformer ratios, tap, time dial, and instantaneous pickup.
   d. Identify cases where either full selective coordination or adequate protection is not achieved, along with recommendations.
4. Arc Flash and Shock Hazard Assessment:
   a. For each scenario, identify at each bus location:
      1) Calculated incident energy and associated working distance.
      2) Calculated arc flash boundary.
      3) Bolted fault current.
      4) Arcing fault current.
      5) Clearing time.
      6) Arc gap distance.
   b. For purposes of producing arc flash and shock hazard warning labels, summarize the maximum incident energy and associated data reflecting the worst-case condition of all scenarios at each bus location.
   c. Identify locations where the calculated maximum incident energy exceeds 40 calories per sq. cm.
   d. Include recommendations for reducing the incident energy at locations where the calculated maximum incident energy exceeds 8 calories per sq. cm.
   e. Include arc flash and shock hazard labels color images printed on regular 8.5x11 in paper.

1.06 QUALITY ASSURANCE

A. Study Preparer Qualifications: Professional electrical engineer licensed in Illinois and with minimum five years' experience in the preparation of studies of similar type and complexity using specified computer software.
   1. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

2. Study preparer may not be employed by the manufacturer of the electrical distribution equipment.
3. Study preparer may be employed by field testing agency.

B. Computer Software for Study Preparation: Use the latest edition of commercially available software utilizing specified methodologies.
1. Acceptable Software Products:
a. EasyPower LLC: www.easypower.com/#sle.
b. ETAP/Operation Technology, Inc.: www.etap.com.
c. SKM Systems Analysis, Inc.: www.skm.com.
d. CGI CYME; www.cyme.com.
e. EDSA Micro Corporation; www.poweranalytics.com

PART 2 - PRODUCTS

2.01 ARC FLASH AND SHOCK HAZARD WARNING LABELS

A. Provide warning labels complying with NFPA 70E to identify arc flash hazards for each work location analyzed by the arc flash and shock risk assessment.
1. Materials: Comply with Section 26 05 53 - Identification for Electrical Systems.
2. Minimum Size: 4 by 6 inches.
3. Legend: Provide custom legend in accordance with NFPA 70E based on equipment-specific data as determined by arc flash and shock risk assessment.
a. Include the following information:
1) Arc flash boundary.
2) Available incident energy and corresponding working distance.
3) Nominal system voltage.
4) Equipment identification.
5) Date calculations were performed.

B. Comply with ANSI Z535.4.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install arc flash and shock hazard warning labels in accordance with Section 26 05 53 - Identification for Electrical Systems.

3.02 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Adjust equipment and protective devices for compliance with studies and recommended settings.

C. Notify Architect/Engineer of Record of any conflicts with or deviations from studies. Obtain direction before proceeding.

D. Submit detailed reports indicating inspection and testing results, and final adjusted settings.

3.03 CLOSEOUT ACTIVITIES

A. See Section 01 78 00 - Closeout Submittals, for closeout submittals.

B. See Section 01 79 00 - Demonstration and Training, for additional requirements.

C. Training: Include as part of the base bid training for Owner's personnel on electrical safety pertaining to arc flash and shock hazards.
   1. Use site-specific arc flash and shock risk assessment report as training reference, supplemented with additional training materials as required.
   2. Provide minimum of eight hours of training.

END OF SECTION

SECTION 260583 - WIRING CONNECTIONS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Electrical connections to equipment.

1.02 REFERENCE STANDARDS

A. National Electrical Code and all applicable local code amendments.

B. NEMA WD 1 - General Color Requirements for Wiring Devices; 1999 (Reaffirmed 2015).

C. NEMA WD 6 - Wiring Devices - Dimensional Specifications; 2016.

D. NFPA 70 - National Electrical Code.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.
2. Determine connection locations and requirements.
3. Review with all other trades and equipment installers all connection requirements prior to initiation of work.

B. Sequencing:
1. Install rough-in of electrical connections before installation of equipment is required.
2. Make electrical connections before required start-up of equipment.

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide wiring device manufacturer's catalog information showing dimensions, configurations, and construction.

C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.05 QUALITY ASSURANCE

A. Products: Listed, classified, and labeled as suitable for the purpose intended.

B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Cords and Caps: NEMA WD 6; match receptacle configuration at outlet provided for equipment.
   1. Colors: Conform to NEMA WD 1.
   2. Cord Construction: NFPA 70, Type SO, multiconductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.
   3. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.
   4. Substitutions: See Section 01 60 00 - Product Requirements.

B. Disconnect Switches: As specified in Section 26 28 16.16 - Enclosed Switches and in individual equipment sections.

C. Wiring Devices: As specified in Section 26 27 26 - Wiring Devices

D. Flexible Conduit: As specified in Section 26 05 33.13 - Conduit for Electrical Systems.

E. Wire and Cable: As specified in Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables.

F. Boxes: As specified in Section 26 05 33.16 - Boxes for Electrical Systems.

2.02 EQUIPMENT CONNECTIONS

A. Equipment connections are as indicated on drawings.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that equipment is ready for electrical connection, wiring, and energization.

3.02 ELECTRICAL CONNECTIONS

A. Make electrical connections in accordance with equipment manufacturer's instructions.

B. Make conduit connections to equipment using flexible conduit. Use liquidtight flexible conduit with watertight connectors in damp or wet locations.

C. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.

D. Provide receptacle outlet to accommodate connection with attachment plug.

E. Provide cord and cap where field-supplied attachment plug is required.

F. Install suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.

G. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.

H. Install terminal block jumpers to complete equipment wiring requirements.

I. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.

J. Coolers and Freezers: Cut and seal conduit openings in freezer and cooler walls, floor, and ceilings.

END OF SECTION

SECTION 260800

COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

1. General Contractor shall coordinate Work of employees and each relevant subcontractor to facilitate the complete commissioning of Electrical Systems, as organized and guided by the CDB-hired Commissioning Provider.
2. Subject to the specific contractor participation roles outlined herein and in Section 01 91 13, *General Commissioning Requirements*, General contractor shall provide all labor, materials, equipment, and services necessary or incidental to the completion of Work in this section.

a. Section Includes:
   1) Commissioning process requirements for electrical systems, assemblies, and equipment.
   2) Requirements for documentation, testing, and training of electrical systems.

B. Related Work: The following items are not included in this Section and are specified under the designated Sections:

1. Division 26 Sections.

1.3 ACTION SUBMITTALS

A. Submit procedural documentation and formal test reports associated with the Work described in this section, for all testing contracted by the General Contractor or any of its subcontractors.

1.4 COMMISSIONING

A. This section governs the commissioning of electrical systems.

B. The following systems and equipment shall be commissioned:

1. Electrical Distribution Panels.
2. Emergency Power Systems.
3. Daylighting Controls.
4. Automatic Occupancy Controls.

C. The General Contractor shall provide the following testing, complete, including labor, scheduling,

coordination, and subcontractor participation. The testing shall be planned and scheduled such that the Commissioning Provider has opportunity to be present during the time of testing, or the test(s) shall be repeated at no additional cost.

D. The above listing of testing may not be comprehensive and does not relieve the General Contractor of any requirements identified elsewhere.

E. The General Contractor shall facilitate scheduling, coordination, and subcontractor participation in any additional testing required to complete the commissioning process, as determined by the Building Commissioning Provider.

PART 2 - PRODUCTS: NOT USED

PART 3 - EXECUTION:

3.1 Provide training of the Owner's operation and maintenance personnel. Coordinate scheduling with the Commissioning Provider.

3.2 Work with the Commissioning Provider always, and in cooperation with other members of the Commissioning Team, to ensure compliance and completion of the commissioning process.

END OF SECTION

SECTION 260813 - TESTING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes requirements for Electrical Testing including, but not limited to:

1. Testing of electrical components and systems.

a. Insulation resistance test.
b. Continuity test.
c. Voltage test.
d. Phase relationship verification.

2. Correction of defective components or systems.
3. Retest of corrected components, systems.

1.2 SUBMITTALS

A. Test reports: Submit six (6) copies of all test reports to Architect/Engineer of Record (3 copies), General Contractor (1).

1. Type each test report on 8-1/2" x 11" paper. Include:

a. Project title and location.
b. Test performed.
c. Data performed
d. Test equipment used.
e. Contractor's name, address and telephone number.
f. Testing firm's name, address and telephone number.
g. Names and tittles of persons:

1) Performing the test.
2) Observing test

h. Statement verifying each test.
i. Nameplate data from each motor and equipment item tested.
j. Test results.
k. Retest results after correction of defective components, systems.
l. Dates and time of test.

2. For each copy, assemble all test reports and bind them in a folder. Label each folder, "Electrical Test Reports" and include Chicago Board of Education Project Number, title and location.

PART 2 - PRODUCTS

2.1 MATERIALS:

A. Furnish all equipment, manpower and casual labor to perform specified testing.

PART 3 - EXECUTION

3.1 PREPARATION

A. Ensure that all electrical work is completed and ready for testing.

B. Disconnect all devices or equipment that may be damaged by application of test voltages, voltage or reversed phase sequence or other procedures.

3.2 TESTING:

A. Conduct tests and adjust equipment to verify compliance with specified performance.

3.3 INSULATION RESISTANCE TESTS

A. Resistance measured: line-to-ground.

B. Perform testing on the following items:

Item Tested	Min. Acceptance Voltage of Test	Resistance in Megohms
No. 2. and Larger Cables (600v)	1000v	50

3.4 CONTINUITY TESTS:

A. Test branch circuits and control circuits to determine continuity of wiring and connection.

3.5 VOLTAGE TESTS

A. Make and record voltage tests and record at the following listed points. Conduct tests under normal load conditions.

1. Terminals of all motors.
2. Terminals of all equipment, i.e., UPS, refrigeration compressors, etc.

3.6 PHASE RELATIONSHIP

A. Examine connections to equipment for proper phase relationships. Verify proper motor rotation.

3.7 CORRECTION OF DEFECTS

A. When tests disclose any unsatisfactory workmanship or equipment furnished under this Contract, correct defects and retest. Repeat tests until satisfactory results are obtained.

B. When any wiring or equipment is damaged by tests, repairs or replace such wiring or equipment. Test repaired items to ensure satisfactory operation.

3.8 CONTRACTOR STARTUP AND REPORTING

A. Contractor shall prepare and submit a complete set of test reports as outlined in this section.

END OF SECTION

SECTION 260919 - ENCLOSED CONTACTORS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. General purpose contactors.

B. Lighting contactors.

1.02 REFERENCE STANDARDS

A. National Electrical Code.

B. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts; 2000, with Errata (2008).

C. NEMA ICS 5 - Industrial Control and Systems: Control Circuit and Pilot Devices; 2017.

D. NEMA ICS 6 - Industrial Control and Systems: Enclosures; 1993 (Reaffirmed 2016).

E. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum); 2013.

F. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.

G. UL 508 - Industrial Control Equipment; Underwriters Laboratories Inc; Current Edition, Including All Revisions.

1.03 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide dimensions, size, voltage ratings and current ratings.

C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

D. Maintenance Data: Include instructions for replacing and maintaining coil and contacts.

1.04 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience and with service facilities within 50 miles of Project.

B. Products: Listed, classified, and labeled as suitable for the purpose intended.

C. Listed and labeled as defined in the National Electrical Code, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Allen-Bradley/Rockwell Automation: ab.rockwellautomation.com.

B. Eaton Corporation: www.eaton.com.

C. General Electric Company: www.geindustrial.com.

D. Schneider Electric; Square D Products: www.schneider-electric.us.

E. ASCO Power Technologies, LP; a division of Emerson Electric Company; www.emerson.com.

2.02 GENERAL PURPOSE CONTACTORS

A. Description: NEMA ICS 2, AC general purpose magnetic contactor.

B. Coil operating voltage: 120 volts, 60 Hertz.

C. Poles: As required to match circuit configuration and control function.

D. Enclosure: NEMA ICS 6, Type 1.

E. Accessories:
1. Pushbutton: ON/OFF.
2. Selector Switch: ON/OFF.
3. Indicating Light: RED.
4. Auxiliary Contacts: One, normally open.

2.03 LIGHTING CONTACTORS

A. Description: NEMA ICS 2 and UL 508, magnetic lighting contactor.

B. Configuration: Electrically operated, mechanically held, refer to drawings for required type of controls.

C. Coil operating voltage: 120 volts, 60 Hertz.

D. Poles: As required to match circuit configuration and control function.

E. Contact Rating: Match branch circuit overcurrent protection, considering derating for continuous loads.

F. Enclosure: NEMA ICS 6, Type 1.

G. Accessories:
1. Pushbutton: ON/OFF.
2. Selector Switch: ON/OFF.
3. Indicating Light: RED.
4. Auxiliary Contacts: One, normally open.

2.04 ACCESSORIES

A. Auxiliary Contacts: NEMA ICS 2, 2 normally open contacts in addition to seal-in contact.

B. Cover Mounted Pilot Devices: NEMA ICS 5, standard type.

C. Pilot Device Contacts: NEMA ICS 5, Form Z, rated A150.

D. Pushbuttons: Unguarded type.

E. Indicating Lights: Transformer, LED type.

F. Selector Switches: Rotary type.

2.05 DISCONNECTS

A. Combination Contactors: Combine contactor with disconnect in common enclosure.

B. Disconnects: Thermal magnetic circuit breaker with integral thermal and instantaneous magnetic trip in each pole; UL listed.

C. Disconnects: Fusible switch assembly; NEMA KS 1, enclosed knife switch with externally operable handle. Fuse clips: Designed to accommodate Class R fuses.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install enclosed contactors where indicated, in accordance with manufacturer's instructions.

B. Install enclosed contactors plumb. Provide supports in accordance with Section 26 05 29 - Hangers and Supports for Electrical Systems.

C. Height: 5 ft. to operating handle.

D. Provide fuses for fusible switches; refer to Section 26 28 13 - Fuses for product requirements.

E. Identify enclosed contactors in accordance with Section 26 05 53 - Identification for Electrical Systems.

3.02 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Inspect and test in accordance with NETA ATS, except Section 4.

C. Perform applicable inspections and tests listed in NETA ATS, Section 7.16.1.

3.03 CLEANING

A. The contractor shall remove all paint spatters and other spots, dirt and debris from the equipment. Clean equipment internally and externally using methods and materials recommended by the manufacturer.

END OF SECTION

SECTION 26 0924 - FJM - LIGHTING CONTROL

PART 1 GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes, but is not limited to the following:

1. Low voltage switching system with Switches, Relay Panels, and relays with provisions for:

a. Time of Day Switching Control (Astronomical time clock)
b. Photocell Control (via Contact Inputs Modules)
c. LED Dimming Control (via 0-10V DC)
d. Wireless Switching Control

2. Indoor photoelectric switches.
3. Switch-box occupancy sensors.
4. Indoor occupancy sensors.

B. Types of Lighting Control Equipment specified in this section include the following:

1. Individual Switches, switch stations and wall plates.

C. Related Sections: The following sections contain requirements that relate to this section:

1. Division 26 Section "Wiring Devices" for wall-box dimmers and manual light switches.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. PIR: Passive infrared.

1.4 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. Coordinate the work to provide luminaires and lamps compatible with the lighting controls to be installed.
5. Notify Architect of any conflicts or deviations from the contract documents to obtain direction prior to proceeding with work.

B. Pre-Wire Meeting – Include time for Lighting Control Manufacturer to conduct on-site meeting prior to commencing work. Manufacturer to review with installer:

1. Low voltage wiring requirements.
2. Separation of power and low voltage/data wiring.
3. Wire labeling.
4. Wireless hub locations and installation.
5. Where Lighting Control Manufacturer Sensor Layout and Tuning service is specified in Part 2 under "LIGHTING CONTROLS - GENERAL REQUIREMENTS", sensor locations to be reviewed in accordance with layout provided by Lighting Control Manufacturer. Lighting Control Manufacturer may direct Contractor regarding sensor relocation should conditions require a deviation from locations indicated.
6. Control locations.
7. Load circuit wiring.
8. Network wiring requirements.
9. Connections to other equipment.
10. Installer responsibilities.

C. Sequencing:

1. Do not install sensors and wall controls until final surface finishes and painting are complete.

1.5 SUBMITTALS

A. Product Data: For each type of product specified. Include data on features, accessories, finishes, and the following:

1. Physical description of lighting controls including dimensions.
2. Product & service warranty information.
3. Occupancy/Vacancy Sensors: Include detailed basic motion detection coverage range diagrams.
4. Wall Dimmers: Include derating information for ganged multiple devices.

B. Shop Drawings:

1. Lighting plan showing location of all switches, sensors, power packs, control zones, and hubs with complete bill of materials.
2. Lighting control sequence of operations.
3. Single line wiring diagrams.
4. Custom faceplate engraving
5. Manufacturer’s installation instructions.

C. Project Record Documents: Record actual installed locations and settings for lighting control system components.

D. Field quality-control test reports.

E. Samples of those products indicated for sample submission in Architect's comments on product data submittal. Include color and finish samples of device plates and other items per Architect's/Engineer's request.

F. Operation and Maintenance Data: Include detailed information on lighting control system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.

G. Warranty: Submit sample of manufacturer's Warranty or Enhanced Warranty as specified in Part 1 under WARRANTY. Submit documentation of final executed warranty completed by Owner's name and registered with manufacturer.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, for their indicated use and installation conditions by a testing agency acceptable to authorities having jurisdiction.

B. Regulatory Requirements: Comply with provisions of the following codes.

1. NFPA 70 "National Electrical Code.": The system shall comply with applicable provisions of the current National Fire Protection Association standard, local building codes and meet all the requirements of the local authorities having jurisdiction.
2. UL and NEMA Compliance: Provide wiring devices which are listed and labeled by UL and comply with applicable UL and NEMA standards.

C. Manufacturer: The equipment manufacturer shall be regularly engaged in the manufacture of energy management and lighting control equipment. Equipment shall have at least a five-year history of successful installation in similar applications.

D. System Checkout and Support: Factory trained Manufacturer Representatives shall be available to verify system installation, proper operation and conformance to customer requirements. Factory or Manufacturer Representatives shall be available for on-site training and telephone support.

E. FCC Emissions: All applicable components/assemblies shall meet emission standards as suitable by the FCC as specified in Part 15, Subpart J for Class A installations.

F. System: The controls shall meet the following specifications:

1. Operational ambient temperature: operating temperature: 32°F to 104°F (–10°C to 40°C).
2. Operational ambient humidity: not to exceed 45% RH at 32°F to 85% RH at 95°F (0°C to 35°C).
3. Static immunity: greater than 15KV.
4. Conducted lighting and line transient immunity: 6 KV spikes.

1.7 Warranty: System shall be provided with a 5 year warranty.

A. Manufacturer's Standard Warranty, With Manufacturer Full-Scope Start-Up

1. Manufacturer Lighting Control System Components.

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.
3) On-site diagnostics for applicable systems.

b. Telephone Technical Support: Available 24 hours per day, 7 days per week, excluding manufacturer holidays.

1.8 SEQUENCE AND SCHEDULING

A. Schedule installation of finish plates after the surface upon which they are installed has received final finish.

1.9 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Coordinate features of devices specified in this Section with systems and components specified in other Sections to form an integrated system of compatible components. Match components and interconnections for optimum performance of specified functions. Include coordination with the following:

1. Division 26 Section "Interior Lighting."
2. Division 26 Section "Exterior Lighting."

PART 2 PRODUCTS

2.1 MANUFACTURERS

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

1. Lighting Control Systems

a. Lutron Electronics Company, Inc.
b. Acuity
c. Wattstopper

B. Substitutions:

1. All proposed substitutions (clearly delineated as such) must be submitted in writing for approval by Architect a minimum of 10 working days prior to the bid date and must be made available to all bidders. Proposed substitutes must be accompanied by a review of the specification noting compliance on a line-by-line basis.
2. Any proposed substitutions to be reviewed by Architect at Contractor's expense
3. 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.

C. Source Limitations: Furnish products produced by a single manufacturer and obtained from a single supplier.

2.2 LIGHTING CONTROLS - GENERAL REQUIREMENTS

A. Provide products listed, classified, and labeled by Underwriter's Laboratories Inc. (UL) as suitable for the purpose indicated.

B. Unless specifically indicated to be excluded, provide all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, programming, etc. as necessary for a complete operating system that provides the control intent indicated.

C. 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.

D. Electrostatic Discharge Tolerance: Design and test equipment to withstand electrostatic discharges without impairment when tested according to IEC 61000-4-2.

E. Power Failure Recovery: When power is interrupted for periods up to 10 years; or and subsequently restored, lights to automatically return to same levels (dimmed setting, full on, or full off) as prior to power interruption.

F. Wireless Devices:

1. Wireless device family includes area or fixture level sensors, area or fixture level load controls for dimming or switching, and load controls that can be mounted in a wallbox, on a junction box, or at the fixture.
2. Wireless devices including sensors, load controls, and wireless remotes or wall stations, can be set up using simple button press programming without needing any other equipment (e.g. central hub, processor, computer, or other smart device).
3. Wireless hub adds the ability to set up the system using any smart device with a web browser (e.g. smartphone, tablet, PC, or laptop).
4. Capable of diagnosing system communications.
5. Capable of having addresses automatically assigned to them.
6. Receives signals from other wireless devices and provides feedback to user.
7. Capable of determining which devices have been addressed.

8. RF Range: 60 feet (18 m) line-of-sight or 30 feet (9 m) through typical construction materials between RF transmitting devices and compatible RF receiving devices.
9. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of CFR, Title 47, Part 15, for Class B application.

G. Wireless Network:

1. RF Frequency: 434 MHz; operate in FCC governed frequency spectrum for periodic operation; continuous transmission spectrum is not permitted.

    a. Wireless sensors, wireless wall stations and wireless load control devices do not operate in the noisy 2.4 GHz frequency band where high potential for RF interference exists.
    b. Wireless devices operate in an uncongested frequency band providing reliable operation.
    c. Fixed network architecture ensures all associated lights and load controls respond in a simultaneous and coordinated fashion from a button press, sensor signal, or command from the wireless hub (i.e. no popcorning).

2. Distributed Architecture: Local room devices communicate directly with each other. If the wireless hub is removed or damaged, local control, sensing, and operation continues to function without interruption.
3. Local room devices communicate directly with each other (and not through a central hub or processor) to ensure:

    a. Reliability of system performance.
    b. Fast response time to events in the space (e.g. button presses or sensor signals).
    c. Independent operation in the event of the wireless hub being removed or damaged.

H. Device Finishes:

1. Wall Controls: To be selected by Architect;
2. Standard Colors: Comply with NEMA WD1 where applicable.
3. Color Variation in Same Product Family: Maximum delta E of 1, CIE L*a*b color units.
4. Visible Parts: Exhibit ultraviolet color stability when tested with multiple actinic light sources as defined in ASTM D4674. Provide proof of testing upon request.
5.

2.3 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.

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 20 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 for drop ceilings 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 place sensor in ideal location and to verify coverage prior to permanent mounting.
k. Ceiling-Mounted Sensors:

1) Provide surface mounting bracket compatible with drywall, plaster, wood, concrete, and compressed fiber ceilings.
2) Provide recessed mounting bracket compatible with drywall and compressed fiber ceilings.

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) Ceiling-Mounted Occupancy/Vacancy Sensor: 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) Wall-Mounted Occupancy/Vacancy Sensor: 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 (1.8 to 2.4 m); 180 degree field of view.
3) Corner-Mounted Occupancy/Vacancy Sensor: 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 (1.8 to 2.4 m); 90 degree field of view.
4) Hallway Occupancy/Vacancy Sensor: Major motion coverage of up to 150 feet (45.7 m) with mounting height of 6 to 8 feet (1.8 to 2.4 m); narrow field of view.

C. Wireless Daylight Sensors:

1. Open-loop basis for daylight sensor control scheme.
2. Stable output over temperature from 32 degrees F (0 degrees C) to 104 degrees F (40 degrees C).
3. Partially shielded for accurate detection of available daylight to prevent fixture lighting and horizontal light component from skewing sensor detection.
4. Provide linear response from 2 to 150 footcandles.
5. Color: White.
6. Mounting: Ceiling surface or junction-box
7. Provide surface mounting bracket compatible with drywall, plaster, wood, concrete, and compressed fiber ceilings.
8. Provide all necessary mounting hardware and instructions for both temporary and permanent mounting.
9. Provide temporary mounting means for drop ceilings 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.

2.4 LOAD CONTROL MODULES

A. Provide wireless load control modules as indicated or as required to control the loads as indicated.

B. Junction Box-Mounted Modules:

1. Plenum rated.
2. 0-10 V Dimming Modules:

a. Products:

1) 8 A dimming module with 0-10V control, without emergency mode;

b. Communicates via radio frequency with up to ten compatible occupancy/vacancy sensors, ten wireless control stations, and one daylight sensor.
c. Single low voltage dimming module with Class 1 or Class 2 isolated 0-10V output signal conforming to IEC 60929 Annex E.2; source or sink automatically configures.
d. Selectable minimum light level.
e. Configurable high- and low-end trim.

f. Relay: Rated for 0-10 V ballasts, LED drivers, or fixtures that conform with NEMA 410.

2.5 WIRED WALLBOX OCCUPANCY SENSORS WITH WIRELESS COMMUNICATION INPUTS

A. A. 0-10 V Wall Dimmer/Switch Combination Occupancy/Vacancy Sensors with Wireless Communication Inputs;

1. Communicates via radio frequency with up to ten compatible wireless occupancy/vacancy sensors, ten wireless control stations, and one wireless daylight sensor.
2. Compatible with sourcing electronic 0-10 V ballasts/drivers, as per IEC 60929 Annex E.2 0-10 V protocol.
3. Selectable option to enable low light feature (automatic-on when ambient light is below threshold). Ambient light threshold to be selectable as either adaptive utilizing occupant feedback (Lutron Smart Ambient Light Detection) or as fixed (high, medium, low, and minimum presets).
4. Occupancy/Vacancy Sensors:

    a. Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
    b. 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.
    c. Programmable to operate as an occupancy sensor (automatic-on and automatic-off) or a vacancy sensor (manual-on and automatic-off).
    d. Turns off lighting after reasonable and adjustable time delay once the last person to occupy the space vacates a room or area; adjustable timeout settings (1, 5, 15, or 20 minutes).
    e. Adjustable sensitivity (high, medium, low, and minimum presets).
    f. Selectable option to inhibit automatic turn-on of lights after manual-off operation while room is occupied for applications such as presentation viewing in conference rooms and classrooms; when room is vacated, returns to normal automatic-on operation after time delay period.
    g. Selectable walk-through mode to override selected timeout and automatically turn off lights if no motion is detected within 3 minutes after initial occupancy for applications where space may be briefly occupied.

5. Dimmer Features:

    a. Adjustable high/low end trims.
    b. Selectable dimming curve (linear or switched).
    c. Selectable fade on/fade off times (15, 5, 2.5, or 0.75 sec).
    d. Adjustable auto-on light level (fully adjustable from one to 100 percent).

6. Dimmer Control: Multi-function tap switch with small, raised rocker for dimmer adjustment.

    a. Rocker raises/lowers light level, with new level becoming the current preset level.
    b. Switch single tap raises lights to preset level or fades lights to off.
    c. Switch double tap raises light to full on level.

7. Switch Control: Switch single tap turns lights on/off.
8. Product(s):

    a. Passive Infrared 0-10 V Wall Dimmer Occupancy/Vacancy Sensor*;* 0-10 V control for 0-10 V fluorescent ballasts/LED drivers (8 A load at 120-277 V, 50 mA max control current); coverage of 900 square feet (81 sq m) with mounting height of 4 feet (1.2 m); 180 degree field of view; multi-location capability using wireless control stations with wallbox mounting adapter.

2.6 WIRELESS CONTROL STATIONS

A. Product(s): As indicated on drawings.

B. Quantity: As indicated on the drawings.

C. Communicates directly to compatible RF receiving devices through use of a radio frequency communications link.

D. Does not require external power packs, power or communication wiring.

E. Allows for easy reprogramming without replacing unit.

F. Button Programming:

1. Single action.
2. Toggle action.

G. Includes LED to indicate button press or programming mode status.

H. Mounting:

1. Capable of being mounted with a table stand or directly to a wall under a faceplate.
2. Faceplates: Provide concealed mounting hardware.

I. Power: Battery-operated with minimum ten-year battery life (3-year battery life for night light models).

J. Finish: To be selected by Architect.

2.7 WIRELESS HUBS

A. Product: As indicated on drawings.

B. Integrated multicolor LED provides feedback on what mode the hub is in for simple identification and diagnosis.

C. Integrated processor and web server allows hub to set up and operate the system without any external connections to outside processors, servers, or the internet.

D. Utilizes Ethernet connection for:

1. Networking up to 64 hubs together to create a larger system.
2. Remote connectivity capabilities, including maintaining system date/time and receiving periodic firmware updates (requires internet connection).

E. A single hub or network of hubs can operate on either a dedicated lighting control only network or can be integrated with an existing building network as a VLAN.

F. Communicates directly to compatible RF devices through use radio frequency communications link; does not require communication wiring; RF range of 71 feet (23 m) through walls to cover an area of 15836 square feet (1471 sq m) (device and hub must be on the same floor).

G. Communicates directly to mobile device (smartphone or tablet) or computer using built-in Wi-Fi, 2.4 GHz 802.11b/g; wireless range of 71 feet (23 m) through walls (device and hub must be on the same floor).

1. Does not require external Wi-Fi router for connecting to the hub.

H. Allows for system setup, control, and monitoring from mobile device or computer using web-based software:

1. Supports paired devices up to maximum number indicated including compatible wireless sensors, wireless control stations, and wireless load devices.
2. Allows for timeclock scheduling of events, both time of day and astronomic (sunrise and sunset).

a. Timeclock is integrated into the unit and does not require a constant internet connection.
b. Retains time and programming information after a power loss.
c. 365-day schedulable timeclock allows for:

1) Scheduling of events years in advance.
2) Setting of recurring events with exceptions on holidays.

d. Time clock events can be scheduled to:

1) Send lights to a desired level and select the fade rate desired to reach that level.
2) Adjust level lights go to when occupied.
3) Adjust level lights go to when unoccupied.
4) Enable/disable occupancy.
5) Control individual devices, areas, or groups of areas. When connected to server, only areas or groups of areas can be controlled with timeclock events.

3. Daylighting:

a. Daylighting can be enabled/disabled. Can be used to override the control currently taking place in the space.

b. Daylight set point can be adjusted with the software to increase or decrease the electric light level in the room based on the same amount of natural light.

4. Allows for control, monitoring, and adjustment from anywhere in the world wireless hub internet connection required).
5. Uses RF signal strength detection to find nearby devices for quick association and programming without having to climb ladders.

    a. Association and setup does not require a factory technician to perform.

6. System using wireless hub(s) can operate with or without connection to the internet.
7. Supports energy reporting.

    a. Reports measured energy data for fixture control modules at accuracy of plus/minus 2 percent or 0.5 W (whichever is higher).
    b. Reports calculated energy data for junction box mounted modules at accuracy of 10 percent.
    c. Reports measured energy for wireless fixture control dongle when paired with driver that supports measured power (measurement accuracy defined by driver specification) or reports calculated power if driver does not have measurement capabilities.

8. Supports automatic demand response for load shedding via:

    a. Local contact closure without need for separate interface.
    b. OpenADR® 2.0b compliant utility command.

9. Support automatic generation of alerts in web-based application for designated events/triggers, including:

    a. Low-battery condition in battery-operated sensors and controls; alert cleared when battery is replaced.
    b. Missing device (e.g., control or sensor); alert cleared when device is detected by system.

10. Wireless hub can be firmware upgraded to provide new software features and system updates.

    a. Firmware update can be done either locally using a wired Ethernet connection or Wi-Fi connection, or remotely if the wireless hub is connected to the internet.

I. Web-Based Application:

1. Accessibility and Platform Support:

    a. Web-based; runs on most HTML5 compatible browsers (including Safari and Chrome).
    b. Supports multiple platforms and devices; runs from a tablet, desktop, laptop, or smartphone.
    c. User interface supports multi-touch gestures such as pinch to zoom, drag to pan, etc.
    d. Utilizes HTTPS (industry-standard certificate-based encryption and authentication for security).

e. Multi-level Password Protected Access: Individual password protection on both the integrated Wi-Fi network and web-based software.
f. WPA2 security for Wi-Fi communication with wireless hub.

2. System Navigation and Status Reporting:

a. Area Tree View: Easy navigation by area name to view status and make programing adjustments through the software.
b. Area and device names can be changed in real time.

3. Setup app available for iOS and Android that allows for:

a. Job registration to extend product warranty.
b. Management of setup for multiple projects in different locations.
c. Creation of handoff documents that are sent directly to a facility manager via email once setup is complete.
d. Backup of Vive wireless hub database to Lutron cloud for hub replacement.
e. Access to native help and instructions to assist user with Vive system setup.

J. API Integration:

1. Support communication, without requiring interface, between lighting control system and third-party systems via RESTful API.
2. Requires one network connection per wireless hub.
3. API Integration Capabilities:

a. Control all zones or subset of zones.

1) Set zones in designated area to specific level.
2) Raise/lower dimmable lights in designated area.

b. Control individual zones.
c. Subscribe to and Monitor:

1) Area status changes (e.g., occupancy, light level, and instantaneous power).
2) Individual zone changes in light level.
3) Alerts (e.g., missing device and low battery).

K. Scenes:

1. Support programmable scenes to control individual devices, areas, or groups of areas on demand.
2. Scenes may be activated via:

a. Contact closure input.
b. API integration.
c. Manual activation in app.

L. Emergency Mode:

a. Support emergency mode to, when triggered, send lights to defined levels and lock out controls for load control modules equipped with emergency mode.

2. Emergency mode may be activated via:

a. Contact closure input.
b. API integration.
c. Manual activation in app.

M. Contact Closure Interface: Provide two contact closure inputs; accepts both momentary and maintained contact closures that can be used for automatic demand response.

N. Rated for use in air-handling spaces as defined in UL 2043.

O. Meets CAL TITLE 24 P6 requirements.

PART 3 EXECUTION

3.1 INSTALLATION OF control DEVICES AND ACCESSORIES

A. Install all control devices and accessories as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and in accordance with recognized industry practices to fulfill project requirements.

B. Mount lighting control devices according to manufacturer's written instructions and requirements in Division 26 Section "Basic Electrical Requirements."

C. Mounting heights indicated are to bottom of unit for suspended devices and to center of unit for wall-mounting devices.

D. Coordinate with other work, including painting, electrical boxes and wiring installations, as necessary to interface installation of wiring devices with other Work.

E. Install control devices only in electrical boxes which are clean; free from excess building materials, dirt, and debris.

F. Install control devices after wiring work is completed.

G. Install wall plates after painting work is completed.

H. Sensor Installation

1. Install and aim sensors in locations to achieve at least 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 CONTROL WIRING INSTALLATION

A. Coordinate this Article with Drawings.

B. Wiring Method: Comply with Division 26 Section "Wire and Cables." Minimum conduit size shall be ¾" Unless noted otherwise

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

D. Install field-mounting transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.

E. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

F. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

G. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standard 486A. Use properly scaled torque indicating hand tool.

H. Install wiring between sensing and control devices according to manufacturer's written instructions and as specified in Division 26 Section "Wire and Cables" for low-voltage connections and digital circuits.

I. Wiring Method: Install all wiring in raceway as specified in Division 26 Section "Raceways and Boxes."

J. Bundle, train, and support wiring in enclosures.

K. Ground equipment.

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

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Electrical Identification."

B. Label time switches and contactors with a unique designation.

3.4 FIELD QUALITY CONTROL

A. Testing: Prior to energizing circuits, test wiring for electrical continuity, and for short-circuits. Ensure proper polarity of connections in maintained. Subsequent to energizing, test wiring devices and demonstrate compliance with requirements, operating each operable device at least six times.

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
2. Operational Test: Verify actuation of each sensor and adjust time delays.
3. Schedule visual and mechanical inspections and electrical tests with at least seven days' advance notice.

a. Inspect control components for defects and physical damage, testing laboratory labeling, and nameplate compliance with the Contract Documents.

4. Check tightness of electrical connections with torque wrench calibrated within previous six months. Use manufacturer's recommended torque values.

B. Electrical Tests: Use particular caution when testing devices containing solid-state components. Perform the following according to manufacturer's written instructions:

1. Continuity tests of circuits.
2. Operational Tests: Set and operate devices to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.

a. Include testing of devices under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.

C. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.

D. Remove and replace lighting control devices where test results indicate that they do not comply with specified requirements.

E. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

F. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

G. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

3.5 CLEANING

A. Cleaning: Clean equipment and devices internally and externally using methods and materials recommended by manufacturers, and repair damaged finishes.

3.6 ADJUSTING

A. On-Site Scene and Level Tuning, include time for Lighting Controls Manufacturer to visit the site to conduct meeting with Lighting Designer and Owner's Representative to make required lighting adjustments to the system for conformance with original design intent.

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

END OF SECTION

SECTION 262100 - LOW-VOLTAGE ELECTRICAL UTILITY SERVICE ENTRANCE

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Electrical service requirements.

1.02 PRICE AND PAYMENT PROCEDURES

A. Allowances:
1. See Section 01 21 00 - Allowances, for allowances affecting this section.
2. Include in the Base Bid the amount $10,000.00 for payment of project electrical utility company fees. Copy Owner's Representative and Architect/Engineer of Record on all paid fees to assure Division 26 contract balancing.

1.03 DEFINITIONS

A. Service Point: The point of connection between the facilities of the serving utility and the premises wiring as defined in the National Electrical Code, and as designated by the Utility Company.

1.04 REFERENCE STANDARDS

A. IEEE C2 - National Electrical Safety Code; 2017.

B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

1.05 ADMINISTRATIVE REQUIREMENTS

A. No later than two (2) weeks following date of the Agreement, notify Utility Company of anticipated date of service.

B. Coordination:
1. Verify the following with Utility Company representative:
   a. Utility Company requirements, including division of responsibility.
   b. Exact location and details of utility point of connection.
   c. Utility easement requirements.
   d. Utility Company charges associated with providing service.
2. Coordinate the work with other trades to avoid placement of other utilities or obstructions within the spaces dedicated for electrical service and associated equipment.
3. Coordinate arrangement of service entrance equipment with the dimensions and clearance requirements of the actual equipment to be installed.
4. Coordinate the work with other installers to provide communication lines required for Utility Company meters.
5. Notify Architect/Engineer of Record of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

C. Arrange for Utility Company to provide permanent electrical service. Prepare and submit documentation required by Utility Company.

D. Utility Company charges associated with providing permanent service to be paid by Owner.

E. Preinstallation Meetings:

1. Preinstallation Meeting: Conduct a preinstallation meeting at least one week prior to the start of the work of this section; require attendance by all affected installers.
2. Ensure required submittals have been provided with sufficient time for review prior to scheduling the preinstallation meeting.
3. Review the detailed requirements for the work of this section and to review the drawings and specifications for this work. Require attendance by all affected installers including but not limited to:
    a. Contractor's Superintendent.
    b. Installer.
    c. Manufacturer/Fabricator Representative.
    d. Utility Company representative.
    e. Other affected Subcontractors.
    f. Architect/Engineer of Record.
    g. Owner's Representative.
4. Record minutes and distribute copies within five (5) days after meeting to participants as well as Architect/Engineer of Record, Owner and those affected by decisions made.

F. Scheduling:
1. Where work of this section involves interruption of existing electrical service, arrange service interruption with Owner.
2. Arrange for inspections necessary to obtain Utility Company approval of installation.

1.06 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product. Include ratings, configurations, standard wiring diagrams, outline and support point dimensions, finishes, weights, service condition requirements, and installed features.

C. Shop Drawings: Include dimensioned plan views and sections indicating locations and arrangement of Utility Company and service entrance equipment, metering provisions, required clearances, and proposed service routing.
1. Obtain Utility company approval of shop drawings prior to submittal.
2. Coordination drawings with dimensional relationship of exterior pad-mounted electrical service entrance equipment with surrounding fencing and building(s) and associated underground raceway installations relative to property line. Show minimum clearances, installed devices, and major features. Include sections depicting underground and aerial equipment clearances relative to grade.

D. Drawings prepared by Utility Company.

E. Project Record Documents: Record actual locations of equipment and installed service routing.

1.07 QUALITY ASSURANCE

A. Comply with the following:
1. IEEE C2 (National Electrical Safety Code).
2. The requirements of the Utility Company.
3. The requirements of the local authorities having jurisdiction.
4. Comply with the National Electrical Code.

B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

C. Products: Listed, classified, and labeled as suitable for the purpose intended.

D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.08 DELIVERY, STORAGE, AND HANDLING

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

B. Store products indoors in a clean, dry space having a uniform temperature to prevent condensation (including outdoor rated products which are not weatherproof until completely and properly installed). Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

C. Handle products carefully to avoid damage to internal components, enclosure, and finish.

PART 2 - PRODUCTS

2.01 ELECTRICAL SERVICE REQUIREMENTS

A. Provide new electrical service consisting of all required conduits, conductors, equipment, metering provisions, supports, accessories, etc. as necessary for connection between Utility Company point of supply and service entrance equipment.

B. Electrical Service Characteristics: As indicated on drawings.

C. Utility Company: As indicated on drawings.

D. Division of Responsibility:
1. Pad-Mounted Utility Transformers:
    a. Transformer Vaults and Pads: Furnished and installed by Contractor per Utility Company requirements.
    b. Transformers: Furnished and installed by Utility Company.
    c. Transformer Grounding Provisions: Furnished and installed by Contractor per Utility Company requirements.
    d. Transformer Protective Bollards: Furnished and installed by Contractor per Utility Company requirements.
    e. Primary:
        1) Trenching and Backfilling: Provided by Contractor.
        2) Conduits: Furnished and installed by Contractor.
        3) Conductors: Furnished and installed by Utility Company.
    f. Secondary:
        1) Trenching and Backfilling: Provided by Contractor.
        2) Conduits: Furnished and installed by Contractor.
        3) Conductors: Furnished and installed by Contractor (Service Point at transformer).
2. Pole-Mounted Utility Transformers:
    a. Utility Poles: Furnished and installed by Utility Company.
    b. Transformers: Furnished and installed by Utility Company.
    c. Transformer Grounding Provisions: Furnished and installed by Utility Company.
    d. Primary: Furnished and installed by Utility Company.
    e. Secondary - Underground Service:
        1) Conduits: Furnished and installed by Contractor.
        2) Conductors: Furnished and installed by Contractor (Service Point at utility pole).

f. Secondary - Overhead Service:
1) Conduits/Service Masts: Furnished and installed by Contractor.
2) Conductors: Furnished and installed by Contractor (Service Point at service mast).

3. Terminations at Service Point: Provided by Utility Company.
4. Metering Provisions:
a. Meter Bases: Furnished and installed by Contractor per Utility Company requirements.
b. Metering Transformer Cabinets: Furnished and installed by Contractor per Utility Company requirements.
c. Metering Compartments in Service Entrance Equipment: Furnished and installed by Contractor per Utility Company requirements.
d. Metering Transformers: Furnished and installed by Utility Company.
e. Conduits Between Metering Transformers and Meters: Furnished and installed by Contractor per Utility Company requirements.
f. Wiring Between Metering Transformers and Meters: Furnished and installed by Utility Company.
g. Communications Conduits for Meters: Furnished and installed by Contractor per Utility Company requirements.

E. Products Furnished by Contractor: Comply with Utility Company requirements.

F. Metered Voltage and service characteristics as indicated on drawings.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that ratings and configurations of service entrance equipment are consistent with the indicated requirements.

C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 PREPARATION

A. Verify and mark locations of existing underground utilities.

3.03 INSTALLATION

A. Install products in accordance with manufacturer's instructions and Utility Company requirements.

B. Perform work in accordance with NECA 1 (general workmanship).

C. Arrange equipment to provide minimum clearances and required maintenance access.

D. Provide required trenching and backfilling in accordance with Section 31 23 16 and Section 31 23 23.

E. Construct cast-in-place concrete pads for utility equipment in accordance with Utility Company requirements and Section 03 30 00.

F. Provide required protective bollards in accordance with Utility Company requirements.

G. Provide required support and attachment components in accordance with Section 26 05 29 - Hangers and Supports for Electrical Systems.

H. Provide grounding and bonding for service entrance equipment in accordance with Section 26 05 26 - Grounding and Bonding for Electrical Systems.

I. Identify service entrance equipment, including main service disconnect(s) in accordance with Section 26 05 53 - Identification for Electrical Systems.

3.04 CLEANING

A. Clean dirt and debris from equipment, enclosures and components according to manufacturer's instructions.

B. Repair scratched or marred exterior surfaces to match original factory finish.

3.05 PROTECTION

A. Protect installed equipment from subsequent construction operations.

END OF SECTION

SECTION 262200 - LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. General purpose transformers.

B. K-factor transformers rated for nonlinear loads.

C. Buck-boost transformers.

D. Control transformers.

1.02 REFERENCE STANDARDS

A. 10 CFR 431, Subpart K - Energy Efficiency Program for Certain Commercial and Industrial Equipment - Distribution Transformers; Current Edition.

B. IEEE C57.12.91 - IEEE Standard Test Code for Dry-Type Distribution and Power Transformers; 2011.

C. IEEE C57.94 - IEEE Recommended Practice for Installation, Application, Operation, and Maintenance of Dry-Type Distribution and Power Transformers; 2015.

D. IEEE C57.96 - IEEE Standard Guide for Loading Dry-Type Distribution and Power Transformers; 2013.

E. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

F. NECA 409 - Standard for Installing and Maintaining Dry-Type Transformers; 2015.

G. NEMA ST 20 - Dry-Type Transformers for General Applications; 2014.

H. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2014.

I. NEMA TP 1 - Guide for Determining Energy Efficiency for Distribution Transformers; 2002.

J. NEMA TP 2 - Standard Test Method for Measuring the Energy Consumption of Distribution Transformers; 2005.

K. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.

L. UL 486A-486B - Wire Connectors; Current Edition, Including All Revisions.

M. UL 506 - Standard for Specialty Transformers; Current Edition, Including All Revisions.

N. UL 1561 - Standard for Dry-Type General Purpose and Power Transformers; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination: Coordinate the work with placement of support framing and anchors required for mounting of transformers. Concrete, reinforcement, and formwork requirements as specified in Division 03.

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. See Section 01 33 29 - LEED Sustainable Design Reporting, when required.

C. Product Data: Include voltage, kVA, impedance, tap configurations, insulation system class and rated temperature rise, efficiency, sound level, enclosure ratings, outline and support point dimensions, weight, required clearances, service condition requirements, and installed features.
   1. Vibration Isolators: Include attachment method and rated load and deflection.
   2. K-factor Rated Transformers: Include K-factor ratings.
   3. Buck-boost Transformers: Include voltage selection tables and wiring diagrams for autotransformer configurations.
   4. Shielded Transformers: Include shielding method and noise attenuation performance.

D. Shop Drawings: Provide dimensioned plan and elevation views of transformers and adjacent equipment with all required clearances indicated.
   1. Small Power Centers: Include panel arrangements.

E. Product certificates signed by manufacturers certifying that their products comply with the specified requirements.

F. Source Quality Control Test Reports: Include reports for tests designated in NEMA ST 20 as design and routine tests.

G. Field Quality Control Test Reports.

H. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

I. Maintenance Data: Include recommended maintenance procedures and intervals.

J. Project Record Documents: Record actual locations of transformers.

1.05 QUALITY ASSURANCE

A. Conform to requirements of the National Electrical Code.

B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three (3) years documented experience.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in the National Electrical Code, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers".

F. Factory Sound-Level Tests: Conduit sound-level tests on equipment for this Project.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to transformer internal components, enclosure, and finish.

1.07 FIELD CONDITIONS

A. Ambient Temperature: Do not exceed the following maximum temperatures during and after installation of transformers.
   1. Greater than 10 kVA: 104 degrees F maximum.
   2. Less than 10 kVA: 77 degrees F maximum.

1.08 WARRANTY

A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. ABB/GE: www.geindustrial.com/#sle.

B. Eaton Corporation: www.eaton.com

C. Schneider Electric; Square D Products: www.schneider-electric.us

D. Siemens Industry, Inc: www.usa.siemens.com.

E. Magnetek Power Electronics Group; www.magnetek.com.

F. Sola/Hevi-Duty; www.solahevidutysales.com

2.02 TRANSFORMERS - GENERAL REQUIREMENTS

A. Description: Factory-assembled, dry type transformers for 60 Hz operation designed and manufactured in accordance with NEMA ST 20 and listed, classified, and labeled as suitable for the purpose intended.

B. Unless noted otherwise, transformer ratings indicated are for continuous loading according to IEEE C57.96 under the following service conditions:
   1. Altitude: Less than 3,300 feet.
   2. Ambient Temperature:
      a. Greater than 10 kVA: Not exceeding 104 degrees F.
      b. Less than 10 kVA: Not exceeding 77 degrees F.

C. Core: High grade, non-aging silicon steel with high magnetic permeability and low hysteresis and eddy current losses. Keep magnetic flux densities substantially below saturation point, even at 10 percent primary overvoltage. Tightly clamp core laminations to prevent plate movement and maintain consistent pressure throughout core length.

D. Impregnate core and coil assembly with non-hydroscopic thermo-setting varnish to effectively seal out moisture and other contaminants.

E. Basic Impulse Level: 10 kV.

F. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.

G. Isolate core and coil from enclosure using vibration-absorbing mounts.

H. Nameplate: Include transformer connection data, ratings, wiring diagrams, and overload capacity based on rated winding temperature rise. nameplates and label products are specified in Section 26 05 53 - Identification for Electrical Systems.

2.03 GENERAL PURPOSE TRANSFORMERS

A. Description: Self-cooled, two winding transformers listed and labeled as complying with UL 506 or UL 1561; ratings as indicated on the drawings.

B. Primary Voltage: As indicated elsewhere in the construction documents.

C. Secondary Voltage: As indicated elsewhere in the construction documents.

D. Insulation System and Allowable Average Winding Temperature Rise:
1. Class 220 degrees C insulation system with 115 degrees C average winding temperature rise above 40 degrees ambient temperature.

E. Coil Conductors: Continuous copper windings with terminations brazed or welded.

F. Winding Taps:
1. Less than 3 kVA: One 5 percent tap above normal full capacity..
2. 3 kVA through 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.
3. 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

G. Energy Efficiency: Comply with 10 CFR 431, Subpart K, current edition.

H. Sound Levels: Standard sound levels complying with NEMA ST 20. Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

I. Mounting Provisions:
1. Less than 15 kVA: Suitable for wall mounting.
2. 15 kVA through 75 kVA: Suitable for wall, floor, or trapeze mounting.
3. Larger than 75 kVA: Suitable for floor mounting.

J. Transformer Enclosure: Comply with NEMA ST 20.
1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
   a. Indoor clean, dry locations: Type 2.
   b. Outdoor locations: Type 3R.
2. Construction: Steel.
   a. Less than 15 kVA: Totally enclosed, non-ventilated.
   b. 15 kVA and Larger: Ventilated.
3. Finish: Manufacturer's standard grey, suitable for outdoor installations.

4. Provide lifting eyes or brackets.

K. Accessories:
1. Mounting Brackets: Provide manufacturer's standard brackets.
2. Weathershield Kits: Provide for ventilated transformers installed outdoors to provide a listed NEMA 250, type 3R assembly.
3. Lug Kits: Sized as required for termination of conductors as indicated on the drawings.

L. Energy Efficiency for Transformers Rated 15 kVA and Larger:
1. Complying with NEMA TP 1, Class 1 efficiency levels.
2. Tested according to NEMA TP 2.

2.04 K-FACTOR TRANSFORMERS RATED FOR NONLINEAR LOADS

A. Description: Self-cooled, two winding transformers listed and labeled as complying with UL 1561, and designed to supply nonlinear loads to the degree designated by the UL defined K-factor; ratings as indicated on the drawings.

B. K-factor Rating: K-4, or higher as indicated in construction documents.

C. Insulation System and Allowable Average Winding Temperature Rise: Class 220 degrees C insulation system with 115 degrees C average winding temperature rise above 40 degrees ambient temperature.

D. Coil Conductors: Continuous copper windings with terminations brazed or welded. Individually insulate secondary conductors and arrange to minimize hysteresis and eddy current losses at harmonic frequencies. Size secondary neutral conductor at twice the secondary phase conductor ampacity.

E. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.

F. K-factor shall not exceed value indicated. Provide value of K-factor on transformer nameplate.

G. Transformer shall incorporate electrostatic shield grounded to the transformer core, designed per requirements as stated in "Accessories" Paragraph below.

H. The neutral bus shall be sized and configured for at least 200 percent of the secondary full load current.

I. Transformer impedance shall be a minimum of 3 and a maximum of 5 percent.

J. Winding Taps:
1. Less than 3 kVA: One 5 percent tap above normal full capacity..
2. 3 kVA through 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.
3. 25 kVA and Larger: Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity.

K. Neutral Bus: Sized to accommodate twice the rated secondary current.

L. Energy Efficiency: Comply with 10 CFR 431, Subpart K.

M. Sound Levels: Standard sound levels complying with NEMA ST 20.

N. Mounting Provisions:
1. Up to 75 kVA: Suitable for wall, floor, or trapeze mounting.

2. Larger than 75 kVA: Suitable for floor mounting.

O. Electrostatic Shield: Provide grounded full-width copper electrostatic shield between primary and secondary windings to attenuate electrical noise.

P. Transformer Enclosure: Comply with NEMA ST 20.
1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
a. Indoor clean, dry locations: Type 2.
b. Outdoor locations: Type 3R.
2. Construction: Steel, ventilated.
3. Finish: Manufacturer's standard grey, suitable for outdoor installations.
4. Provide lifting eyes or brackets.

Q. Accessories:
1. Mounting Brackets: Provide manufacturer's standard brackets.
2. Weathershield Kits: Provide for ventilated transformers installed outdoors to provide a listed NEMA 250, type 3R assembly.
3. Lug Kits: Sized as required for termination of conductors as indicated on the drawings.
4. Vibration isolators to reduce transfer of a vibration.

R. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

2.05 BUCK-BOOST TRANSFORMERS

A. Description: Self-cooled, four winding, buck-boost transformers listed and labeled as complying with UL 506 or UL 1561, and suitable for field connection as an autotransformer; ratings as indicated on the drawings.

B. Insulation System and Allowable Average Winding Temperature Rise:
1. Less than 0.25 kVA: Class 105 degree C insulation system with 55 degrees C rise.
2. 0.25 kVA and Larger: Class 180 degree C insulation system with 115 degree C rise.

C. Coil Conductors: Continuous windings.

D. Lugs: Suitable for terminating conductors sized for full rated load ampacity of transformer when operating in buck-boost configuration indicated.

E. Mounting Provisions: Suitable for wall mounting.

F. Transformer Enclosure: Comply with NEMA ST 20.
1. Environment Type per NEMA 250: Type 3R.
2. Construction: Steel, totally enclosed, non-ventilated.
3. Finish: Manufacturer's standard grey, suitable for outdoor installations.

2.06 CONTROL AND SIGNAL TRANSFORMERS

A. Description: Self-cooled, two-winding dry type.

B. Comply with NEMA ST 1 “Specialty transformers” and UL Standard UL 506 “Specialty Transformers”.

C. Enclosure: Suitable for the environment.
1. Finish Color: Manufacturers standard paint over corrosion resistant pretreatment and primer.

D. Ratings: Continuous Duty. Where ratings are not indicated, provide capacity exceeding peak load by 50 percent minimum.

2.07 SOURCE QUALITY CONTROL

A. Factory test transformers according to NEMA ST 20.

B. Sound Level Tests: Perform factory test designated in NEMA ST 20 as "design" test on each production unit.

C. Test and inspect transformers according to IEEE C57.12.91.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that suitable support frames and anchors are installed where required and that mounting surfaces are ready to receive transformers.

C. Perform pre-installation tests and inspections on transformers per manufacturer's instructions and as specified in NECA 409. Correct deficiencies prior to installation.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

A. Perform work in accordance with NECA 1 (general workmanship).

B. Install products in accordance with manufacturer's instructions.

C. Install transformers in accordance with NECA 409 and IEEE C57.94.

D. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

E. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

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

G. Use flexible conduit, under the provisions of Section 26 05 33.13 - Conduit for Electrical Systems, 2 feet minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.

H. Tighten electrical connections and terminals according to manufacturer’s published torque-tightening values. Where manufacturer’s values are not furnished use those specified in UL 486A-486B.

I. Arrange equipment to provide minimum clearances as specified on transformer nameplate for air circulation for cooling, and in accordance with manufacturer's instructions and the National Electrical Code.

J. Mount wall-mounted transformers using integral flanges or accessory brackets furnished by the manufacturer.
   1. Install transformers level and plumb with wall brackets fabricated by transformer manufacturer.

K. Mount floor-mounted transformers on properly sized 3 inch high concrete pad constructed in accordance with Section 03 30 00.

L. Mount floor-mounted transformers using vibration isolators suitable for isolating the transformer noise from the building structure.
   1. Transformers above 300 kVA located within the building shall be mounted on isolation units utilizing type MS springs. Spring units shall have a minimum static deflection of 1.5 inches.
   2. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions.

M. Mount trapeze-mounted transformers as indicated.

N. Provide grounding and bonding in accordance with Section 26 05 26 - Grounding and Bonding for Electrical Systems.

O. Remove shipping braces and adjust bolts that attach the core and coil mounting bracket to the enclosure according to manufacturer's recommendations in order to reduce audible noise transmission.

P. Where not factory-installed, install lugs sized as required for termination of conductors as indicated.

Q. Where furnished as a separate accessory, install transformer weathershield per manufacturer's instructions.

R. Identify transformers in accordance with Section 26 05 53 - Identification for Electrical Systems.

3.03 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Inspect and test in accordance with NETA ATS, except Section 4.

C. Perform inspections and tests listed in NETA ATS Sections 7.2.1.1 and 7.2.1.2. Tests and inspections listed as optional are not required.
   1. 167 kVA single phase, 500 kVA three phase and smaller:
      a. Perform turns ratio tests at all tap positions.
   2. Larger than 167 kVA single phase and 500 kVA three phase:
      a. Verify that control and alarm settings on temperature indicators are as specified.
      b. Perform excitation-current tests on each phase.
      c. Measure the resistance of each winding at each tap connection.
      d. Perform an applied voltage test on all high- and low-voltage windings-to-ground.

D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.04 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.05 CLEANING

A. Clean dirt and debris from transformer components according to manufacturer's instructions.

B. Repair scratched or marred exterior surfaces to match original factory finish.

3.06 COMMISSIONING AND DEMONSTRATION

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 10 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.

D. After completing installation, cleaning and testing, touch up scratches and mars on finish to match original finish.

END OF SECTION

SECTION 262413 - SWITCHBOARDS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Low-voltage (600 V and less) switchboards and associated accessories for service and distribution applications.

B. Overcurrent protective devices for switchboards.

1.02 REFERENCE STANDARDS

A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service; Revision E with Supplement 1, 2013.

B. IEEE C57.13 - IEEE Standard Requirements for Instrument Transformers; 2016.

C. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

D. NECA 400 - Standard for Installing and Maintaining Switchboards; 2007.

E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2014.

F. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum); 2013.

G. NEMA PB 2 - Deadfront Distribution Switchboards; 2011.

H. NEMA PB 2.1 - General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less; 2013.

I. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.

J. UL 98 - Enclosed and Dead-Front Switches; Current Edition, Including All Revisions.

K. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures; Current Edition, Including All Revisions.

L. UL 869A - Reference Standard for Service Equipment; Current Edition, Including All Revisions.

M. UL 891 - Switchboards; Current Edition, Including All Revisions.

N. UL 977 - Fused Power-Circuit Devices; Current Edition, Including All Revisions.

O. UL 1053 - Ground-Fault Sensing and Relaying Equipment; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by the National Electrical Code.

2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
4. Coordinate with manufacturer to provide shipping splits suitable for the dimensional constraints of the installation.
5. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
    a. Notify Owner no fewer than seven (7) days in advance of proposed interruption of electric service.
    b. Indicate method of providing temporary electric service if interruption will last longer than eight (8) hours.
    c. Do not proceed with interruption of electric service without Owner's written permission
6. Installation Pathway: Remove and replace access, fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
7. Notify Architect/Engineer of Record of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

B. Preinstallation Meetings:
1. Preinstallation Meeting: Conduct a preinstallation meeting at least one week prior to the start of the work of this section; require attendance by all affected installers.
2. Ensure required submittals have been provided with sufficient time for review prior to scheduling the preinstallation meeting.
3. Review the detailed requirements for the work of this section and to review the drawings and specifications for this work. Require attendance by all affected installers including but not limited to:
    a. Contractor's Superintendent.
    b. Installer.
    c. Manufacturer/Fabricator Representative.
    d. Utility Company representative.
    e. Other affected Subcontractors.
    f. Architect/Engineer of Record.
    g. Owner's Representative.
4. Record minutes and distribute copies within five (5) days after meeting to participants as well as Architect/Engineer of Record, Owner and those affected by decisions made.

C. Service Entrance Switchboards:
1. Coordinate with Utility Company to provide switchboards with suitable provisions for electrical service and utility metering, where applicable.
2. Coordinate with Owner to arrange for Utility Company required access to equipment for installation and maintenance.
3. Obtain Utility Company approval of switchboard prior to fabrication.
4. Arrange for inspections necessary to obtain Utility Company approval of installation.

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for switchboards, enclosures, overcurrent protective devices, and other installed components and accessories.
1. Include characteristic trip curves for each type and rating of overcurrent protective device.

C. Shop Drawings: Indicate dimensions, voltage, bus ampacities, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
   1. Include dimensioned plan and elevation views of switchboards and adjacent equipment with all required clearances indicated.
   2. Include wiring diagrams showing all factory and field connections.
   3. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
   4. Include documentation of listed series ratings upon request.
   5. Include documentation demonstrating selective coordination.

D. Service Entrance Switchboards: Contractor shall include documentation of Utility Company approval stamp of switchboard submittals and shop drawings.

E. Source Quality Control Test Reports: Include reports for tests designated in NEMA PB 2 as production (routine) tests.

F. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

G. Field Quality Control Test Reports.

H. Project Record Documents: Record actual installed locations of switchboards and final equipment settings.

I. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.

J. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. See Section 01 60 00 - Product Requirements, for additional provisions.
   2. Enclosure Keys: Two (2) of each different key.
   3. Electronic Trip Circuit Breakers: Provide one (1) portable test set.
   4. Indicating Lights: Equal to 10 percent of amount installed for each size and type, but no fewer than one (1) of each size and type.
   5. Potential Transformer Fuses: Equal to 10 percent of amount installed for each size and type, but no fewer than two (2) of each size and type.
   6. Control-Power Fuses: Equal to 10 percent of amount installed for each size and type, but no fewer than two (2) of each size and type.

K. 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.

1.05 QUALITY ASSURANCE

A. Conform to requirements of the National Electrical Code.

B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.
   1. Obtain switchboards through one source from a single manufacturer.

D. Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent equipment and surfaces. Comply with indicated maximum dimensions.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in the National Electrical Code, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. Comply with NEMA PB 2, "Deadfront Distribution Switchboards".

1.06 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store switchboards in accordance with manufacturer's instructions, NECA 400, and NEMA PB 2.1.

B. Store in a clean, dry space having a uniform temperature to prevent condensation (including outdoor switchboards, which are not weatherproof until completely and properly installed). Where necessary, provide temporary enclosure space heaters or temporary power for permanent factory-installed space heaters.

C. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

D. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

1.07 FIELD CONDITIONS

A. Maintain field conditions within required service conditions during and after installation.

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
   1. Notify Board no fewer than seven (7) days in advance of proposed interruption of electric service.
   2. Indicate method of providing temporary electric service in interruption will last longer than eight (8) hours.
   3. Do not proceed with interruption of electric service without Owner's written permission.

1.08 WARRANTY

A. Each piece of equipment shall be warranted by the equipment manufacturer to be free of defects in material and workmanship for a period of twelve (12) months from the date of Preliminary Acceptance. The equipment supplier shall provide a full year of warranty on the entire system, including on-the-premises maintenance service during normal working hours at no cost to Owner for parts or labor.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Switchboards - Other Acceptable Manufacturers:
   1. ABB/GE: www.geindustrial.com/#sle.
   2. Eaton Corporation: www.eaton.com.
   3. Schneider Electric; Square D Products: www.schneider-electric.us
   4. Siemens Industry, Inc: www.usa.siemens.com

B. Products other than basis of design are subject to compliance with specified requirements and prior approval of Engineer. By using products other than basis of design, Contractor accepts responsibility for costs associated with any necessary modifications to related work, including any design fees.

C. Source Limitations: Furnish switchboards and associated components produced by a single manufacturer and obtained from a single supplier.

2.02 SWITCHBOARDS

A. Provide switchboards consisting of all required components, control power transformers, instrumentation and control wiring, accessories, etc. as necessary for a complete operating system.

B. Provide products listed, classified, and labeled as suitable for the purpose intended.

C. Description: Dead-front switchboard assemblies complying with NEMA PB 2, and listed and labeled as complying with UL 891; ratings, configurations and features as indicated on the drawings.

D. Hinged Front Panels: Allow access to circuit breakers, metering, accessory, and blank compartments.

E. Front-Connected Switchboards:
1. Main Device(s): Fixed, individually-mounted..
2. Feeder Devices: Panel/group-mounted.
3. Arrangement: Front accessible only (not rear accessible), front and rear aligned..
4. Gutter Access: Bolted covers.

F. Rear-Connected Switchboards:
1. Main Device(s): Individually-mounted.
2. Feeder Devices: Individually-mounted.
3. Compartmentalization: Provide barriered compartments for each overcurrent protective device, distribution bus, and rear cable connection area.
4. Arrangement: Rear accessible, front and rear aligned.
5. Rear Access: Bolted covers.
6. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws for access to rear interior of switchboard.

G. Service Entrance Switchboards:
1. Listed and labeled as suitable for use as service equipment according to UL 869A.
2. For solidly-grounded wye systems, provide factory-installed main bonding jumper between neutral and ground busses, and removable neutral disconnecting link for testing purposes.
3. Comply with Utility Company requirements for electrical service.
    a. Utility Metering Compartment: Fabricated compartment and section complying with utility company's requirements. If separate vertical section is required for utility metering, match and align with basic switchboard.
4. Utility Metering Provisions: Provide separate barriered compartment complying with Utility Company requirements where indicated or where required by Utility Company. Include hinged sealable door and provisions for Utility Company current transformers (CTs), potential transformers (PTs), or potential taps as required.
5. See Section 26 21 00 - Low-Voltage Electrical Service Entrance for additional requirements.

H. Nominal System Voltage: Indicated on Drawings.

I. Main-Bus Continuous Amperage: Indicated on Drawings.

J. Service Conditions:

1. Provide switchboards and associated components suitable for operation under the following service conditions without derating:
    a. Altitude: Less than 6,600 feet.
    b. Ambient Temperature:
        1) Switchboards Containing Molded Case or Insulated Case Circuit Breakers: Between 23 degrees F and 104 degrees F.
        2) Switchboards Containing Fusible Switches: Between -22 degrees F and 104 degrees F.

K. Short Circuit Current Rating, Fully Rated:
1. Provide switchboards with listed short circuit current rating not less than the available fault current at the installed location as determined by short circuit study performed in accordance with Section 26 05 73 - Power System Studies.

L. Selectivity: Where the requirement for selectivity is indicated, furnish products as required to achieve selective coordination.

M. Main Devices: Configure for top or bottom incoming feed as indicated or as required for the installation. Provide separate pull section and/or top-mounted pullbox as indicated or as required to facilitate installation of incoming feed.

N. Bussing: Sized in accordance with UL 891 temperature rise requirements.
1. Through bus (horizontal cross bus) to be fully rated through full length of switchboard (non-tapered). Tapered bus is not permitted.
2. Provide fully rated neutral bus unless otherwise indicated, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
3. Provide solidly bonded equipment ground bus through full length of switchboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
4. Phase and Neutral Bus Material: Hand-drawn copper of 98 percent conductivity with feeder circuit-breaker line connections.
5. Ground Bus Material: 1/4-by-2-inch minimum-size, hard-drawn copper. of 98 percent conductivity, equipped with pressure connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
6. Contact Surface of Buses: Silver-plated.
7. Load Terminals: Insulated, rigidly braced, silver-plated, copper runback bus extensions equipped with pressure connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full ampere rating of circuit-breaker position.
8. Main Phase Buses, Neutral Buses, and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
9. Neutral Buses: 100 percent of the ampacity of phase buses, unless otherwise indicated, equipped with pressure connectors for outgoing circuit neutral cables. Bus extensions for busway feeder neutral bus shall be braced.

O. Conductor Terminations: Suitable for use with the conductors to be installed.
1. Line Conductor Terminations:
    a. Main and Neutral Lug Material: Hard-drawn copper of 98 percent conductivity, suitable for terminating coper conductors only..
        1) Plating: Silver-Plated.
    b. Main and Neutral Lug Type: Mechanical.
2. Load Conductor Terminations:
    a. Lug Material: Copper, suitable for terminating copper conductors only.
        1) Plating: Silver-plated.

b. Lug Type:
1) Provide mechanical lugs unless otherwise indicated.

P. Enclosures:
1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
a. Indoor Clean, Dry Locations: Type 1 or Type 2 (drip-proof).
2. Finish: Manufacturer's standard unless otherwise indicated.
3. Enclosure Space Heaters:
a. Provide in each switchboard section installed outdoors and in unconditioned indoor spaces.
b. Size according to manufacturer's recommendations for worst case ambient temperature to prevent condensation.
c. Heater Control: Thermostat.
d. Heater Power Source: Provide connection to transformer factory-installed in switchboard or suitable external branch circuit as indicated or as required.

Q. Comply with NFPA 70E for arc flash labels.

R. Future Provisions:
1. Prepare designated spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
2. Equip distribution sections with full height vertical bussing to accommodate maximum utilization of space for devices.
3. Where designated spaces for future device provisions are not indicated, include provisions for minimum of 4 device(s) rated at 10 percent of rating of switchboard main or incoming feed.
4. Arrange and equip through bus and ground bus to accommodate future installation of additional switchboard sections.

S. Surge Protective Devices: Where factory-installed, internally mounted surge protective devices are provided in accordance with Section 26 43 00 - Surge Protective Devices, list switchboards as a complete assembly including surge protective device.

T. Ground Fault Protection: Where ground-fault protection is indicated, provide system listed and labeled as complying with UL 1053.
1. Where overcurrent protective devices equipped with integral ground fault protection are used, provide separate neutral current sensor where applicable.
2. Where accessory ground fault sensing and relaying equipment is used, equip companion overcurrent protective devices with ground-fault shunt trips.
a. Use zero sequence or residual ground fault detection method unless otherwise indicated.
b. Provide test panel and field-adjustable ground fault pick-up and delay settings.
c. Provide zone selective interlocking capability where indicated, capable of communicating with other electronic trip circuit breakers and external ground fault sensing systems to control ground fault delay functions for system coordination purposes.

U. Arc Flash Energy-Reducing Maintenance Switching: For circuit breakers rated 1200 A or higher, provide a local accessory switch with status indicator light that permits selection of a maintenance mode with alternate electronic trip unit settings for reduced fault clearing time.

V. Board Metering:
1. Provide microprocessor-based digital electrical metering system including all instrument transformers, wiring, and connections necessary for measurements specified.
2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
3. Measured Parameters:

a. Voltage (Volts AC): Line-to-line, line-to-neutral for each phase.
b. Current (Amps): For each phase and neutral.
c. Frequency (Hz).
d. Real power (kW): For each phase, 3-phase total.
e. Reactive power (kVAR): For each phase, 3-phase total.
f. Apparent power (kVA): For each phase, 3-phase total.
g. Power factor.
h. Real energy (kWh).
i. Reactive energy (kVARh).
j. Apparent energy (kVAh).
k. Current demand.
l. Power demand: Real, reactive, and apparent.

4. Meter Accuracy: Plus/minus 1.0 percent.
5. Features:
   a. Communications Capability: Compatible with system indicated. Provide all accessories necessary for proper interface.
   b. KYZ pulse output.
   c. Adjustable demand interval.
   d. Remote monitoring capability via PC.

W. Instrument Transformers:
1. Comply with IEEE C57.13.
2. Select suitable ratio, burden, and accuracy as required for connected devices.
3. Current Transformers:
   a. Connect secondary to shorting terminal blocks.
   b. Ratios shall be as indicated with accuracy class and burden suitable for connected relays, meters, and instruments.
4. Potential Transformers:
   a. Include primary and secondary fuses with disconnecting means.
   b. Secondary voltage rating of 120V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
5. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3kV.

2.03 OVERCURRENT PROTECTIVE DEVICES

A. General:
1. Provide with provisions for locking in the open/off position with a maximum of three (3) padlocks.
2. Provide key interlocking according to the scheme described and shown on the drawings.
3. Ground fault protection shall be provided for solidly grounded wye connected services over 150 volts to ground for all main and feeder devices rated 1000 amperes and as indicated on the drawings.

B. Circuit Breakers:
1. Interrupting Capacity:
   a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than specified minimum requirements.
   b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
2. Molded Case Circuit Breakers:
   a. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers; listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.

b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
c. NEMA AB 3 with Minimum Interrupting Capacity: Fully rated.
d. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
    1) Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 100 amperes and larger.
    2) Provide interchangeable trip units where indicated.
e. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
f. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
    1) Provide the following field-adjustable trip response settings:
        a) Long time pickup, adjustable by replacing interchangeable trip unit or by setting dial.
        b) Long time delay.
        c) Short time pickup and delay.
        d) Instantaneous pickup.
        e) Ground fault pickup and delay where ground fault protection is indicated.
    2) Provide zone selective interlocking capability where indicated, capable of communicating with other electronic trip circuit breakers and external ground fault sensing systems to control short time delay and ground fault delay functions for system coordination purposes.
    3) Provide communication capability where indicated: Compatible with system indicated.
g. Provide the following circuit breaker types where indicated:
    1) 100 Percent Rated Circuit Breakers: Listed for application within the switchboard where installed at 100 percent of the continuous current rating.
    2) Current Limiting Circuit Breakers: Without using fusible elements, designed to limit the let-through energy to a value less than the energy of a one-half cycle wave of the symmetrical prospective current when operating within its current limiting range.
h. Provide the following features and accessories where indicated or where required to complete installation:
    1) Shunt Trip: 120V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
    2) Pad-Lock Provision: For locking circuit breaker handle in OFF position.
    3) Auxiliary Switch: Two SPDT switches suitable for connection to system indicated for indicating when circuit breaker has tripped or been turned off.
        a) With "a" and "b" contacts, "a" contacts mimic circuit-breaker contracts, "b" contacts operate in reverse of circuit-breaker contacts.
    4) Undervoltage Release: Set to operate at 35 to 75 percent of rated voltage with field-adjustable time delay to prevent nuisance tripping.
    5) Alarm Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped.
i. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity.
    1) Integrally mounted relay and trip with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
j. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
k. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.

2.04 SOURCE QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Factory test switchboards according to NEMA PB 2, including the following production (routine) tests on each switchboard assembly or component:
   1. Dielectric tests.
   2. Mechanical operation tests.
   3. Grounding of instrument transformer cases test.
   4. Electrical operation and control wiring tests, including polarity and sequence tests.
   5. Ground-fault sensing equipment test.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that the ratings and configurations of the switchboards and associated components are consistent with the indicated requirements.

C. Verify that mounting surfaces are ready to receive switchboards.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install switchboards in accordance with NECA 1 (general workmanship), NECA 400, and NEMA PB 2.1.

C. Arrange equipment to provide required clearances and maintenance access.

D. Where switchboard is indicated to be mounted with inaccessible side against wall, provide minimum clearance of 1/2 inch between switchboard and wall.

E. Provide required support and attachment components in accordance with Section 26 05 29 - Hangers and Supports for Electrical Systems.

F. Install switchboards plumb and level.

G. Unless otherwise indicated, mount switchboards on properly sized 4 inch high concrete pad constructed in accordance with Section 03 30 00.

H. Provide grounding and bonding in accordance with Section 26 05 26 - Grounding and Bonding for Electrical Systems.

I. Install all field-installed devices, components, and accessories.

J. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.

K. Set field-adjustable circuit breaker tripping function settings as determined by overcurrent protective device coordination study performed in accordance with Section 26 05 73 - Power System Studies.

L. Set field-adjustable ground fault protection pickup and time delay settings as indicated.

M. Provide filler plates to cover unused spaces in switchboards.

N. Identify switchboards in accordance with Section 26 05 53 - Identification for Electrical Systems.

O. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

P. 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.

3.03 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Provide services of a manufacturer's authorized representative to observe installation and assist in inspection and testing. Include manufacturer's reports with submittals.

C. Disconnect surge protective devices (SPDs) prior to performing any high potential testing. Replace SPDs damaged by performing high potential testing with SPDs connected.

D. Before energizing switchboard, perform insulation resistance testing in accordance with NECA 400 and NEMA PB 2.1.

E. Inspect and test in accordance with NETA ATS, except Section 4.

F. Perform inspections and tests listed in NETA ATS, Section 7.1.

G. Fusible Switches: Perform inspections and tests listed in NETA ATS, Section 7.5.1.1.

H. Molded Case and Insulated Case Circuit Breakers: Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for all main circuit breakers. Tests listed as optional are not required.

I. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by the National Electrical Code.
   1. Perform inspections and tests listed in NETA ATS, Section 7.14. The insulation-resistance test on control wiring listed as optional is not required.

J. Meters: Perform inspections and tests listed in NETA ATS, Section 7.11.2.

K. Instrument Transformers: Perform inspections and tests listed in NETA ATS, Section 7.10. The dielectric withstand tests on primary windings with secondary windings connected to ground listed as optional are not required.

L. Test shunt trips to verify proper operation.

M. Correct deficiencies and replace damaged or defective switchboards or associated components.

N. Submit detailed reports indicating inspection and testing results and corrective actions taken.

3.04 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

B. Adjust alignment of switchboard covers and doors.

3.05 CLEANING

A. See Section 01 74 19 - LEED Construction Waste Management and Disposal, for additional requirements.

B. Clean dirt and debris from switchboard enclosures and components according to manufacturer's instructions.

C. Repair scratched or marred surfaces to match original factory finish.

3.06 CLOSEOUT ACTIVITIES

A. See Section 01 78 00 - Closeout Submittals, for closeout submittals.

B. See Section 01 79 00 - Demonstration and Training, for additional requirements.

C. Training: Train Owner's personnel on operation, adjustment, and maintenance of switchboard and associated devices.
   1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
   2. Provide minimum of four (4) hours of training.
   3. Instructor: Manufacturer's authorized representative.
   4. Location: At project site.

3.07 PROTECTION

A. Protect installed switchboards from subsequent construction operations.

END OF SECTION

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Power distribution panelboards.

B. Lighting and appliance panelboards.

C. Overcurrent protective devices for panelboards.

1.02 REFERENCE STANDARDS

A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service; Revision E with Supplement 1, 2013.

B. NECA 407 - Standard for Installing and Maintaining Panelboards; 2015.

C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2014.

D. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts; 2000, with Errata (2008).

E. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum); 2013.

F. NEMA PB 1 - Panelboards; 2011.

G. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less; 2013.

H. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.

I. NFPA 70E - Standard for Electrical Safety in the Workplace; 2017.

J. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.

K. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations; Current Edition, Including All Revisions.

L. UL 67 - Panelboards; Current Edition, Including All Revisions.

M. UL 98 - Enclosed and Dead-Front Switches; Current Edition, Including All Revisions.

N. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures; Current Edition, Including All Revisions.

O. UL 869A - Reference Standard for Service Equipment; Current Edition, Including All Revisions.

P. UL 943 - Ground-Fault Circuit-Interrupters; Current Edition, Including All Revisions.

Q. UL 1053 - Ground-Fault Sensing and Relaying Equipment; Current Edition, Including All Revisions.

R. UL 1699 - Arc-Fault Circuit-Interrupters; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by the National Electrical Code.
2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
3. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted panelboards where indicated.
4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
5. Notify Architect/Engineer of Record of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for panelboards, enclosures, overcurrent protective devices, and other installed components and accessories.
1. Include characteristic trip curves for each type and rating of overcurrent protective device.

C. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
1. Include dimensioned plan and elevation views of panelboards and adjacent equipment with all required clearances indicated.
2. Include wiring diagrams showing all factory and field connections.
3. Clearly indicate short circuit current ratings.
4. Include documentation of listed series ratings.

D. Source Quality Control Test Reports: Include reports for tests designated in NEMA PB 1 as routine tests.

E. Field Quality Control Test Reports.

F. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

G. Project Record Documents: Record actual installed locations of panelboards and actual installed circuiting arrangements.
1. Panelboard Schedules: For installation in panelboards. Submit final typewritten versions after load balancing.

H. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.
1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

I. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. See Section 01 60 00 - Product Requirements, for additional provisions.

2. Panelboard Keys: Six (6) spares of each different key.
3. See Section 26 28 13 - Fuses for requirements for spare fuses and spare fuse cabinets.

1.05 QUALITY ASSURANCE

A. Conform to the National Electrical Code.

B. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories through on source from a single manufacturer.

C. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

D. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three (3) years documented experience.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in the National Electrical Code, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

F. Comply with NEMA PB 1.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Receive, inspect, handle, and store panelboards in accordance with manufacturer's instructions and NECA 407.

B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

C. Handle carefully in accordance with manufacturer's written instructions to avoid damage to panelboard internal components, enclosure, and finish.

1.07 FIELD CONDITIONS

A. Maintain ambient temperature within the following limits during and after installation of panelboards:
1. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.
2. Panelboards Containing Fusible Switches: Between -22 degrees F and 104 degrees F.

B. Altitude: Not exceeding 6600 feet.

C. Interruption of Existing Electrical Service: Do not interrupt electric service to facilities occupied by Board or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
1. Notify Architect/Engineer of Record and Owner's Representative not fewer than seven (7) working days in advance of proposed interruption of electrical service.
2. Do not proceed with interruption of electrical service without Architect/Engineer of Record's and Owner's Representative written permission.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. ABB/GE: www.geindustrial.com/#sle.

B. Eaton Corporation: www.eaton.com.

C. Schneider Electric; Square D Products: www.schneider-electric.us.

D. Siemens Industry, Inc: www.usa.siemens.com.

2.02 PANELBOARDS - GENERAL REQUIREMENTS

A. Provide products listed, classified, and labeled as suitable for the purpose intended.

B. Short Circuit Current Rating, Fully Rated:

1. Provide panelboards with listed short circuit current rating not less than the available fault current at the installed location as determined by short circuit study performed in accordance with Section 26 05 73 - Power System Studies.
2. Listed series ratings are acceptable, except where not permitted by motor contribution according to the National Electrical Code.
3. Label equipment utilizing series ratings as required by the National Electrical Code.
4. Panelboards shall be provided with minimum AIC ratings as per the following tables where not indicated on the drawings:

208 and 240V			480V	
amps	Minimum AIC Rating (kA)		amps	Minimum AIC Rating (kA)
100	10		100	42
125	10		125	42
150	22		150	42
200	42		200	42
225	42		225	65
250	42		250	65
400	65		400	65
600	65		600	65
800	65		800	65
1000	65		1000	65
1200	65		1200	65
1600	65		1600	65
2000	100		2000	100
2500	100		2500	100
3000	100		3000	100
3500	100		3500	100
4000	100		4000	100

5.

C. Mains: Configure for top or bottom incoming feed as indicated or as required for the installation.

D. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.

E. Bussing: Sized in accordance with UL 67 temperature rise requirements.
   1. Provide fully rated neutral bus unless otherwise indicated, with a suitable lug for each feeder or branch circuit requiring a neutral connection.
   2. Provide solidly bonded equipment ground bus in each panelboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.

F. Conductor Terminations: Suitable for use with the conductors to be installed.

G. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
   1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
      a. Indoor Clean, Dry Locations: Type 1.
      b. Outdoor Locations: Type 3R.
      c. Kitchen Areas: NEMA 250, Type 4x, stainless steel.
      d. Other Wet of Damp Indoor Locations: NEMA 250, Type 4.
   2. Boxes: Galvanized steel unless otherwise indicated.
      a. Provide wiring gutters sized to accommodate the conductors to be installed.
      b. Increase gutter space as required where sub-feed lugs, feed-through lugs, gutter taps, or oversized lugs are provided.
   3. Fronts:
      a. Fronts for Surface-Mounted Enclosures: Same dimensions as boxes.
      b. Fronts for Flush-Mounted Enclosures: Overlap boxes on all sides to conceal rough opening.
      c. Finish for Painted Steel Fronts: Manufacturer's standard grey unless otherwise indicated.
   4. Lockable Doors: All locks keyed alike unless otherwise indicated.
   5. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
   6. Skirt for Surface-Mounted Panelboards: Same gage and finish as panelboard front with flanges for attachment to panelboard, wall, and ceiling or floor.
   7. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panels.
   8. Directory Card: With transparent protective cover, mounted in metal frame, inside panelboard door.

H. Comply with NFPA 70E for arc flash labels.

I. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.

J. Surge Protective Devices: Where factory-installed, internally mounted surge protective devices are provided in accordance with Section 26 43 00 - Surge Protective Devices, list and label panelboards as a complete assembly including surge protective device.

K. Ground Fault Protection: Where ground-fault protection is indicated, provide system listed and labeled as complying with UL 1053.
   1. Where electronic circuit breakers equipped with integral ground fault protection are used, provide separate neutral current sensor where applicable.
   2. Where accessory ground fault sensing and relaying equipment is used, equip companion overcurrent protective devices with ground-fault shunt trips.
      a. Use zero sequence ground fault detection method unless otherwise indicated.
      b. Provide test panel and field-adjustable ground fault pick-up and delay settings.
      c. Provide zone selective interlocking capability where indicated, capable of communicating with other electronic trip circuit breakers and external ground fault sensing systems to control ground fault delay functions for system coordination purposes.

L. Selectivity: Where the requirement for selectivity is indicated, furnish products as required to achieve selective coordination.

M. Provide the following features and accessories where indicated or where required to complete installation:
1. Feed-through lugs.
2. Sub-feed lugs.

N. Phase and Ground Buses:
1. Material: Hard-drawn copper, 98 percent conductivity.
2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.

O. Service Equipment Label: UL labeled for use as service equipment for panelboards with main service disconnect switches.

2.03 POWER DISTRIBUTION PANELBOARDS

A. Description: Panelboards complying with NEMA PB 1, power and feeder distribution type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.

B. Conductor Terminations:
1. Main and Neutral Lug Material: Copper, suitable for terminating copper conductors only.
2. Main and Neutral Lug Type: Compression.

C. Bussing:
1. Phase and Neutral Bus Material: Copper.
2. Ground Bus Material: Copper.

D. Circuit Breakers:
1. Main Overcurrent Protective Devices: Circuit breaker or Fused switch.
2. Provide bolt-on type or plug-in type secured with locking mechanical restraints for circuit breaker frame sizes 125A and smaller.
3. For Circuit-Breaker Frame Sizes Larger than 125A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
4. Provide thermal magnetic circuit breakers unless otherwise indicated.
5. Provide electronic trip circuit breakers where indicated.
6. Fused switches where indicated on the Drawings.

E. Enclosures:
1. Provide surface-mounted enclosures unless otherwise indicated.
2. Fronts: Provide lockable hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.
3. Provide clear plastic circuit directory holder mounted on inside of door.

2.04 LIGHTING AND APPLIANCE PANELBOARDS

A. Description: Panelboards complying with NEMA PB 1, lighting and appliance branch circuit type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.

B. Conductor Terminations:
1. Main and Neutral Lug Material: Copper, suitable for terminating copper conductors only.

2. Main and Neutral Lug Type: Compression.

C. Bussing:
1. Phase Bus Connections: Arranged for sequential phasing of overcurrent protective devices.
2. Phase and Neutral Bus Material: Copper.
3. Ground Bus Material: Copper.

D. Circuit Breakers: Thermal magnetic bolt-on type unless otherwise indicated.

E. Enclosures:
1. Provide surface-mounted or flush-mounted enclosures as indicated.
2. Fronts: Provide lockable hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.
3. Provide clear plastic circuit directory holder mounted on inside of door.

2.05 OVERCURRENT PROTECTIVE DEVICES

A. Molded Case Circuit Breakers:
1. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
2. For Circuit-Breaker Frame Sizes 125A and Smaller: Bolt-on circuit breakers.
3. For Circuit-Breaker Frame Sizes Larger Than 125A: Bolt-on circuit breaker; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
4. Interrupting Capacity:
   a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
      1) 10,000 rms symmetrical amperes at 240 VAC or 208 VAC.
      2) 14,000 rms symmetrical amperes at 480 VAC.
   b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
5. Conductor Terminations:
   a. Provide mechanical lugs unless otherwise indicated.
   b. Provide compression lugs where indicated.
   c. Lug Material: Copper, suitable for terminating copper conductors only. Mechanical style, suitable for number, size, trip ratings, and conductor materials.
6. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
   a. Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 250 amperes and larger.
   b. Provide interchangeable trip units where indicated.
7. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
   a. Provide the following field-adjustable trip response settings:
      1) Long time pickup, adjustable by replacing interchangeable trip unit or by setting dial.
      2) Long time delay.
      3) Short time pickup and delay.
      4) Instantaneous pickup.
      5) Ground fault pickup and delay where ground fault protection is indicated.
   b. Provide zone selective interlocking capability where indicated, capable of communicating with other electronic trip circuit breakers and external ground fault sensing systems to control short time delay and ground fault delay functions for system coordination purposes.

c. Provide communication capability where indicated: Compatible with system indicated.

8. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
9. Provide the following circuit breaker types where indicated:
   a. Ground Fault Circuit Interrupter (GFCI) Circuit Breakers: Listed as complying with UL 943, class A for protection of personnel.
   b. Ground Fault Equipment Protection Circuit Breakers: Designed to trip at 30 mA for protection of equipment.
   c. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Combination type listed as complying with UL 1699.
   d. 100 Percent Rated Circuit Breakers: Listed for application within the panelboard where installed at 100 percent of the continuous current rating.
   e. Current Limiting Circuit Breakers: Without using fusible elements, designed to limit the let-through energy to a value less than the energy of a one-half cycle wave of the symmetrical prospective current when operating within its current limiting range.
10. Provide listed switching duty rated circuit breakers with SWD marking for all branch circuits serving fluorescent lighting; Type HACR for heating, air-conditioning, and refrigerating equipment.
11. Provide listed high intensity discharge lighting rated circuit breakers with HID marking for all branch circuits serving HID lighting.
12. Do not use tandem circuit breakers.
13. Do not use handle ties in lieu of multi-pole circuit breakers.
14. Provide multi-pole circuit breakers for multi-wire branch circuits as required by the National Electrical Code.
15. Provide the following features and accessories where indicated or where required to complete installation:
   a. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage where indicated on drawings.
   b. Handle Pad-Lock Provision: For locking circuit breaker handle in OFF position.
   c. 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.
   d. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
   e. Alarm Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped.
   f. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   g. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
   h. Multipole units enclosed in a single housing or factory-assembled to operate as a single unit.
16. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front mounted, field-adjustable trip setting.

2.06 SOURCE QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Factory test panelboards according to NEMA PB 1.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that the ratings and configurations of the panelboards and associated components are consistent with the indicated requirements.

C. Verify that mounting surfaces are ready to receive panelboards.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.

C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and the National Electrical Code.

D. Provide required supports in accordance with Section 26 05 29 - Hangers and Supports for Electrical Systems.

E. Install panelboards plumb.

F. Install flush-mounted panelboards so that trims fit completely flush to wall with no gaps and rough opening completely covered.

G. Mount panelboards such that the top of trim is 74 inches above the finished floor, unless otherwise indicated.

H. Mount floor-mounted power distribution panelboards on properly sized 3 inch high concrete pad constructed in accordance with Section 03 30 00 - Cast-in-Place Concrete.

I. Provide minimum of four spare 1 inch trade size conduits out of each flush-mounted panelboard stubbed into accessible space above ceiling and below floor.

J. Provide grounding and bonding in accordance with Section 26 05 26 - Grounding and Bonding for Electrical Systems.
   1. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on isolated/insulated ground bus.
   2. Terminate branch circuit isolated grounding conductors on isolated/insulated ground bus only. Do not terminate on solidly bonded equipment ground bus.

K. Install all field-installed branch devices, components, and accessories.

L. Provide fuses complying with Section 26 28 13 - Fuses for fusible switches as indicated.

M. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.

N. Multi-Wire Branch Circuits: Group grounded and ungrounded conductors together in the panelboard as required by the National Electrical Code.

O. Set field-adjustable circuit breaker tripping function settings as determined by overcurrent protective device coordination study performed according to Section 26 05 73 - Power System Studies.

P. Set field-adjustable ground fault protection pickup and time delay settings as indicated.

Q. Provide filler plates to cover unused spaces in panelboards.

R. Provide circuit breaker lock-on devices to prevent unauthorized personnel from de-energizing essential loads where indicated. Also, provide for the following:
1. Emergency and night lighting circuits.
2. Fire detection and alarm circuits.
3. Communications equipment circuits.
4. Intrusion detection and access control system circuits.
5. Video surveillance system circuits.

S. Identify panelboards in accordance with Section 26 05 53 - Identification for Electrical Systems.

3.03 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Inspect and test in accordance with NETA ATS, except Section 4.

C. Fusible Switches: Perform inspections and tests listed in NETA ATS, Section 7.5.1.1.

D. Molded Case Circuit Breakers: Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for all main circuit breakers and circuit breakers larger than 250 amperes. Tests listed as optional are not required.
1. Perform insulation-resistance tests on all control wiring with respect to ground.
2. Test functions of the trip unit by means of secondary injection.

E. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by the National Electrical Code.
1. Perform inspections and tests listed in NETA ATS, Section 7.14. The insulation-resistance test on control wiring listed as optional is not required.

F. Test GFCI circuit breakers to verify proper operation.

G. Test AFCI circuit breakers to verify proper operation.

H. Procure services of a qualified manufacturer's representative to observe installation and assist in inspection, testing, and adjusting. Include manufacturer's reports with field quality control submittals.

I. Correct deficiencies and replace damaged or defective panelboards or associated components.

3.04 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

B. Adjust alignment of panelboard fronts.

C. Load Balancing: For each panelboard, rearrange circuits such that the difference between each measured steady state phase load does not exceed 20 percent and adjust circuit directories accordingly. Maintain proper phasing for multi-wire branch circuits.

3.05 CLEANING

A. Clean dirt and debris from panelboard enclosures and components according to manufacturer's instructions.

B. Repair scratched or marred exterior surfaces to match original factory finish.

3.06 COMMISSIONING AND DEMONSTRATION

A. Training: Arrange and pay for the services of factory-authorized service representatives to demonstrate Panelboards and OCPD's and train Owner's maintenance personnel.

B. Conduct a minimum of one half (1/2) day of training in operation and maintenance as specified in Division 01 Section "Closeout Procedures". Include both classroom training and hands on equipment operation and maintenance procedures.

C. Schedule training with at least seven (7) days' advance notice.

D. Balancing Loads: After Preliminary Acceptance, but not more than two (2) months after Final Acceptance, conduct load-balancing measurements and make circuit changes as follows:
1. Perform measurements during period of normal working load as advised by Owner.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility. Make special arrangements with Owner to avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. Recheck loads after circuit changes during normal load period. Record all load readings before and after changes and submit test records.
4. Tolerance: Difference exceeding twenty (20) percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as required to meet this minimum requirement.

E. Contractor Start-Up and Reporting. Prepare for acceptance tests as follows:
1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

F. Contractor Start-Up and Reporting. Perform the following field tests and inspections and prepare test reports:
1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. 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.

END OF SECTION

SECTION 262713 - ELECTRICITY METERING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes equipment for utility company's electricity metering and electricity metering for Owner’s use.

1.3 SUBMITTALS

A. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes. Describe electrical characteristics, features, and operating sequences, both automatic and manual. Include the following:

1. Electricity-metering equipment.

B. Shop Drawings for Electricity-Metering Equipment:

1. Dimensioned plans and sections or elevation layouts.

2. Wiring Diagrams: Power, signal, and control wiring specific to this Project. Identify terminals and wiring designations and color codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features.

3. Mounting and anchoring devices recommended by manufacturer to resist seismic forces specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Manufacturer Seismic Qualification Certification for Electricity-Metering Equipment: Submit certification that equipment components and their mounting and anchorage provisions have been designed to remain in place without separation of any parts or loosening of factory-made connections when subjected to the seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculations.

2. Detailed description of equipment mounting and anchorage devices on which the certification is based and their installation requirements.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For electricity-metering equipment to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Receive, store, and handle modular meter center as specified in NECA 400.

1.6 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 Owner no fewer than two days in advance of proposed interruption of electrical service.

2. Do not proceed with interruption of electrical service without Owner's written permission.

1.7 COORDINATION

A. Electrical Service Connections: Coordinate with utility companies and components they furnish as follows:

1. Comply with requirements of utilities providing electrical power and communication services.

2. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

a. Cutler-Hammer; Eaton Corporation.

b. General Electric Company; Electrical Distribution & Control Div.

c. Siemens Energy & Automation, Inc.

d. Square D; Schneider Electric.

2.2 EQUIPMENT FOR ELECTRICITY METERING BY UTILITY COMPANY

A. Current-Transformer Cabinets: Factory-coordinated assembly of a main service terminal box with lugs only. Comply with requirements of electrical power utility company.

1. Available Manufacturers:

a. Cutler-Hammer; Eaton Corporation.

b. General Electric Company; Electrical Distribution & Control Div.

c. Siemens Energy & Automation, Inc.

d. Square D; Schneider Electric.

e. Milbank.

f. Erickson Electrical Equipment Co.

2. Housing: NEMA 250, Type 3R enclosure.

a. Structural strength of the housing, its anchorage and component attachment provisions, and anchorage devices recommended for anchoring the housing in place shall be adequate to prevent separation of equipment and its components from their installed positions during a seismic event as defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

3. Minimum Short-Circuit Rating: 100,000 amperes symmetrical at rated voltage.

4. Meter Socket: Comply with requirements of electrical power utility company. Type as approved by utility company, with rating coordinated with indicated tenant feeder circuit rating.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with equipment installation requirements in NECA 1.

B. Install equipment for utility company metering. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by utility company.

C. Install modular meter center according to NECA 400 switchboard installation requirements.

3.2 FIELD QUALITY CONTROL

A. Test Owner's electricity-metering installation for proper operation, accuracy, and usability of output data.

1. Connect a load of known kilowatt rating, 1.5 kW minimum, to a circuit supplied by metered feeder.

2. Turn off circuits supplied by metered feeder and secure them in off condition.

3. Run test load continuously for eight hours, minimum, or longer to obtain a measurable meter indication. Use test load placement and setting that ensures continuous, safe operation.

4. Check and record meter reading at end of test period and compare with actual electricity used based on test load rating, duration of test, and sample measurements of supply voltage at test load connection. Record test results.

5. Repair or replace deficient or malfunctioning metering equipment, or correct test setup; then retest. Repeat for each meter in installation until proper operation of entire system is verified.

END OF SECTION

SECTION 262714 - ELECTRICITY SUB-METERING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes equipment for electricity sub-metering for Owner's use. Contractor to provide all digital multi-function electronic power sub-meters, enclosures, split-core current transformers, line and low voltage cabling, conduit, communication converters, modems, ethernet cards, interface modules, protocol gateways, hardware, meter reading software, licenses, and programming for a complete sub-metering turn-key system. Provide software integration for all electrical metering to totalize use, to record demand, and to store data over a 48 month period. This software integration protocol shall be provided for both local and web-based monitoring.

B. In order to meet the advanced energy metering requirements, power meters shall possess the following qualities and capabilities:

1. Must be permanently installed, record at intervals of 15min and transmit data to a remote location.
2. Electricity meters must record both consumption and demand. Whole-building electricity meters should record the power factor, if appropriate.
3. The data collection system must use a local area network, building automation system, wireless network, or comparable communication infrastructure.
4. The system must be capable of storing all meter data for at least 36 months.
5. The data must be remotely accessible.
6. All meters in the system must be capable of reporting hourly, daily, monthly, and annual energy use.
7. Measurements must record every 15 minutes, be available to each tenant, and maintained for 48 months.

1.03 SUBMITTALS

A. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes. Describe electrical characteristics, features, and operating sequences, both automatic and manual. Include the following:

1. Electricity-metering equipment.

B. Shop Drawings for Electricity Sub-Metering Equipment:

1. Dimensioned plans and sections or elevation layouts.
2. Wiring Diagrams: Power, signal, and control wiring specific to this Project. Identify terminals and wiring designations and color codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For electricity-metering equipment to include in emergency, operation, and maintenance manuals.

E. Provide location of manufacture or extraction.

F. Provide product cost.

G. Provide Material Ingredients documentation in accordance with Section 018113 – sustainable design requirements.

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Receive, store, and handle modular meter center as specified in NECA 400.

1.06 COORDINATION

A. Electrical Service Connections: Coordinate with utility companies and components they furnish as follows:

1. Comply with requirements of utilities providing electrical power and communication services.
2. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

PART 2 - PRODUCTS

2.01 EQUIPMENT FOR ELECTRICITY SUB-METERING BY OWNER

2.02 Products shall not have any chemicals on the Red list as described in Section 018113 – sustainable design requirements.

A. Manufacturers: Basis of design shall be Electro Industries/GuageTech™. Subject to compliance with requirements, provide comparable products by one of the following alternative manufacturers:

1. GE EPM 6000

2. Eaton Power Xpert Meter 2000

B. Acceptable product for individual metering is Electro Industries/GaugeTech, Model: ENCSHK250-277-60-10-V2-D2-INP100S-X

1. Kilowatt-Hour/Demand Meter: Electronic single and three-phase meters, measuring electricity use and demand.
2. The meter shall be UL listed and CE marked.

3. The meter shall come pre-wired as per NEC coloring code in a UL approved NEMA 1 enclosure.

4. The meter shall have an accuracy of +/- 0.1% or better for voltage and amperes, and 0.2% for power and energy functions. The meter shall meet the accuracy requirements of IEC 62053-22 (Class 0.2%) and ANSI C12.20 (Class 0.2%).

5. The meter shall have 2 MB of onboard datalogging which can be later field expandable via V-Switch firmware update.

6. The meter shall include 2 independent communications ports on the back and face plate, with advanced features.

   a. One port shall provide Modbus RTU over RS485

   b. One port shall provide Modbus TCP/IP over Ethernet

C. Acceptable product for multipoint metering is Electro Industries/GaugeTech, Model: ENCMP200-Y-60-10-V2-WIFI-MDSN-X

1. Unit shall be UL listed and CE marked.

2. The meter shall come pre-wired as per NEC coloring code in a UL approved NEMA 1 enclosure.

3. Unit shall have 24 CT inputs which will allow for the unit to be able to monitor up to 8, 3 phase circuits.

4. Unit shall have accuracy of +/- 0.5% or better for voltage and current, and 0.5% for power and energy. Unit shall meet accuracy requirements of IEC 62053-22 (Class 0.5S) and ANSI C12.20 (Class 0.5 CL).

5. Unit shall have Modbus RTU over RS485, Modbus TCP/IP over Ethernet, and WiFi communications.

6. Unit shall have datalogging up to 32 MB.

D. For specification information, contact:

1. Electro Industries/GaugeTech, 1800 Shames Drive, Westbury, NY 11590, Phone: 516-334-0870, Fax: 516-338-4741, www.electroind.com

E. The meter shall be UL listed, CE marked, and ANSI C12.20 certified.

1. The meter shall be designed for Multifunction Electrical Measurement on 3 phase power systems. The meter shall perform to spec in harsh electrical applications in high and low voltage power systems.

   a. The meter shall support 3 Element Wye, 2.5 Element Wye, 2 Element Delta, 4 wire Delta systems.

   b. The meter shall accept universal voltage input.

   c. The meter's surge withstand shall conform to IEEE C37.90.1.

   d. The meter shall be user programmable for voltage range to any PT ratio.

   e. The meter shall accept a burden up to 0.36VA per phase, Max at 600 V, and 0.014 VA at 120 volts.

   f. The meter shall accept a voltage input range of up to 576 volts Line to Neutral, and up to 721 volts Line to Line.

   g. The meter shall accept a current reading of up to 11 Amps continuous.

   h. The meter shall have color-coordinated voltage and current inputs.

   i. The meter shall have a phasor diagram, through software, that clearly shows wiring status.

2. The meter shall use a dual input method for current inputs. Method one shall allow the CT to pass directly through the meter without any physical termination on the meter. The second method shall provide additional termination pass through bars, allowing the CT leads to be terminated on the meter. The meter must support both termination methods.

   a. Fault Current Withstand shall be 100 A for 10 seconds, 300 A for 3 seconds, and 500 A for 1 second.

   b. The meter shall be programmable for current to any CT ratio. DIP switches or other fixed ratios shall not be acceptable.

c. The meter shall accept a burden of 0.005 VA per phase, Max at 11 A.
d. The meter shall begin reading at 0.1% of the nominal current.
e. Pass through wire gauge dimension of 0.177" / 4.5 mm shall be available.
f. All inputs and outputs shall be galvanically isolated to 2500 volts AC.
g. The meter shall accept current inputs of class 10: (0 to 10) A, 5 A Nominal, and class 2 (0 to 2) A, 1 A Nominal Secondary.

3. The meter shall have an accuracy of +/- 0.1% or better for voltage and current, and 0.2% for power and energy functions. The meter shall meet the accuracy requirements of IEC 62053-22 (Class 0.2%) and ANSI C12.20 (Class 0.2%). ANSI C12.20 shall have a third party certification. The meter shall have a Frequency measurement accuracy of not less than 0.007 Hz.
a. The meter shall provide true RMS measurements of voltage, - phase to neutral and phase-to-phase; and current, per phase and neutral.
b. The meter shall calculate RMS readings, sampling at over 400 samples per cycle on all channels measured readings continuously with no cycle blind spots.
c. The meter shall utilize 24 bit Analog to Digital conversion.
d. The meter shall provide THD (% of Total Harmonic Distortion). Harmonic magnitude recording to the 40th order shall be available for voltage and current harmonics.

4. The meter shall provide a simultaneous voltage and current waveform recorder.
a. The meter shall be capable of recording 512 samples per cycle for a voltage sag or swell, or for a current fault event.
b. The meter shall provide pre- and post-event recording capability.
c. The meter shall have a programmable sampling rate for the waveform recorder.
d. The meter shall have an advanced DSP design that allows power quality triggers to be based on a 1 cycle updated RMS.
e. The meter shall allow up to 170 events to be recorded.
f. The meter shall store waveform data in a first-in, first-out circular buffer to insure that data is always being recorded.

5. The meter shall include a three-line, bright red, 0.56" LED display.
a. The meter shall fit in both DIN 92 mm and ANSI C39.1 round cut-outs.
b. The meter must display a % of Load Bar on the front panel to provide an analog feel. The % Load bar shall have not less than 10 segments.

6. The meter shall be available in transducer only version, with no display.
a. The meter shall mount directly to a DIN rail and provide RS485 Modbus or DNP 3.0 output.

7. Power meter shall include virtual measurement upgrade packs (V-Switch™ keys), which shall allow user to upgrade in field without removing installed meter.
a. The six Virtual Upgrade packs shall be:

1) V, A, kW, kVAR, PF, kVA, Freq., kWh, kVAh, kVARh, and I/O Expansion - V1
2) Above with 2 Megabytes of memory for Data logging - V2
3) Above with Power Quality Harmonics - V3
4) Above, with Limit and Control Functions - V4
5) Above, with 64 samples per cycle Waveform Recorder and 3 Megabytes of memory for Data-logging - V5
6) Above, with 512 samples per cycle Waveform Recorder and 4 Megabytes of memory for Data-logging - V6

8. The V-Switch™ keys must be able to be implemented without physically removing the installed meter.
9. The meter shall include 2 independent communications ports on the back and face plate, with advanced features.

a. One port shall provide RS485 communication speaking Modbus ASCII, Modbus RTU, or DNP3 protocol through back plate.

b. Baud rates shall be from 1200 baud to 57600 baud for the RS485 port.

c. The meter shall provide an optical IrDA port (through faceplate), as the second communication port, which shall allow the unit to be set up and programmed using a PDA or remote laptop without need for a communication cable.

10. The meter shall provide user configured fixed window or rolling window demand. This shall allow the user to set up the particular utility demand profile.

a. Readings for kW, kVAR, kVA and PF shall be calculated using utility demand features.

b. All other parameters shall offer max and min capability over the user selectable averaging period.

c. Voltage shall provide an instantaneous max and min reading displaying the highest surge and lowest sag seen by the meter.

d. The meter shall provide an update rate of every 6 cycles for Watts, VAR and VA. All other parameters shall be every 60 cycles.

11. The meter shall support a power supply of (90 to 265) volts AC and (100 to 370) volts DC. Universal AC/DC Supply shall be available and shall have a burden of less than 11 VA. An optional power supply of (18-60) volts DC shall be available.

12. The meter shall provide Limits Alarms and Control Capability as follows:

a. Limits can be set for any measured parameter.

b. Up to 16 limits can be set.

c. Limits shall be based on % of Full Scale settings.

d. Manual Relay Control shall be available through software.

e. Relay set delays and reset delays shall be available.

f. Relay control shall be available through DNP over Ethernet with the Ethernet Option card.

13. The meter shall have data logging capability with the 2, 3, and 4 Megabyte memory upgrade (Virtual Upgrade packs 2-6). The meter shall have a real-time clock that allows for time stamping of all the data in the meter when log events are created. The meter with Virtual Upgrade packs 2-4 shall have six logs; the meter with Virtual Upgrade packs 5 and 6 shall also have the Waveform Log:

a. The meter shall have three historical logs for trending profiles. Each log shall be capable of being programmed with up to 64 parameters. The user shall have the ability to allocate memory between the three historical logs in order to increase or decrease the memory allotted to each of the logs.

b. The meter shall have a log for Limits Alarms. The Limits log shall provide magnitude and duration of an event, time-stamp, and log value. The log must be capable of recording to 2048 events.

c. The meter shall have a log for System Events. The System Events log shall record the following occurrences with a time-stamp: Demand Resets, Password Requests, System Startup, Energy Resets, Log Resets, Log Reads, Programmable Settings Changes, and Critical Data Repairs.

d. The meter shall have a log for I/O changes. The I/O Change log shall provide a time-stamped record of any Relay Outputs and any Input Status changes. The log must be capable of recording up to 2048 events.

e. The meter with Virtual Upgrade packs 5 and 6 shall have a log which is capable of recording a waveform both when a user-programmed value goes out of limit and when the value returns to within limit.

14. The meter shall have I/O expandability through two Option card slots on the back.

a. The cards shall be capable of being installed in the field, without removing the meter from installation.

b. The meter shall auto-detect the presence of any I/O Option cards.

c. The Option card slots shall accept I/O cards in all of the following formats: 100BaseT Ethernet Communication Card; Four Channel Bi-directional 0-1mA Output Card; Four Channel 4-20mA Output Card; Two Relay Outputs/2 Status Inputs Card; Four Pulse Output/4 Status Inputs Card; Fiber Optic Card; IEC 61850 Protocol Ethernet Network Card.

d. The meter shall be capable of accepting any combination of up to two cards.

1) When two Ethernet cards are installed in the meter, an independent IP address and MAC address shall be assignable to each card.

e. The Ethernet Option Card shall provide the meter with 100BaseT Ethernet functionality. The Ethernet Option card shall:

1) Allow the meter to speak with 12 simultaneous sockets of Modbus TCP, so that multiple requests for data can be received simultaneously.

2) Allow the meter to speak with 5 simultaneous sockets of DNP over TCP/IP so that multiple requests can be handled simultaneously, using standard and optional ports.

3) Allow the meter to speak with both Modbus TCP and DNP over Ethernet simultaneously.

4) Allow auto transmit/receive detection for straight or null RJ45 cables.

5) Provide an embedded Web server that allows access to metered readings through the Internet, using any standard Web browser from a PC, smart phone, or tablet PC.

6) Provide email on configured alarms.

7) Provide email notification of meter status and readings data on a programmed schedule.

8) Provide data push of up to 15 meter readings to a cloud server with the JSON structure, such as Lucid BuildingOS®.

9) Provide heightened security by allowing setup of an exclusive TCP/IP client. When the client is communicating though the meter's network card, no other communication to that network card will be allowed, to protect against unauthorized programming.

10) The meter shall be programmable to shut down unused network services to protect against meter tampering.

f. The 1mA Output Option Card shall provide the following features:

1) 4 channel, bi-directional 0-1 mA outputs.

2) Assignable to any measured parameter.

3) 0.1% of Full Scale accuracy throughout range and load.

4) Maximum load impedance to 10k Ohms, with no accuracy losses.

g. The 20mA Output Option Card shall provide the following features:

1) 4 channel, 4-20 mA outputs.

2) Assignable to any measured parameter.

3) 0.1% of Full Scale accuracy throughout range and load.

4) Maximum load impedance to 850 Ohms, with no accuracy losses.

5) Loop powered using up to 24 volts DC.

h. The Relay Output/Status Input Option Card shall provide the following features:

1) 2 Relay outputs, 2 Status inputs.

2) Status Inputs – Wet/Dry Auto Detect up to 150 volts DC.

3) Trigger on User Set Limits/Alarms (with Virtual Upgrade pack 4).

4) Set delays and Reset delays.

i. The Pulse Output/Digital Input Option Card shall provide the following features:

1) 4 KYZ pulse/4 Status inputs.

2) Programmable to any energy parameter and pulse value.

3) Programmable to End of Interval pulse.

4) Can function for manual relay control and limit based control (with Virtual Upgrade pack 4).

5) 120 mA continuous load current.

6) DNP input.

j. The Fiber Optic Option Card shall provide the following features:

1) Built in logic to mimic RS485 half-duplex bus, allowing the user to daisy chain meters for low installation cost.

2) ST Terminated Option.

3) Versatile Link Terminated Option.

4) Modbus and DNP3 protocols available.

k. The IEC 61850 Protocol Ethernet Network Option Card shall provide the

l. following features:

1) Integrates into any IEC 61850 network.

2) Provides support for Modbus and IEC 61850 protocols simultaneously.

3) Configurable for multiple logical nodes.

4) Provides buffered and unbuffered reporting.

5) Provides dual Ethernet IEC 61850 Protocol Network option cards.

6) Is certified by a 3rd party Authorized IEC61850 Test Laboratory.

7) Is capable of supporting two Ethernet /IP connections with separate /IP addresses, each running IEC 61850 protocol.

8) Provide heightened security by allowing setup of an exclusive TCP/IP client. When the client is communicating though the meter's network card, no other communication to that network card will be allowed, to protect against unauthorized programming.

15. The meter shall have transformer loss, line loss, and total substation loss compensation.

a. Substation losses shall be programmable for Watts and VARs, and for Ferris and Copper losses.

b. The meter shall have CT and PT compensation to set compensation factors for errors in CTs and PTs connected to the meter.

16. The meter shall have a standard 5-year warranty.

17. Power meter shall be able to be stored in (-20 to +70) degrees C.

a. Operating temperature shall be (-20 to +70) degrees C.

b. NEMA 12 faceplate rating shall be available for the power meter.

18. The meter shall be a traceable revenue meter, which shall contain a utility grade test pulse allowing power providers to verify and confirm that the meter is performing to its rated accuracy.

19. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.

20. Display: Digital liquid crystal, indicating accumulative kilowatt hours, current time and date, current demand, historic peak demand, and time and date of historic peak demand.

21. Programmable Contact Module: Unit shall have push-button switches and a display for setting the demand level at which an integral set of Form C contacts shall be operated to initiate indicated action.

22. Enclosure: NEMA 250, Type 1 minimum, with hasp for padlocking or sealing.

23. Identification: Comply with Division 26 Section "Identification for Electrical Systems."

24. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.

25. Sensors: Current-sensing type, with current or voltage output, selected for optimum range and accuracy for ratings of circuits indicated for this application.

a. Type: Split core.

26. Meter Accuracy: Nationally recognized testing laboratory certified to comply with ANSI C12.1.

27. Current-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.

28. Protocol Gateway

a. The unit shall be CE marked.

b. The unit shall be a standalone device that can connect to Electro Industries (EIG)'s meters, and GE's PQMII meter, through the meters' RS485 serial port.

c. The unit shall take the Modbus protocol data from the meter and translate it into other protocols.

1) The unit shall be available in two models.

2) 1 model shall take the Modbus protocol data and change it into BACnet/IP, BACnet MS/TP, DF1, EtherNet/IP, or Metasys N2 protocol

3) 1 model shall take the Modbus protocol data and change it into LonWorks protocol.

29. The unit shall have appropriate serial port and Ethernet connections to connect to the field protocol Host unit.

30. The unit shall have the capability to automatically detect which EIG meter it is connected to.
    a. The unit shall load into memory all object lists for the available protocols for the meter as soon as the meter is auto-detected.
    b. Auto-discovery shall be enabled and disabled via Dip switches.

31. The unit support the following EIG meters:
    a. Shark® 100 meter
    b. Shark® 200 meter
    c. Shark® 250 meter
    d. Shark® 270 meter
    e. Nexus® 1252 meter
    f. Nexus® 1262 meter
    g. Nexus® 1272 meter
    h. Nexus® 1500 meter
    i. MP200-Y metering system
    j. MP200-S metering system
    k. DMMS 425 meter
    l. PQMII meter

32. The unit shall supply up to 1500 BACnet data points and up to 1000 LonWorks data points; supporting multiple meters. The number of power and energy data points supplied for each of the EIG meters is as follows:
    a. Shark® 100 meter: 56
    b. Shark® 200 meter: 68
    c. Shark® 270 meter: 67
    d. Nexus® 1252 meter: 48
    e. Nexus® 1262 meter: 48
    f. Nexus® 1272 meter: 48
    g. Nexus® 1500 meter: 56
    h. MP200-Y metering system: 241
    i. MP200-S metering system: 571
    j. DMMS 425 meter: 46
    k. PQMII meter: 62

33. DIP switches shall be used to set MAC Address, Node-ID, and Baud Rate for the unit.

34. The unit shall have a graphical user interface (GUI).
    a. The GUI shall be viewable through any standard Web browser.
    b. The GUI shall provide the capability of changing the device's IP address for use with BACnet/IP and EtherNet/IP protocols.
    c. The GUI shall provide the capability of changing the Node Offset for use with BACnet/IP and BACnet MS/TP protocols.
    d. The GUI shall contain EIG contact information.

35. The unit shall have a password protection option.

36. The unit's RS485 connection shall be a 6-pin input supporting both RS485 communication and 9-30 VDC/12-24VAC power supply.

37. The unit shall come in a kit that includes the unit, a 3 foot RS485 communication cable, a 120/220V to 24VDC power supply, a user manual on a CD, and a Quickstart guide.

38. The unit's dimensions shall be: 4.5 L x 3.2 W x 1.6 in H (11.5 cm L x 8.3 cm W x 4.1 cm H).

39. The unit's operating temperature shall be: -40°F to 167°F (-40°C to 75°C).

40. The unit shall have a standard 5-year warranty.

41. The following models shall be acceptable:
    a. ProtoCom-KT - ProtoCom Kit for BACnet and other protocols provided by Electro Industries / GaugeTech, Westbury NY 516-334-0870 www.electroind.com.
    b. ProtoCom-Lon-KT - ProtoCom-Lon Kit for LonWorks protocol provided by Electro Industries / GaugeTech 516-334-0870 www.electroind.com

F. Electrical Power Monitoring Software: The electrical power monitoring software shall allow for the Owner to easily view his/her power monitoring data in chart/graph format. In addition, with advanced analytics, the software shall provide insights through A.I, so that the Owner can take "actionable steps" to reduce his/her energy consumption and mitigate potentially damaging power quality events.

1. The Basis of Design for electrical the power monitoring software is Electro Industries/GaugeTech's EnergyPQA.
2. The AI driven cloud-based system shall enable enterprise energy management and power quality analysis. The cloud-based system shall identify facilities and individual circuits most in need of power quality and energy efficiency improvements.
3. The cloud-based system shall encompass multiple components, including a meter management on-premises software application with databasing, meter configuration, push to cloud.
4. The cloud-based system shall enable setup of multiple facilities containing multiple meters.
5. Trend data shall be available for all meters and facilities connected to the cloud system. Multiple dashboard and comparison graphs including AI driven future predictions shall be available for facility and meter level usage analysis.
6. The cloud-based system shall provide enterprise-level summary reporting and facility comparison.
7. The cloud-based system shall predict energy usage and max demand for each metered circuit, using artificial intelligence and machine learning to show predicted energy usage for as far ahead as the end of the calendar year, with past usage and 30-day energy usage predictions for any metered circuit.
8. The cloud-based system shall provide a full complement of power quality viewing capability.
9. The system shall provide recorded waveforms, voltage surges and sags, and current fault signatures.
10. The system shall automatically plot CBEMA and SEMI F-47 power quality graphs, THD, monthly power factor, and all meter-programmed alarm limits.
11. The waveform fault analysis viewer shall allow for zoom and pan and selectable overlay.
12. The waveform fault analysis shall provide location (direction) of the power quality event (upstream or downstream) and direction of the power harmonics.
13. The waveform fault viewer shall enable single cycle waveform view with RMS data, harmonics, annotations, and ranges.
14. The cloud-based system shall support meter totalization for the purpose of creating aggregated meters representing a single load and for creating one main feeder meter for each facility. This feeder meter shall be used to provide enterprise comparison data. The meter totalization shall also be used to add or subtract a totalized meter for sub-metering purposes.
15. The cloud-based system shall alarm via email on a new predicted peak demand at each metered circuit up to three days in advance, enabling proactive load management. Predicted demand must use artificial intelligence and machine learning and must predict a new peak demand at least 3 days in advance. The system shall also send alarm emails on power quality events, waveform capture, and out of limit conditions.
16. The cloud-based system shall have a reporting feature that lets the user set up and generate reports.
17. The cloud-based system shall have C-Suite-level reports that analyze energy efficiency and power quality risk to identify worst buildings and circuits in the enterprise.
18. The cloud-based system shall have a scheduler to facilitate emailing of reports and alarm emails. All alarm emails shall link back to the original event in the system via a hyperlink located within the email.
19. The cloud-based system shall provide advanced cyber security.
20. All web services shall be behind a web application firewall.

21. There shall be no direct access to user databases.
22. The system data shall be fully secured through an HTTPS secure socket layer.
23. Encrypted and salted passwords and API keys shall be used when collecting data to the system.
24. There shall be an Admin user who is able to set up and make changes to facilities, meters, and other user accounts.
25. User access to facility data shall be configurable to limit access.
26. Security audit logs shall be stored.
27. There shall be dual factor authentication using a 128-bit encrypted key sent over email or text message to prevent fraudulent account access.
28. Data shall be stored at the customer facility and in the cloud.
29. The cloud-based system shall have a meter management software with configuration and a data collection component.
30. The meter management component shall auto-discover and download all stored logs from networked meters. The software shall also group the meters to facilitate meter management.
31. The meter management component shall upload meter data to the cloud automatically at programmable intervals.
32. The meter management component shall periodically perform health check scans of network meters.
33. The meter management component shall support automatic detection analytics of meter wiring and installation errors.
34. The meter management component shall maintain error logs and status logs and provide diagnostic tools for forensic analysis of the complete energy system's integrity.
35. The configuration component shall enable local and remote meter configuration.
36. The configuration component shall enable trending of data, including all measured parameters.
37. The data collection component shall have memory for storing trending and power quality data.
38. There shall be a log viewer to facilitate trending and power quality analysis.
39. The system shall have a billing component. The billing component shall support:
    a. Detailed rate structure configuration, including peak and off-peak periods for up to four seasons, weekend and holiday rates, fixed charges, coincident peak demand, and tiered rates.
    b. Usage totalization at a location.
    c. Measurement of energy usage and commodities such as steam, water, gas, etc.
    d. Automatic generation of custom designed monthly usage billing and/or invoicing.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with equipment installation requirements in NECA 1.

B. Install equipment for utility company metering. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by utility company.

C. Install modular meter center according to NECA 400 switchboard installation requirements.

3.02 FIELD QUALITY CONTROL

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

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform all tests and inspections with the assistance of a factory-authorized service representative.

D. Tests and Inspections:

1. Equipment and Software Setup:

a. Set meter date and time clock.
b. Test, calibrate, and connect pulse metering system.
c. Set and verify billing demand interval for demand meters.
d. Report settings and calibration results.
e. Set up reporting and billing software, insert billing location names and initial constant values and variable needed for billing computations.
f. Set up three year and long-term trending.

2. Connect a load of known kilowatt rating, 1.5 kW minimum, to a circuit supplied by metered feeder.
3. Turn off circuits supplied by metered feeder and secure them in off condition.
4. Run test load continuously for eight hours minimum, or longer, to obtain a measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.
5. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.
6. Generate test report and billing for each tenant or activity from the meter reading tests.

E. Electricity metering will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.03 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.04 DEMONSTRATION

A. Engage a factory-authorized service representative to provide on-site training of Owner's clerical and maintenance personnel to use, adjust, operate, and maintain the electronic metering and software.

END OF SECTION

SECTION 262716 - FLOOR BOXES

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Floor boxes:
   1. Multi-service floor boxes for on-grade concrete floors.

1.2 RELATED SECTIONS

A. Section 07 84 13 - Penetration Firestopping Mortars.

B. Section 26 05 00 - Common Work Results for Electrical: Electrical systems and components.

C. Section 28 05 00 - Common Work Results for Electronic Safety and Security: Security systems and components.

D. Section 27 00 00 - Communications: Communications systems and components.

1.3 REFERENCES

A. ASTM International (AST M): ASTM E 814 - Standard Test Method for Fire Tests of Penetration Firestop Systems.

B. National Fire Protection Association (NFPA): NFPA 70 - National Electrical Code.

C. City of Chicago Building Code.

D. Underwriters Laboratories Inc. (UL):
   1. UL 5 - Surface Metal Raceways and Fittings.
   2. UL 94 - Test for Flammability of Plastic Materials for Parts in Devices and Appliances.
   3. UL 514A - Metallic Outlet Boxes.

1.4 SUBMITTALS

A. Submit under provisions of Section 01 30 00.

B. Product Data: Manufacturer's data sheets and descriptive literature on each product to be used, including:
   1. Preparation instructions and recommendations.
   2. Storage and handling requirements and recommendations.
   3. Installation methods.

C. Shop Drawings: Indicate raceway layouts, each system component required for complete system, raceway lengths, device types, locations, elevations, details, sections and attachment to other work; identify all circuits.

D. Test Reports: Certified reports from independent testing laboratory supporting compliance of raceway system to specified requirements.

E. Manufacturer's instructions: Printed installation instructions for each system component; include storage requirements.

F. Project Record Documents: If variations from approved shop drawings occur during installation of

raceway system, submit final as-built drawings indicating such variations.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Firms regularly engaged in manufacture of raceway and box distribution products and systems of the types and sizes required, whose products have been in satisfactory use in similar service for not less than 10 years.

B. Source Limitation: Obtain each type of round recessed raised and stage floor box through one source from a single manufacturer.

C. Mock-Up: Provide a mock-up for evaluation of surface preparation techniques and application workmanship.
1. Finish areas designated by Architect.
2. Do not proceed with remaining work until workmanship, appearance and performance are approved by Architect.
3. Refinish mock-up area as required to produce acceptable work.

D. Electrical Components, Devices, and Accessories: Comply with requirements of applicable local codes, NEC, UL, and NEMA Standards pertaining to indoor service poles and architectural columns. Listed and labeled in accordance with NFPA 70, Article 100.

E. Electrical Floor Boxes and Components: Comply with requirements of applicable local codes, NEC, UL, and NEMA Standards pertaining to floor boxes and components. Meet or exceed UL Fire Classification requirements for recessed and flush style boxes. Listed and labeled in accordance with NFPA 70, Article 100.

F. Electrical Boxes and Fittings: Comply with requirements of applicable local codes, NEC, UL, ETL, and NEMA Standards pertaining to boxes and fittings. Listed and labeled in accordance with NFPA 70, Section 300-21.

G. Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

H. Accessibility Compliance: Design device flange to meet ADA Accessibility Guidelines as to changes in floor and ground surface levels. Flanges shall be beveled so the slope is no greater than 1:2.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store products in manufacturer's unopened packaging until ready for installation.

B. Store and handle in strict compliance with manufacturer's written instructions and recommendations.

C. Protect from damage due to weather, excessive temperature, and construction operations.

1.7 PROJECT CONDITIONS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's recommended limits.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturers:

1. Wiremold®, which is located at: 60 Woodlawn St. ; West Hartford, CT 06110; Toll Free Tel: 877-295-3472; Tel: 860-233-6251; Fax: 860-232-2062; Email:customer.support-wm@legrand.us; Web:www.legrand.us/Wiremold.aspx
2. Hubbell Inc.

B. Requests for substitutions will be considered in accordance with provisions of Section 01 60 00, and should include documentation of UL listings and a sample of components.

2.2 FLOOR BOXES FOR ON-GRADE CONCRETE FLOORS

A. Configurations: Boxes shall be four-gang configurations or a single unit with two to eleven independent wiring compartments with epoxy coated stamped steel. Boxes shall be available in deep and shallow versions. Covers shall be flush Style Rectangular Covers (for use with tile, finished concrete and Terrazzo floors). Boxes shall provide pre- and post-pour adjustments. Multiple gang boxes shall also provide a removable barrier between the individual compartments for greater capacity when required and wireway used to pass wires from one compartment to the other.
1. 12" x 12" x 3.5" Deep Epoxy Coated Stamped Steel Floor Boxes for Concrete Floors.

B. Cover:
1. Acceptable Product: Manufactured of die-cast aluminum and available in brushed aluminum finish and powder-coated paint finishes (black, gray, bronze, nickel and brass as selected by architect). Activation covers shall be available in flanged and flangeless versions. Covers shall be available with options for tile or carpet inserts, or flush covers. The cover's hinge shall allow for the cover to open 180 degrees. The furniture feed covers shall come equipped with one 1 inch (25 mm) trade size screw plug opening and one combination 1-1/4 inches (32 mm) and 2 inches (52 mm) trade size screw plug.
   a. Flanged covers shall be 7-3/4 inches L by 6-9/16 inches W (197 mm by 167 mm).
   b. Flangeless covers shall be 6-3/4 inches L by 5-9/16 inches W (171 mm by 142 mm).
2. Acceptable Product: Manufactured of die-cast aluminum alloy and available in powder-coated gray finish. The covers shall be available in carpet and tile versions. Provide covers with two gaskets (one for carpet and one for tile) to go under the trim flange to maintain scrub water tightness. The carpet covers shall be surface mounted and the tile covers shall be flush with the finished floor covering. The covers shall have spring loaded slides to allow cables to

C. Metallic Floor Boxes:
1. Material: Stamped steel and painted with a fusion-bonded epoxy; box interior and exterior painted; 1-3/8 inches (35 mm) pre-pour adjustment; 3/4 inch (19 mm) post-pour adjustment.
2. Box Type: Rectangular.
3. Service: Multiple.
4. Cover Construction: Die-cast aluminum.
5. Cover Plates and Flanges: Brushed aluminum.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine conditions under which raceways and boxes are to be installed. Do not proceed with installation until substrates have been properly prepared and deviations from Manufacturer's recommended tolerances are corrected. Commencement of installation constitutes acceptance of conditions.

3.2 PREPARATION

A. Prepare substrates using the methods recommended by the manufacturer for achieving the best

result for the substrate under the project conditions.

B. If preparation is the responsibility of another installer, notify Architect in writing of deviations from Manufacturer's recommended installation tolerances and conditions.

3.3 INSTALLATION - GENERAL

A. Install in accordance with manufacturer's instructions for system components and approved shop drawings. Coordinate installation with adjacent work to ensure proper clearances and to prevent electrical hazards.

B. Install in accordance with complete system instruction sheets.

C. Install enclosures to be mechanically continuous and connected to all electrical outlets, boxes, device mounting brackets, and cabinets, in accordance with manufacturer's installation sheets.

D. Install enclosures to be electrically continuous and bonded in accordance with the National Electric Code for proper grounding.
   1. Mechanical Security: Raceway systems shall be mechanically continuous and connected to all electrical outlets, boxes, device mounting brackets, and cabinets, in accordance with Manufacturer's installation sheets.
   2. Electrical Security: Metal raceway shall be electrically continuous and bonded in accordance with the National Electric Code for proper grounding.
   3. Raceway Support: Raceway shall be supported at intervals not exceeding 5 feet (1524 mm) or in accordance with Manufacturer's installation sheets.
   4. Accessories: Provide accessories as required for a complete installation, including insulated bushings and inserts where required by manufacturer.
   5. Unused Openings: Close unused raceway openings using manufacturer's recommended accessories.

3.4 FLOOR BOX INSTALLATION

A. Strictly comply with manufacturer's installation instructions and recommendations and approved shop drawings. Coordinate installation with adjacent work to ensure proper clearances and to prevent electrical hazards.
   1. Mechanical Security: Raceway systems shall be mechanically continuous and connected to all electrical outlets, boxes, device mounting brackets, and cabinets, in accordance with manufacturer's installation sheets.
   2. Electrical Security: Metal raceway shall be electrically continuous and bonded in accordance with the National Electric Code for proper grounding.
   3. Raceway Support: Raceway shall be supported at intervals not exceeding 5 feet or in accordance with manufacturer's installation sheets.
   4. Accessories: Provide accessories as required for a complete installation, including insulated bushings and inserts where required by manufacturer.
   5. Unused Openings: Close unused raceway openings using manufacturer's recommended accessories.

B. Saw-cut existing concrete floor slab and install floor boxes to permit all wiring to be completed at floor level. Patch floor slab to match existing construction.

3.5 PROTECTION

A. Clean exposed surfaces using non-abrasive materials and methods recommended by manufacturer.

B. Protect installed products until completion of project.

C. Touch-up, repair or replace damaged products before Substantial Completion.

END OF SECTION

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes the following:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Solid-state fan speed controls.
4. Wall-switch.
5. Communications outlets.
6. Pendant cord-connector devices.
7. Cord and plug sets.
8. Floor service outlets, poke-through assemblies, service poles, and multi-outlet assemblies.
9. Pedestal outdoor service outlet assemblies.
10. Controlled Receptacles.
11. USB Charger Receptacles.
12. Pendant retractable cord reel.

1.2 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

1.3 SUBMITTALS

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

B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.

C. Field quality-control test reports.

D. Operation and Maintenance Data: Wiring devices shall be provided with all manufacturers' packing label warnings and instruction manuals that include labeling conditions. Provide a collection of manufacturer recommended operation and maintenance practices for each type of product including, but not limited to:

1. Tools required.
2. Acceptable cleaners and recommended cleaning practices.
3. Replacement parts list.
4. Manufacturer service department contact information.
5. Submittal data.
6. Intended operation narrative.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in the National Electrical Code, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 101.

D. Comply with National Electrical Code.

1.5 DELIVERY, STORAGE AND HANDLING

A. Effectively protect all materials, accessories, and components form any damage or injury from the time of fabrication until final Owner acceptance.

B. Deliver equipment in fully enclosed vehicles after specified environmental conditions have been permanently established in spaces where equipment is to be placed.

C. Store equipment in spaces with environments controlled within manufacturer's ambient temperature and humidity tolerances for non-operating equipment.

1.6 COORDINATION

A. Receptacles for Owner-Furnished Equipment: Match plug configurations.

1.7 EXTRA MATERIALS

A. Furnish extra materials described in subparagraphs below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Service/Power Poles: One for every 10, but no less than one.
2. Floor Service Outlet Assemblies: One for every 10, but no less than one.
3. Poke-Through, Fire-Rated Closure Plugs: One for every five floor service outlets installed, but no less than two.

1.8 LEED REQUIREMENTS

A. Within 30-days after the date of system acceptance, record drawings of the actual installation shall be provided to the building owner.

B. Implement an independent commissioning authority to review the contractor submittals relative to systems being commissioned.

C. Implement providing the owner with a single manual that contains the information required for re-commissioning building systems.

D. Use a minimum of 20% of wiring devices that are manufactured regionally within a radius of 500 miles.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Wiring Devices:

    a. **Leviton Mfg. Company Inc.**
    b. **Pass & Seymour/Legrand; Wiring Devices & Accessories**
    c. **Arrow hart**

2. Poke-Through, Floor Service Outlets, and Telephone/Power Poles:

    a. Hubbell, Inc.
    b. Pass & Seymour/Legrand; Wiring Devices & Accessories

3. Wiremold Co. Multi-Outlet Assemblies:

    a. Hubbell Incorporated; Wiring Device-Kellems.
    b. Wiremold Co.

4. Pendant Cord Reel System:

    a. KH Industries
    b. Hubbell
    c. McMaster-Carr

2.2 STRAIGHT BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A**: Tamper-proof,** "DECORATOR" style. Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498 and Federal Specification W-C-596. Pre-wired pigtail connectors that accommodate Fed Spec receptacles are approved. Pigtail connectors must be crimped and welded terminal right-angle application connector.

1. Products: Subject to compliance with requirements, provide one of the following:

    a. **Leviton Mfg. Company Inc.**
    b. **Pass & Seymour/Legrand; Wiring Devices & Accessories**
    c. **Arrow hart**

2.3 GFCI RECEPTACLES

A. General Description: **Tamper-proof,** "DECORATOR" style, Straight blade, type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped. Units shall fit in a 2-3/4" deep outlet box without an adapter.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:

2.4 **OMITTED.**

2.5 TWIST-LOCKING RECEPTACLES

A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.

2.6 PENDANT RETRACTABLE CORD REEL DEVICES

A. Description: Retractable NEMA 2 rated cord reel complete with two back-to-back 125 volts, 20 amp, NEMA 5-20R GFCI receptacles; heavy-duty, industrial grade. Powder coat finish.

1. Body: 25'-0" cord length.
2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.
3. Operation: Lift/Drag (ratchet lock). Adjustable ratchet can be engaged (positive lock) or disengaged (constant tension) as needed. Adjustable ball stop included.
4. Conductor: 125V, #12 AWG, 3-conductor, SJOW cord type.
5. **Pendant retractable cord-reel assemblies installed in finished lay-in ceiling tiles or drywall ceiling shall be equipped with plenum rated cord-reel enclosure. Manufacturer: Hubble HBLIPRBOX or Equal.**

2.7 SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches, 120/277 V, 20 A:

C. Pilot Light Switches, 20 A:

1. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."

D. Key-Operated Switches, 120/277 V, 20 A:

1. Description: Single pole, with factory-supplied key in lieu of switch handle.

E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.

F. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

2.8 FAN SPEED CONTROLS

A. Modular, 120-V, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters. Comply with UL 1917.

1. Continuously adjustable slider, 5 A.
2. Three-speed adjustable slider, 1.5 A.

2.9 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.

2. Material for Finished Spaces: 0.035-inch thick, satin-finished stainless steel**, Type No. 302 (18-8)** except as noted otherwise on drawings.
3. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum with lockable cover.

2.10FLOOR SERVICE FITTINGS

A. Type: Modular, flush-type, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: Rectangular, die-cast aluminum with satin finish.

D. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.

E. Refer to Specification Section 26 27 16 – Floor Boxes.

2.11POKE-THROUGH ASSEMBLIES

A. Description: Factory-fabricated and -prewired assembly of below-floor junction box with multi-channeled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly as specified above.

1. Service Outlet Assembly: Flush type with devices coordinated with drawings and Division 27 Section “Data Communications Horizontal Cabling”.
2. Size: Selected to fit nominal 3-inch cored holes in floor and matched to floor thickness.
3. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
4. Closure Plug: Arranged to close unused 3-inch cored openings and reestablish fire rating of floor.
5. Wiring Raceways and Compartments: Sized for a minimum of four No. 12 AWG conductors and a minimum of four (4) 4-pair Category 6 UTP communication cables. Comply with requirements of Division 27 Section “Data Communications Horizontal Cabling” for Category 6 UTP components.
6. Communications Outlets: Modular, color-coded RJ45 jacks for UTP cable. Coordinate jack type with drawing requirements and Division 27 Section “Data Communications Horizontal Cabling”.

2.12MULTIOUTLET ASSEMBLIES

A. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

B. Raceway Material: Metal, with manufacturer's standard corrosion-resistant finish.

C. Wire: No. 12 AWG.

2.13SERVICE POLES

A. Description: Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.

1. Poles: Nominal 2.5-inch-square cross section, with height adequate to extend from floor to at least 6 inches above ceiling, and with separate channels for power wiring and voice and data communication cabling.
2. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.

3. Finishes: Manufacturer's standard painted finish and trim combination.
4. Wiring Raceways and Compartments: Sized for minimum of five No. 12 AWG power and ground conductors and a minimum of four (4) 4-pair Category 6 UTP communication cables. Comply with requirements of Division 27 Section “Data Communications Horizontal Cabling” for Category 6 UTP components
5. Power Receptacles: Two duplex, 20-A, heavy-duty, NEMA WD 6 configuration 5-20R units.
6. Communications Outlets: Modular, color-coded RJ45 jacks for UTP cable. Coordinate jack type with drawing requirements and Division 27 Section “Data Communications Horizontal Cabling”.

2.14PEDESTAL OUTDOOR SERVICE OUTLET ASSEMBLIES

A. Description: Factory-assembled, UL listed, field installed and wired 42” high pedestal mounted outlet device, complete with RGS conduit concealed within pedestal casing. Hinge top with or without integral base. Product Basis-of-Design: PEDOC™ Power Solutions, LLC, 600 Carboy, Mt Prospect, IL 60056, (800) 518-0330, www.pedocpower.com.

1. Material: Material is polished 14 gage stainless steel finish. Provide powder coated where indicated on the drawings. Finish shall be selected by architect.
2. Mounting: Provided with a removable front cover which provides adequate room for anchoring, raceway placement and wire or cable installation. Slots are provided on the sides to provide conduit entry points for raceways and cables. Pedestal can accommodate conduit raceways up to 1 inch through the wire slots, or up to 1 1-2” through the bottom. The receptacle device shall be mounted at 18” above finished grade to center of device. Pedestal is intended for direct ground burial with concealed RGS conduit raceways within the pedestal housing.
3. Power Receptacle: Straight blade, non-feed through type. Single GFCI, tamper-resistant duplex, 20-A, heavy-duty, NEMA WD 6 configuration 5-20R receptacle and include indicator light that is lighted when device is tripped.

2.15CONTROLLED RECEPTACLES

A. Description: Commercial grade, UL Fed Spec W596G, Tamper-Resistant Duplex Controlled Receptacle, NEMA 5-20R, 20 Amp, 125 Volt AC Decorator Duplex. Temporary override button/test and Green LED indicator to show power available and low voltage class 2 wiring terminals. Impact and chemical resistant. Flus fit design.

1. Automatic Receptacle Control: 50% of all 125 volt 15- and 20-ampere receptacles in private offices, conference rooms, printing/copying rooms, break rooms, classrooms, and individual workstations shall be automatically switched off when the space in which they are located is not occupied. All individual workstations created with modular furniture shall be required to have at least 50% of the receptacles in each workstation automatically controlled.
2. All controlled receptacles shall be visually distinct from non-controlled receptacles. Switched receptacles shall be identified by receptacle color, indication lights integral to the receptacle, permanently marked/engraved receptacle labeling, etc. Regardless of the means of identification, maintaining clear, uniform identification throughout a building will increase occupant understanding and reduce confusion.
3. All controlled receptacles shall be controlled via Relay Panel(s) or local stand-alone ceiling mounted occupancy/vacancy sensors. Provide all required conduit, wiring, relays, etc. for a complete and functional controlled receptacle system.

2.16USB CHARGER RECEPTACLES

A. Description: Commercial grade, UL Fed Spec USB Charger Tamper-Resistant Duplex Receptacle, with one type A and one type C high power USB Ports, 5 Amp, 5 Volt DC, 15 or 20 Amp, 125 Volt AC Decorator Duplex. Green LED indicator to show USB power available. Impact and chemical resistant. Flus fit design.

2.17FINISHES

A. Color:

1. Wiring Devices Connected to Normal Power System: White, or as directed by the architect and required by Chicago Electrical Code or device listing.
2. Wiring Devices connected to automatic control system (Controlled Receptacles): White, Green or as selected by architect.
3. Wiring Devices Connected to Emergency Power System: Solid Red.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Coordination with Other Trades:

1. Take steps to insure that devices and their boxes are protected. 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 the 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 just 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 Chicago Electrical Code, 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. Pig-tailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they 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, 2/3 to 3/4 of the way around terminal screw.
6. Modular wiring devices are seen as an acceptable alternative at the discretion of the contractor. Receptacles must meet UL498 and Federal Specification WC-596 requirements. Switches must meet UL20 and Federal Specification WC-896 requirements. Prewired terminal right angle application pigtail connectors must be crimped and welded.
7. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
8. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
9. Tighten unused terminal screws on the device.

10. 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. 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.

F. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

G. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.
2. Switches: Where 3 or more switches are ganged, and elsewhere where indicated, identify each switch with approved legend engraved with black-filled lettering on face of wall plate.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.
3. Test Wiring Devices: Test wiring devices for proper polarity and ground continuity. Operate each operable device at least 6 times.

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 not acceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Replace damaged or defective components.

3.4 CLEANING

A. The contractor shall remove all paint spatters and other spots, dirt and debris from the equipment. Clean equipment and devices internally and externally using methods and materials recommended by the manufacturer. Replace stained or improperly painted wall plates or devices.

3.5 CONTRACTOR STARTUP AND REPORTING

A. Contractor shall prepare and submit a complete set of record drawings, test reports, operation and maintenance data and certificates as outlined in this Section.

3.6 COMMISSIONING AND DEMONSTRATION

A. After system checkout and adjustment, the contractor shall operate the system for the review of the owner and architect. Necessary adjustments or modifications shall be made as required by the owner or architect.

END OF SECTION

SECTION 262813 - FUSES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Fuses.

B. Spare fuse cabinet.

1.02 REFERENCE STANDARDS

A. NEMA FU 1 - Low Voltage Cartridge Fuses; 2012.

B. UL 248-1 - Low-Voltage Fuses - Part 1: General Requirements; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate fuse clips furnished in equipment provided under other sections for compatibility with indicated fuses.
      a. Fusible Switches for Switchboards: See Section 26 24 13 - Switchboards.
      b. Fusible Switches for Panelboards: See Section 26 24 16 - Panelboards.
      c. Fusible Enclosed Switches: See Section 26 28 16.16 - Enclosed Switches.
      d. Fusible Switches for Enclosed Motor Controllers: See Section 26 29 13 - Enclosed Controllers.
   2. Coordinate fuse requirements according to manufacturer's recommendations and nameplate data for actual equipment to be installed.
   3. Notify Architect/Engineer of Record of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard data sheets including voltage and current ratings, interrupting ratings, time-current curves, and current limitation curves.
   1. Spare Fuse Cabinet: Include dimensions.
   2. Fuse size for elevator feeders and elevator disconnect switches.

C. Maintenance Materials: Furnish the following for Board's use in maintenance of project.
   1. See Section 01 60 00 - Product Requirements, for additional provisions.
   2. Extra Fuses: Quantity equal to twenty percent of each fuse type and size, but no fewer than one (1) set of three (3) of each type and size.
   3. Fuse Pullers: One (1) set(s) compatible with each type and size installed.
   4. Spare Fuse Cabinet Keys: Two (2).
   5. Operation and Maintenance Manual:
      a. In addition to items specified in Sections 01 77 00 - Closeout Procedures and 01 78 00 - Closeout Submittals, include the following:
         1) Let-through current curves for fuses with current-limiting characteristics.
         2) Time-current curves, coordination charts and tables, and related data.
         3) Ambient temperature adjustment information.

1.05 QUALITY ASSURANCE

A. Comply with the National Electrical Code.

B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Bussmann, a division of Eaton Corporation: www.cooperindustries.com.

B. Littelfuse, Inc: www.littelfuse.com.

C. Ferraz Shawmut, Inc.: www.ferrazfuses.com.

2.02 APPLICATIONS

A. Service Entrance:
1. Fusible Switches up to 600 Amperes: Class RK1, fast-acting, non-time-delay.
2. Fusible Switches Larger Than 600 Amperes: Class L, fast-acting, non-time-delay.

B. Feeders:
1. Fusible Switches up to 600 Amperes: Class RK1, time-delay.
2. Fusible Switches Larger Than 600 Amperes: Class L, time-delay.

C. General Purpose Branch Circuits: Class RK1, time-delay.

D. Individual Motor Branch Circuits: Class RK1, time-delay.

E. In-Line Protection for Pole-Mounted Luminaires: Class CC, time-delay.

F. Primary Protection for Control Transformers: Class CC, time-delay.

2.03 FUSES

A. Provide products listed, classified, and labeled as suitable for the purpose intended.

B. Unless specifically indicated to be excluded, provide fuses for all fusible equipment as required for a complete operating system.

C. Provide fuses of the same type, rating, and manufacturer within the same switch.

D. Comply with UL 248-1.

E. Unless otherwise indicated, provide cartridge type fuses complying with NEMA FU 1, Class and ratings as indicated.

F. Voltage Rating: Suitable for circuit voltage.

G. All fuses shall be of the same manufacture to ensure retention of selective coordination as designed.

H. General: Apply current limiting fuses as indicated and as follows:
   1. New general purpose fusible switches: Apply for the following class types:
      a. 0-600 Amperes: Class RK1, dual element time delay; LPN-RK, LPS-RK.
      b. 601-1,200 Amperes, Motor or Transformer Circuit: Class L, time delay; Lo-Peak KRPC.
   2. Bolted Pressure Switches: Class L, time delay.
   3. Switches in Switchboards: Apply the following classes and types:
      a. 60-600 Amperes: Class RK1, dual element time delay; LPN-RK, LPS-RK.
      b. 601 Amperes and Above: Class L, time delay; Lo-Peak KRPC.
   4. Existing General-Purpose Switches:
      a. 30-600 Amperes: Class RK1, dual element time delay; LPN-RK, LPS-RK.
      b. 601-1,200 Amperes: Class L, time delay; Lo-Peak KRPC.

I. Selectivity: Where the requirement for selectivity is indicated, furnish products as required to achieve selective coordination.

J. Provide the following accessories where indicated or where required to complete installation:
   1. Fuse holders: Compatible with indicated fuses.
   2. Fuse Reducers: For adapting indicated fuses to permit installation in switch designed for fuses with larger ampere ratings.
   3. Fuse pullers.
   4. Fuse pull rings.
   5. Handling poles with extensions.
   6. Pole grapplers, prongs, clamps, etc.

K. Provide fuseholders to accommodate the fuses specified. Coordinate installation with assembly manufacturers as applicable. Provide pins or other physical rejection features when current limiting fuses are specified, and non-current limiting fuses of the same dimensions are available.

L. Where ambient temperature to which fuses are directly exposed is less than 40 deg F or more than 100 deg F, apply manufacturer’s ambient temperature adjustment factors to fuse ratings.

M. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size.

2.04 SPARE FUSE CABINET

A. Description: Wall-mounted sheet metal cabinet with shelves and hinged door with key-coded cam lock and pull, suitably sized to store spare fuses and fuse pullers specified with 15 percent spare capacity minimum.

B. Finish: Gray, baked enamel unless otherwise indicated.

C. Identification: "SPARE FUSES" in 1-1/2 inch high letters on exterior of cabinet door.

D. Fuse Puller: For each size of fuse.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that fuse ratings are consistent with circuit voltage and manufacturer's recommendations and nameplate data for equipment.

B. Verify that mounting surfaces are ready to receive spare fuse cabinet.

C. Verify that conditions are satisfactory for installation prior to starting work.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

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

F. Fuses shall not be installed in the equipment until the installation is complete, tested and ready to be energized. Paralleling of fuses will not be permitted.

G. All fuses shall be sized as indicated on the Contract Drawings. Where fuse ratings are not indicated for fuses used to provide motor backup protection or as short circuit protection, such fuses shall be sized in accordance with the heavy service recommendations of the fuse manufacturer.

3.02 FUSE APPLICATIONS

A. Service Entrance: Class L, fast acting.

B. Feeders: Class L, time delay.

C. Motor Branch Circuits: Class RK1, time delay.

D. Other Branch Circuits: Class RK1, time delay.

3.03 INSTALLATION

A. Do not install fuses until circuits are ready to be energized.

B. Install fuses with label oriented such that manufacturer, type, and size are easily read.

C. Install spare fuse cabinet where indicated.

D. Identify spare fuse cabinet in accordance with Section 26 05 53 - Identification for Electrical Systems.

E. Fuses shall not be installed in the equipment until the installation is complete, tested and ready All low voltage fuses are sized based on the results of short circuit and coordination study as specified in Section 26 05 73 - Power System Studies.

F. The Contractor shall affix to the inside of the door of each fuse enclosure a label or sticker indicating the proper type and rating of fuse. The fuse manufacturer’s labels shall be used.

G. Install typewritten labels indicating fuse replacement information on inside door of each fused switch.

3.04 DEMONSTRATION AND TRAINING

A. Training: Arrange and pay for the services of factory-authorized service representatives to demonstrate OCPD’s and train Board's maintenance personnel.

B. Conduct a minimum of one half (1/2) day of training in operation and maintenance as specified in the Sections 01 77 00 - Closeout Procedures and 01 79 00 - Demonstration and Training. Include both classroom training and hands on equipment operation and maintenance procedures.

C. Schedule training with at least seven (7) days' advance notice.

END OF SECTION

SECTION 262816.13 - ENCLOSED CIRCUIT BREAKERS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Enclosed circuit breakers.

1.02 REFERENCE STANDARDS

A. National Electrical Code.

B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2014.

D. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less; 2013.

E. NEMA PB 2.1 - General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less; 2013.

F. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.

G. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.

H. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations; Current Edition, Including All Revisions.

I. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures; Current Edition, Including All Revisions.

J. UL 869A - Reference Standard for Service Equipment; Current Edition, Including All Revisions.

K. UL 943 - Ground-Fault Circuit-Interrupters; Current Edition, Including All Revisions.

L. UL 1053 - Ground-Fault Sensing and Relaying Equipment; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate work with other trades. Avoid placement of ductwork, piping, equipment, or other potential obstructions within dedicated equipment spaces and within working clearances for electrical equipment required by the National Electrical Code.
   2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
   3. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted enclosed circuit breakers where indicated.
   4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
   5. Notify Architect/Engineer of Record of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for circuit breakers, enclosures, and other installed components and accessories.
   1. Include characteristic trip curves for each type and rating of circuit breaker.

C. Shop Drawings: Indicate outline and support point dimensions, voltage and current ratings, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
   1. Include dimensioned plan and elevation views of enclosed circuit breakers and adjacent equipment with all required clearances indicated.
   2. Include wiring diagrams showing all factory and field connections.

D. Field Quality Control Test Reports.

E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

F. Project Record Documents: Record actual installed locations of enclosed circuit breakers.

G. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.
   1. Spare Indicating Lights: Provide three (3) of each type installed.

1.05 QUALITY ASSURANCE

A. Comply with the National Electrical Code.

B. Electrical Components, Devices and Accessories: Listed and labeled as defined in the National Electrical Code, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

D. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

E. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

F. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.06 COMPATIBILITY

A. Protective devices added to existing assemblies shall have compatible interrupting ratings with the existing assembly and shall be of the original manufacturer. If not available, modify or extend the assembly to accept compatible protective devices of same manufacturer as supplied in new assemblies.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to enclosed circuit breaker internal components, enclosure, and finish.

1.08 FIELD CONDITIONS

A. Maintain ambient temperature between 23 degrees F and 104 degrees F during and after installation of enclosed circuit breakers.

B. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated.
   1. Notify Architect/Engineer of Record and Owner's Representative not fewer than seven (7) working days in advance of proposed interruption of electrical service.
   2. Do not proceed with interruption of electrical service without Architect/Engineer of Record's and Owner's Representative written permission.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. ABB/GE: www.geindustrial.com/#sle.

B. Eaton Corporation: www.eaton.com.

C. Schneider Electric; Square D Products: www.schneider-electric.us.

D. Siemens Industry, Inc: www.usa.siemens.com.

E. Source Limitations: Furnish enclosed circuit breakers and associated components produced by a single manufacturer and obtained from a single supplier.

2.02 ENCLOSED CIRCUIT BREAKERS

A. Description: Units consisting of molded case circuit breakers individually mounted in enclosures.

B. Provide products listed, classified, and labeled as suitable for the purpose intended.

C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
   1. Altitude: Less than 6,600 feet.
   2. Ambient Temperature: Between 23 degrees F and 104 degrees F.

D. Short Circuit Current Rating:
   1. Provide enclosed circuit breakers with listed short circuit current rating not less than the available fault current at the installed location as determined by short circuit study performed in accordance with Section 26 05 73 - Power System Studies.

E. Enclosed Circuit Breakers Used for Service Entrance: Listed and labeled as suitable for use as service equipment according to UL 869A.

F. Conductor Terminations: Suitable for use with the conductors to be installed.

G. Provide thermal magnetic circuit breakers unless otherwise indicated.

H. Provide electronic trip circuit breakers where indicated.

I. Provide insulated, groundable fully rated solid neutral assembly where a neutral connection is required, with a suitable lug for terminating each neutral conductor.

J. Provide solidly bonded equipment ground bus in each enclosed circuit breaker, with a suitable lug for terminating each equipment grounding conductor.

K. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
   1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
      a. Indoor Clean, Dry Locations: Type 1.
      b. Outdoor Locations: Type 3R.
      c. Kitchen Areas: Type 4X, stainless steel.
      d. Other Wet or Damp Indoor Locations: Type 4.
   2. Finish for Painted Steel Enclosures: Manufacturer's standard, factory applied grey unless otherwise indicated.
   3. Provide surface-mounted enclosures unless otherwise indicated.

L. Provide externally operable handle with means for locking in the OFF position.

M. Ground Fault Protection: Where ground-fault protection is indicated, provide system listed and labeled as complying with UL 1053.
   1. Where electronic circuit breakers equipped with integral ground fault protection are used, provide separate neutral current sensor where applicable.
   2. Where accessory ground fault sensing and relaying equipment is used, equip companion circuit breakers with ground-fault shunt trips.
      a. Use zero sequence ground fault detection method unless otherwise indicated.
      b. Provide test panel and field-adjustable ground fault pick-up and delay settings.
      c. Provide zone selective interlocking capability where indicated, capable of communicating with other electronic trip circuit breakers and external ground fault sensing systems to control ground fault delay functions for system coordination purposes.
      d. Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

N. Selectivity: Where the requirement for selectivity is indicated, furnish products as required to achieve selective coordination.

2.03 MOLDED CASE CIRCUIT BREAKERS

A. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489; ratings, configurations, and features as indicated on the drawings.

B. Interrupting Capacity:
   1. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:
      a. 10,000 rms symmetrical amperes at 240 VAC or 208 VAC.
      b. 14,000 rms symmetrical amperes at 480 VAC.
   2. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.

C. Conductor Terminations:
   1. Provide mechanical lugs unless otherwise indicated.
   2. Provide compression lugs where indicated.
   3. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.

D. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
   1. Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 250 amperes and larger.
   2. Provide interchangeable trip units where indicated.

E. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
   1. Provide the following field-adjustable trip response settings:
      a. Long time pickup, adjustable by replacing interchangeable trip unit or by setting dial.
      b. Long time delay.
      c. Short time pickup and delay.
      d. Instantaneous pickup.
      e. Ground fault pickup and delay where ground fault protection is indicated.

F. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.

G. Provide the following circuit breaker types where indicated:
   1. Ground Fault Circuit Interrupter (GFCI) Circuit Breakers: Listed as complying with UL 943, class A for protection of personnel.
   2. Ground Fault Equipment Protection Circuit Breakers: Designed to trip at 30 mA for protection of equipment.
   3. Current Limiting Circuit Breakers: Without using fusible elements, designed to limit the let-through energy to a value less than the energy of a one-half cycle wave of the symmetrical prospective current when operating within its current limiting range.

H. Provide listed switching duty rated circuit breakers with SWD marking for all branch circuits serving fluorescent lighting.

I. Provide listed high intensity discharge lighting rated circuit breakers with HID marking for all branch circuits serving HID lighting.

J. Provide listed HACR marked circuit breaker for heating, air-conditioning, and refrigerating equipment.

K. Provide the following features and accessories where indicated or where required to complete installation:
   1. Shunt Trip: Provide 120V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
   2. Auxiliary Switch: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
   3. Undervoltage Trip: Set to operate at 35 to 86 percent of rated voltage with field-adjustable 0.1 to 0.6 second time delay.
   4. Alarm Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped.

L. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

M. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that the ratings of the enclosed circuit breakers are consistent with the indicated requirements.

C. Verify that mounting surfaces are ready to receive enclosed circuit breakers.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Perform work in accordance with NECA 1, NEMA PB 1.1, and NEMA PB 2.1.

C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and the National Electrical Code.

D. Provide required supports in accordance with Section 26 05 29 - Hangers and Supports for Electrical Systems.

E. Install enclosed circuit breakers plumb.

F. Install flush-mounted enclosed circuit breakers so that trims fit completely flush to wall with no gaps and rough opening completely covered.

G. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed circuit breakers such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.

H. Provide grounding and bonding in accordance with Section 26 05 26 - Grounding and Bonding for Electrical Systems.

I. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.

J. Set field-adjustable circuit breaker tripping function settings as determined by overcurrent protective device coordination study performed according to Section 26 05 73 - Power System Studies.

K. Set field-adjustable ground fault protection pickup and time delay settings as indicated.

L. Identify enclosed circuit breakers in accordance with Section 26 05 53 - Identification for Electrical Systems.

M. Install wiring between OCPDs and control/indication devices as specified.

N. Install new circuit protective devices to existing assemblies when shown on drawings. Rearrange existing circuit protective devices and provide bus extensions, hardware, enclosure modifications, etc., to accomplish the installations. Modify assemblies, directories or add nameplates to match existing.

3.03 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Inspect and test in accordance with manufacturer's instructions and NETA ATS, except Section 4.

C. Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for circuit breakers used for service entrance. Tests listed as optional are not required.

D. Ground Fault Protection Systems: Test in accordance with manufacturer's instructions as required by the National Electrical Code.
   1. Perform inspections and tests listed in NETA ATS, Section 7.14. The insulation-resistance test on control wiring listed as optional is not required.

E. Test GFCI circuit breakers to verify proper operation.

F. Test shunt trips to verify proper operation.

G. Correct deficiencies and replace damaged or defective enclosed circuit breakers.

3.04 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.05 STARTUP AND REPORTING

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Prepare for acceptance testing as follows:
   1. Inspect mechanical and electrical connections.
   2. Verify switch and relay type and labeling verification.
   3. Verify rating of installed fuses.
   4. Inspect proper installation of type, size, quantity, and arrangement of mounting or anchorage devices complying with manufacturer's certification.

C. Perform the following field tests and inspections and prepare test reports:
   1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.06 CLEANING

A. Clean dirt and debris from circuit breaker enclosures and components according to manufacturer's instructions.

B. Repair scratched or marred exterior surfaces to match original factory finish.

3.07 CLOSEOUT ACTIVITIES

A. See Section 01 78 00 - Closeout Submittals, for closeout submittals.

B. Training: Arrange and pay for the services of factory-authorized service representative to demonstrate OCPDs and train Owner's maintenance personnel.

C. Conduct a minimum of one half (1/2) day of training in operation and maintenance as specified in the Sections 01 77 00 - Closeout Procedures and 01 79 00 - Demonstration and Training. Include both classroom training and hands on equipment operation and maintenance procedures.

D. Schedule training with at least seven (7) days' advance notification.

END OF SECTION

SECTION 26 28 16.16 - ENCLOSED SWITCHES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Enclosed safety switches.

1.02 REFERENCE STANDARDS

A. National Electrical Code.

B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2014.

D. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum); 2013.

E. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less; 2013.

F. NEMA PB 2.1 - General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less; 2013.

G. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.

H. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.

I. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations; Current Edition, Including All Revisions.

J. UL 98 - Enclosed and Dead-Front Switches; Current Edition, Including All Revisions.

K. UL 869A - Reference Standard for Service Equipment; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades. Avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and within working clearances for electrical equipment required by the National Electrical Code.
   2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
   3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
   4. Notify Architect/Engineer of Record of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for enclosed switches and other installed components and accessories.

C. Shop Drawings: Indicate outline and support point dimensions, voltage and current ratings, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
   1. Include dimensioned plan and elevation views of enclosed switches and adjacent equipment with all required clearances indicated.
   2. Include wiring diagrams showing all factory and field connections.

D. Field Quality Control Test Reports.

E. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

F. Project Record Documents: Record actual locations of enclosed switches.

G. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.

H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
   1. See Section 01 60 00 - Product Requirements, for additional provisions.
   2. See Section 26 28 13 - Fuses for requirements for spare fuses and spare fuse cabinets.

1.05 QUALITY ASSURANCE

A. Comply with the National Electrical Code.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in the National Electrical Code, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

D. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three (3) years documented experience.

E. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to enclosed switch internal components, enclosure, and finish.

1.07 FIELD CONDITIONS

A. Maintain ambient temperature between -22 degrees F and 104 degrees F during and after installation of enclosed switches.

B. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Architect/Engineer of Record and Owner's Representative no fewer than seven days in advance of proposed interruption of electrical service.
   2. Indicate method of providing temporary utilities.
   3. Do not proceed with interruption of electrical service without Architect/Engineer of Record and Owner's Representative's written permission.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. ABB/GE: www.geindustrial.com/#sle.

B. Eaton Corporation: www.eaton.com.

C. Schneider Electric; Square D Products: www.schneider-electric.us.

D. Siemens Industry, Inc: www.usa.siemens.com.

E. Boltswitch, Inc.: www.boltswitch.com.

F. Source Limitations: Furnish enclosed switches and associated components produced by a single manufacturer and obtained from a single supplier.

2.02 ENCLOSED SAFETY SWITCHES

A. Description: Quick-make, quick-break enclosed safety switches listed and labeled as complying with UL 98; heavy duty; ratings, configurations, and features as indicated on the drawings.

B. Provide products listed, classified, and labeled as suitable for the purpose intended.

C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
   1. Altitude: Less than 6,600 feet.
   2. Ambient Temperature: Between -22 degrees F and 104 degrees F.

D. Horsepower Rating: Suitable for connected load.

E. Voltage Rating: Suitable for circuit voltage.

F. Short Circuit Current Rating:
   1. Provide enclosed safety switches, when protected by the fuses or supply side overcurrent protective devices to be installed, with listed short circuit current rating not less than the available fault current at the installed location as determined by short circuit study performed in accordance with Section 26 05 73 - Power System Studies.
   2. Minimum Ratings:
      a. Switches Protected by Class H Fuses: 10,000 rms symmetrical amperes.
      b. General Duty Single Throw Switches Protected by Class R Fuses: 100,000 rms symmetrical amperes.
      c. Heavy Duty Single Throw Switches Protected by Class R or Class L Fuses: 200,000 rms symmetrical amperes.

d. Double Throw Switches Protected by Class R Fuses: 100,000 rms symmetrical amperes.

G. Enclosed Safety Switches Used for Service Entrance: Listed and labeled as suitable for use as service equipment according to UL 869A.

H. Provide with switch blade contact position that is visible when the cover is open.

I. Fuse Clips for Fusible Switches: As required to accept fuses indicated.
1. Where NEMA Class R fuses are installed, provide rejection feature to prevent installation of fuses other than Class R.

J. Conductor Terminations: Suitable for use with the conductors to be installed.

K. Provide insulated, groundable fully rated solid neutral assembly where a neutral connection is required, with a suitable lug for terminating each neutral conductor.

L. Provide solidly bonded equipment ground bus in each enclosed safety switch, with a suitable lug for terminating each equipment grounding conductor.

M. Enclosures: Comply with NEMA 250, and list and label as complying with UL 50 and UL 50E.
1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
a. Indoor Clean, Dry Locations: Type 1.
b. Outdoor Locations: Type 3R.
c. Kitchen Areas: Type 4X, stainless steel.
d. Other Wet or Damp Indoor Locations: Type 4.
2. Finish for Painted Steel Enclosures: Manufacturer's standard, factory applied grey unless otherwise indicated.

N. Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.

O. Heavy Duty Switches:
1. Comply with NEMA KS 1.
2. Conductor Terminations:
a. Provide mechanical lugs unless otherwise indicated.
b. Provide compression lugs where indicated.
c. Lug Material: Copper, suitable for terminating copper conductors only.
3. Provide externally operable handle with means for locking in the OFF position, capable of accepting three padlocks.
a. Provide means for locking handle in the ON position where indicated.

P. General Duty Switches:
1. Conductor Terminations:
a. Provide mechanical lugs.
b. Lug Material: Copper, suitable for terminating copper conductors only.
2. Provide externally operable handle with means for locking in the OFF position, capable of accepting two padlocks.

Q. Provide the following features and accessories where indicated or where required to complete installation:
1. Hubs: As required for environment type; sized to accept conduits to be installed.
2. Integral fuse pullers.

3. Auxiliary Switch: SPDT switch suitable for connection to system indicated, with auxiliary contact operation before switch blades open and after switch blades close.
4. Viewing Window: Positioned over switch blades for visual confirmation of contact position with door closed.
5. Interlocked Receptacle: Integral pre-wired three phase, three wire, grounded type receptacle interlocked with switch mechanism to prevent insertion or removal of plug with switch in the ON position and to prevent switch from being placed in the ON position without matching plug inserted. Provide receptacle configuration as required to accept plug as indicated on the drawings.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that the ratings of the enclosed switches are consistent with the indicated requirements.

C. Verify that mounting surfaces are ready to receive enclosed safety switches.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Perform work in accordance with NECA 1, NEMA PB 1.1, and NEMA PB 2.1.

C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and the National Electrical Code.

D. Provide required supports in accordance with Section 26 05 29 - Hangers and Supports for Electrical Systems.

E. Install enclosed switches plumb.

F. Except where indicated to be mounted adjacent to the equipment they supply, mount enclosed switches such that the highest position of the operating handle does not exceed 79 inches above the floor or working platform.

G. Provide grounding and bonding in accordance with Section 26 05 26 - Grounding and Bonding for Electrical Systems.

H. Provide fuses complying with Section 26 28 13 - Fuses for fusible switches as indicated or as required by equipment manufacturer's recommendations.

I. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.

J. Identify enclosed switches in accordance with Section 26 05 53 - Identification for Electrical Systems.

3.03 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Inspect and test in accordance with NETA ATS, except Section 4.

C. Perform inspections and tests listed in NETA ATS, Section 7.5.1.1.

D. Correct deficiencies and replace damaged or defective enclosed safety switches or associated components.

3.04 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.05 STARTUP AND REPORTING

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Prepare for acceptance testing as follows:
   1. Inspect mechanical and electrical connections.
   2. Verify switch and relay type and labeling verification.
   3. Verify rating of installed fuses.
   4. Inspect proper installation of type, size, quantity, and arrangement of mounting or anchorage devices complying with manufacturer's certification.

C. Perform the following field tests and inspections and prepare test reports:
   1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.06 CLEANING

A. Clean dirt and debris from switch enclosures and components according to manufacturer's instructions.

B. Repair scratched or marred exterior surfaces to match original factory finish.

3.07 CLOSEOUT ACTIVITIES

A. See Section 01 78 00 - Closeout Submittals, for closeout submittals.

B. Training: Arrange and pay for the services of factory-authorized service representative to demonstrate OCPDs and train Owner's maintenance personnel.

C. Conduct a minimum of one half (1/2) day of training in operation and maintenance as specified in Sections 01 77 00 - Closeout Procedures and 01 79 00 - Demonstration and Training. Include both classroom training and hands on equipment operation and maintenance procedures.

D. Schedule training with at least seven (7) days' advance notification.

END OF SECTION

SECTION 262913 - ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Enclosed NEMA controllers for low-voltage (600 V and less) applications:
   1. Magnetic motor starters.
   2. Manual motor starters.
   3. Motor-starting switches without overload protection.

B. Overcurrent protective devices for motor controllers, including overload relays.

C. Control accessories:
   1. Auxiliary contacts.
   2. Pilot devices.
   3. Control and timing relays.
   4. Control power transformers.
   5. Control terminal blocks.

1.02 REFERENCE STANDARDS

A. National Electrical Code.

B. IEEE C57.13 - IEEE Standard Requirements for Instrument Transformers; 2016.

C. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2015.

D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2014.

E. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts; 2000, with Errata (2008).

F. NEMA ICS 5 - Industrial Control and Systems: Control Circuit and Pilot Devices; 2017.

G. NEMA ICS 6 - Industrial Control and Systems: Enclosures; 1993 (Reaffirmed 2016).

H. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum); 2013.

I. NEMA MG 1 - Motors and Generators; 2017.

J. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.

K. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures; Current Edition, Including All Revisions.

L. UL 60947-1 - Low-Voltage Switchgear and Controlgear - Part 1: General Rules; Current Edition, Including All Revisions.

M. UL 60947-4-1 - Low-Voltage Switchgear and Controlgear - Part 4-1: Contactors and Motor-starters - Electromechanical Contactors and Motor-starters; Current Edition, Including All Revisions.

1.03 ADMINISTRATIVE REQUIREMENTS

A. Coordination:
   1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances required by the National Electrical Code.
   2. Coordinate the work to provide motor controllers and associated overload relays suitable for use with the actual motors to be installed.
   3. Coordinate the work to provide controllers and associated wiring suitable for interface with control devices to be installed.
   4. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
   5. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
   6. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated.
      a. Notify Architect/Engineer of Record and Owner's Representative not fewer than seven (7) working days in advance of proposed interruption of electrical service.
      b. Do not proceed with interruption of electrical service without Architect/Engineer of Record's and Owner's Representative written permission.
   7. Notify Architect/Engineer of Record of any conflicts with or deviations from the contract documents. Obtain direction before proceeding with work.

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide manufacturer's standard catalog pages and data sheets for motor controllers, enclosures, overcurrent protective devices, and other installed components and accessories.
   1. Include characteristic trip curves for each type and rating of overcurrent protective device.

C. Shop Drawings: Indicate dimensions, voltage, controller sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
   1. Include dimensioned plan and elevation views of enclosed controllers and adjacent equipment with all required clearances indicated.
   2. Include wiring diagrams showing all factory and field connections.
   3. Clearly indicate whether proposed short circuit current ratings are fully rated or, where acceptable, series rated systems.
   4. Include documentation of listed series ratings.
   5. Include documentation demonstrating selective coordination.

D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

E. Field Quality Control Test Reports.

F. Project Record Documents: Record actual installed locations of controllers and final equipment settings.
   1. Include nameplate data of actual installed motors and associated overload relay selections and settings.
   2. Motor Circuit Protectors: Include magnetic instantaneous trip settings.
   3. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around enclosed controllers where pipe and ducts are prohibited. Show enclosed controller layout and relationships between electrical

components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

4. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load current
5. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

G. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.

H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. See Section 01 60 00 - Product Requirements, for additional provisions.
2. Electronic Trip Circuit Breakers: Provide one (1) portable test set.
3. Indicating Lights: Two (2) of each different type.
4. See Section 26 28 13 - Fuses for requirements for spare fuses and spare fuse cabinets.

1.05 QUALITY ASSURANCE

A. Comply with the National Electrical Code.

B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience and that maintains within 50miles of project site a service center capable of providing training, parts, and emergency maintenance and repairs.

D. Installer Qualifications: Company with minimum five years documented experience of successful installation on projects utilizing motor controllers similar to that required for this project.

E. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in the National Electrical Code, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

G. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed controllers, minimum clearances between enclosed controllers, and for adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

B. Handle carefully in accordance with manufacturer's written instructions to avoid damage to internal components, enclosure, and finish.

1.07 FIELD CONDITIONS

A. Maintain field conditions within required service conditions during and after installation.

B. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Architect/Engineer of Record and Owner's Representative no fewer than seven days in advance of proposed interruption of electrical service.
   2. Indicate method of providing temporary utilities.
   3. Do not proceed with interruption of electrical service without Architect/Engineer of Record and Owner's Representative's written permission.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. ABB/GE: www.geindustrial.com/#sle.

B. Eaton Corporation: www.eaton.com.

C. Schneider Electric; Square D Products: www.schneider-electric.us.

D. Siemens Industry, Inc: www.usa.siemens.com.

E. Source Limitations: Furnish enclosed motor controllers and associated components produced by a single manufacturer and obtained from a single supplier.
   1. Motor-starting switches without overload protection may be produced by the same manufacturer as the wiring devices used for this project.

2.02 ENCLOSED CONTROLLERS

A. Provide enclosed controller assemblies consisting of all required components, control power transformers, instrumentation and control wiring, accessories, etc. as necessary for a complete operating system.

B. Provide products listed, classified, and labeled as suitable for the purpose intended.

C. Description: Enclosed controllers complying with NEMA ICS 2, and listed and labeled as complying with UL 60947-1 and UL 60947-4-1; ratings, configurations and features as indicated on the drawings.

D. Service Conditions:
   1. Provide controllers and associated components suitable for operation under the following service conditions without derating:
      a. Altitude:
         1) Class 1 Km Equipment (devices utilizing power semiconductors): Less than 3,300 feet.
         2) Class 2 Km Equipment (electromagnetic and manual devices): Less than 6,600 feet.
      b. Ambient Temperature: Between 32 degrees F and 104 degrees F.
   2. Provide controllers and associated components suitable for operation at indicated ratings under the service conditions at the installed location.

E. Starters shall be manual type for motors 1/3 HP and smaller and magnetic type motors 1/2 HP and larger.

F. Contracts shall open each underground connection to the motor.

G. Starter contact shall be twin-break, silver-to-silver, renewable contacts with one set of contacts for each phase.

H. Short Circuit Current Rating:
   1. Provide controllers with listed short circuit current rating not less than the available fault current at the installed location as determined by short circuit study performed in accordance with Section 26 05 73 - Power System Studies.
   2. Listed series ratings are acceptable, except where not permitted by motor contribution according to the National Electrical Code.
   3. Label equipment utilizing series ratings as required by the National Electrical Code.

I. Selectivity: Where the requirement for selectivity is indicated, furnish products as required to achieve selective coordination.

J. Conductor Terminations: Suitable for use with the conductors to be installed.

K. Enclosures:
   1. Comply with NEMA ICS 6.
   2. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
      a. Indoor Clean, Dry Locations: Type 1.
      b. Outdoor Locations: Type 3R.
      c. Kitchen Areas: Type 4X, stainless steel.
      d. Other Wet or Damp Locations: Type 4.
      e. Hazardous (Classified) Locations: Type 7C , as required for the classification of the installed location.
   3. Finish: Manufacturer's standard unless otherwise indicated.

L. Instrument Transformers:
   1. Comply with IEEE C57.13.
   2. Select suitable ratio, burden, and accuracy as required for connected devices.
   3. Current Transformers: Connect secondaries to shorting terminal blocks.
   4. Potential Transformers: Include primary and secondary fuses with disconnecting means.

M. Magnetic Motor Starters: Combination type unless otherwise indicated.
   1. Combination Magnetic Motor Starters: NEMA ICS 2, Class A combination motor controllers with magnetic contactor(s), externally operable disconnect and overload relay(s).
   2. Noncombination Magnetic Motor Starters: NEMA ICS 2, Class A noncombination motor controllers with magnetic contactor(s) and overload relay(s).
   3. Configuration: Full voltage, non-reversing unless otherwise indicated.
   4. Minimum Starter Size: NEMA Size 0.
   5. Use of non-standard starter sizes smaller than specified standard NEMA sizes is not permitted.
   6. Disconnects: Circuit breaker type.
      a. Circuit Breakers: Motor circuit protectors (magnetic-only) unless otherwise indicated or required. NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
      b. Provide externally operable handle with means for locking in the OFF position. Provide safety interlock to prevent opening the cover with the disconnect in the ON position with capability of overriding interlock for testing purposes.
      c. Provide auxiliary interlock for disconnection of external control power sources where applicable.
      d. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by an NRTL.
      e. Non-fusible Disconnecting Means: NEMA KS 1, heavy-duty, nonfusible switch.

7. Overload Relays: Bimetallic thermal type, melting alloy and solid state unless otherwise indicated.
    a. Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 20 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.
    b. Adjustable Overload Relay: Dip switch selectable for motor running overload protection with NEMA ICS 2, Class 20 tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Provide relay with Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
8. Pilot Devices Required:
    a. Furnish local pilot devices for each unit as specified below unless otherwise indicated on drawings.
    b. Single-Speed, Non-Reversing Starters:
        1) Pushbuttons: START-STOP.
        2) Selector Switches: HAND/OFF/AUTO.
        3) Indicating Lights: Green ON, Red OFF.
    c. Single-Speed, Reversing Starters:
        1) Pushbuttons: FOR-REV-STOP.
        2) Selector Switches: FOR/OFF/REV.
        3) Indicating Lights: Green FOR, Green REV, Red OFF.
    d. Two-Speed Starters:
        1) Pushbuttons: FAST-OFF-SLOW.
        2) Selector Switches: SLOW/OFF/FAST.
        3) Indicating Lights: Green FAST, Red OFF, Amber SLOW.
9. 120 V; obtained from integral control power transformer with a control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

N. Manual Motor Starters:
1. Description: NEMA ICS 2, Class A manually-operated motor controllers with overload relay(s) and "quick-make, quick breaker" toggle action.
2. Configuration: Non-reversing unless otherwise indicated.
3. Marked to show whether unit is "OFF", "ON", or "TRIPPED".
4. Where the motor is interlocked and controlled by another device, the motor starter shall be marked “Hand-Off-Auto”.
5. Fractional-Horsepower Manual Motor Starters:
    a. Furnish with toggle operator.
    b. Overload Relays: Bimetallic or melting alloy thermal type with heater rating clearly indicated.
    c. Provide means for locking operator in the OFF position.
    d. Single pole for 120 Volt, two pole for 208 Volt operation.
    e. Trip-free toggle operated with on-off-reset position clearly indicated with neon pilot light for run indication.
    f. Ambient-compensated type with inverse-time-current characteristics and NEMA ICS 2, Class 20 tripping characteristics. Provide one overload for single pole switch and two overloads for two pole switch. Sensor shall match to nameplate, full-load current of specific motor to which they connect and shall have appropriate adjustment for duty cycle.
6. Integral-Horsepower Manual Motor Starters:
    a. Furnish with toggle or pushbutton operator.
    b. Overload Relays: Bimetallic or melting alloy thermal type.
    c. Provide means for locking operator in the OFF position.

d. Provide auxiliary contact where indicated; normally open (NO) or normally closed (NC) as indicated or as required.

O. Motor-Starting Switches: Horsepower-rated switches without overload protection; toggle operator.

P. Reduced-Voltage Enclosed Controller: Solid-State, Reduced-Voltage Controller: NEMA ICS 2, suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.
1. Adjustable acceleration rate control utilizing voltage or current ramp, and adjustable starting torque control with up to 500 percent current limitation for 20 seconds.
2. Surge suppressor in solid-state power circuits providing 3-phase protection against damage from supply voltage surges ten (10) percent or more above nominal line voltage.
3. LED indicators showing motor and control status, including the following conditions:
   a. Control power available.
   b. Controller on.
   c. Overload trip.
   d. Loss of phase.
   e. Shorted silicon-controlled rectifier.
4. Automatic voltage-reduction controls to reduce voltage when motor is running at light load.
5. Motor running contactor operating automatically when full voltage is applied to motor.
6. Shorting contactor:
   a. A microprocessor shall control the operation of the shorting contactor via an output relay.
   b. The shorting contractor shall close, shorting the thyristors after the motor current is below 130% of motor FLA and voltage is below nominal voltage (indicating ramp complete), and open on a stop command to allow deceleration ramp.
7. Motor must be automatically protected from solid state component failure by one of the following means:
   a. Shunt trip coil to trip disconnect in the event of a controller fault condition including a shorted thyristor.
   b. Isolation contactor that opens when the motor is stopped or when the controller detects a fault condition including a shorted thyristor.

2.03 OVERCURRENT PROTECTIVE DEVICES

A. Overload Relays:
1. Provide overload relays and, where applicable, associated current elements/heaters, selected according to actual installed motor nameplate data, in accordance with manufacturer's recommendations and the National Electrical Code; include consideration for motor service factor and ambient temperature correction, where applicable.
2. Inverse-Time Trip Class Rating: Class 20 unless otherwise indicated or required.
3. Trip-free operation.
4. Visible trip indication.
5. Resettable.
   a. Employ manual reset unless otherwise indicated.
   b. Do not employ automatic reset with two-wire control.
6. Bimetallic Thermal Overload Relays:
   a. Interchangeable current elements/heaters.
   b. Adjustable trip; plus/minus 10 percent of nominal, minimum.
   c. Trip test function.
   d. Provide isolated alarm contact where indicated.
7. Melting Alloy Thermal Overload Relays:
   a. Interchangeable current elements/heaters.
   b. Provide isolated alarm contact where indicated.
8. Solid-State Overload Relays:
   a. Selectable inverse-time trip class rating; available ratings of Class 10, 20, and 30, minimum.

b. Adjustable full load current.
c. Phase loss protection.
d. Phase imbalance protection.
e. Ground fault protection.
f. Ambient temperature insensitive.
g. Thermal memory.
h. Repeat Trip Accuracy: Plus/minus 2 percent, minimum.
i. Trip test function.
j. Provide isolated alarm contact.
k. Provide communication capability where indicated: Compatible with system indicated.

B. Circuit Breakers:
1. Interrupting Capacity (not applicable to motor circuit protectors):
a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than specified minimum requirements.
b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
2. Motor Circuit Protectors:
a. Description: Instantaneous-trip circuit breakers furnished with magnetic instantaneous tripping elements for short circuit protection, but not with thermal inverse time tripping elements for overload protection; UL 489 recognized only for use as part of a listed combination motor controller with overload protection; ratings, configurations, and features as indicated on the drawings.
b. Provide field-adjustable magnetic instantaneous trip setting.
c. Provide the following features and accessories where indicated or where required to complete installation:
1) Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.
2) Pad-Lock Provision: For locking circuit breaker handle in OFF position.
3) Auxiliary Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped or been turned off.
4) Undervoltage Release: For tripping circuit breaker upon predetermined drop in coil voltage with field-adjustable time delay to prevent nuisance tripping.
5) Alarm Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped.
3. Molded Case Circuit Breakers:
a. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers; listed and labeled as complying with UL 489; ratings, configurations, and features as indicated on the drawings.
1) Provide thermal magnetic circuit breakers unless otherwise indicated.
2) Provide electronic trip circuit breakers where indicated.
b. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
1) Provide field-adjustable magnetic instantaneous trip setting for circuit breaker frame sizes 225 amperes and larger.
2) Provide interchangeable trip units where indicated.
c. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
1) Provide the following field-adjustable trip response settings:
a) Long time pickup, adjustable by replacing interchangeable trip unit or by setting dial.
b) Long time delay.
c) Short time pickup and delay.

d) Instantaneous pickup.
e) Ground fault pickup and delay where ground fault protection is indicated.

d. Provide the following features and accessories where indicated or where required to complete installation:
1) Shunt Trip: Provide coil voltage as required for connection to indicated trip actuator.
2) Pad-Lock Provision: For locking circuit breaker handle in OFF position.
3) Auxiliary Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped or been turned off.
4) Undervoltage Release: For tripping circuit breaker upon predetermined drop in coil voltage with field-adjustable time delay to prevent nuisance tripping.
5) Alarm Switch: SPDT switch suitable for connection to system indicated for indicating when circuit breaker has tripped.

2.04 CONTROL ACCESSORIES

A. Auxiliary Contacts:
1. Comply with NEMA ICS 5.
2. Provide number and type of contacts indicated or required to perform necessary functions, including holding (seal-in) circuit and interlocking, plus one normally open (NO) and one normally closed (NC) spare contact for each magnetic motor starter, minimum.

B. Pilot Devices:
1. Comply with NEMA ICS 5; heavy-duty type.
2. Nominal Size: 30 mm.
3. Pushbuttons: Unless otherwise indicated, provide momentary, non-illuminated type with flush button operator; normally open or normally closed as indicated or as required.
4. Selector Switches: Unless otherwise indicated, provide maintained, non-illuminated type with knob operator; number of switch positions as indicated or as required.
5. Indicating Lights: Push-to-test type unless otherwise indicated.
6. Provide LED lamp source for indicating lights and illuminated devices.

C. Control and Timing Relays:
1. Comply with NEMA ICS 5.
2. Provide number and type of relays indicated or required to perform necessary functions.
3. Timing Relays: Electronic.
a. Adjustable Timing Range: As required for application.
4. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable undervoltage setting.

D. Control Power Transformers:
1. Size to accommodate burden of contactor coil(s) and all connected auxiliary devices, plus 25 percent spare capacity.
2. Include primary and secondary fuses.

E. Control Terminal Blocks: Include 25 percent spare terminals.

F. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

G. Elapsed Time Meters: Heavy duty with digital readout in hours.

H. Use fractional-horsepower manual controllers for single-phase motors, unless otherwise indicated.

I. Push-Button Stations: In covers of magnetic controllers for manually started motors where indicated, start contact connected in parallel with sealing auxiliary contact for low-voltage protection.

J. Hand-Off-Automatic Selector Switches: In covers of manual and magnetic controllers of motors started and stopped by automatic controls or interlocks with other equipment.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that ratings of enclosed controllers are consistent with the indicated requirements.

C. Verify that mounting surfaces are ready to receive enclosed controllers.

D. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Install controllers in accordance with NECA 1 (general workmanship).

C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and the National Electrical Code.

D. Provide required support and attachment components in accordance with Section 26 05 29 - Hangers and Supports for Electrical Systems.
   1. Install freestanding equipment on concrete bases. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

E. Install enclosed controllers plumb and level.

F. Provide grounding and bonding in accordance with Section 26 05 26 - Grounding and Bonding for Electrical Systems.

G. Install all field-installed devices, components, and accessories.

H. Where accessories are not self-powered, provide control power source as indicated or as required to complete installation.

I. Set field-adjustable controllers and associated components according to installed motor requirements, in accordance with manufacturer's recommendations and the National Electrical Code.

J. Set field-adjustable circuit breaker tripping function settings as determined by overcurrent protective device coordination study performed in accordance with Section 26 05 73 - Power System Studies.

K. Identify enclosed controllers in accordance with Section 26 05 53 - Identification for Electrical Systems.

L. Install wiring between enclosed controlled according to Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables. Buckle, train, and support wiring in enclosures.

M. Connect hand-off-automatic switch and other automatic-control devices where applicable.

1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
2. Connect selector switches with enclosed controller circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.03 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Inspect and test in accordance with NETA ATS, except Section 4.

C. Motor Starters: Perform inspections and tests listed in NETA ATS, Section 7.16.1.1. Tests listed as optional are not required, except for the following:
1. Verify motor-running protection.
2. Perform insulation-resistance tests on all control wiring with respect to ground.

D. Molded Case Circuit Breakers: Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for circuit breakers larger than 100 amperes. Tests listed as optional are not required, except for the following:
1. Perform insulation-resistance tests on all control wiring with respect to ground.
2. Test functions of the trip unit by means of secondary injection.

E. Correct deficiencies and replace damaged or defective enclosed controllers or associated components.

F. Submit detailed reports indicating inspection and testing results and corrective actions taken.

3.04 ADJUSTING

A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.

3.05 STARTUP AND REPORTING

A. Comply with NETA ATS Article 7.16.

B. Prepare for acceptance tests as follows:
1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
1. Assist in field testing of equipment including pretesting and adjusting of solid-state controllers.
2. Report results in writing.

D. Pretesting: On completing installation of the system, perform the following preparations for tests:
1. Make insulation resistance tests of conducting parts of motor control components; and of connecting supply, feeder, and control circuits. For devices containing solid-state components, use test equipment and methods recommended by the manufacturer.
2. Make continuity tests of circuits.
3. Provide set of Contract Documents to test personnel. Include full updating on final system configuration and parameters where they supplement or differ from those indicated in original Contract Documents.

4. Provide manufacturer’s instructions for installation and testing of motor control devices to test personnel.

E. Visual and mechanical inspection: Include the following inspections and related work:
1. Motor-Control Device Ratings and Settings: Verify that ratings and settings as installed are appropriate for final loads and final arrangement and parameters. Recommend final protective-device ratings and settings where differences are found. Use accepted revised ratings or settings to make the final system adjustments. Prepare and submit load current and overload relay heater list.
2. Inspect for defects and physical damage, NRTL labeling, and nameplate compliance with current project drawings.
3. Exercise and perform operational tests of mechanical components and other devices in accordance with manufacturer’s instructions.
4. Check tightness of electrical connections of devices with calibrated torque wrench. Use manufacturer’s recommended torque values.
5. Clean devices using manufacturer’s approved methods and materials.
6. Verify proper fuse types and ratings in fusible devices.

F. Electrical Tests: Perform the following in accordance with manufacturer’s instructions:
1. Insulation resistance test of motor control devices conducting parts to the extent permitted by the manufacturer’s instructions. Insulation resistance less than 10 megohms is not acceptable.
2. Use primary current injection to check performance characteristics of motor-circuit protectors and for overload relays of controllers for motors 15 horsepower and larger. Trip characteristics not within manufacturer’s published time-current tolerances are not acceptable.
3. Make adjustments for final settings of adjustable-trip devices.
4. Test auxiliary protective features such as loss of phase, phase unbalance and undervoltage to verify operation.
5. Check for improper voltages at terminals in controllers that have external control wiring when controller disconnect is opened.

G. Correct deficiencies and retest motor control devices. Verify by the system tests that specified requirements are met.

H. Set field-adjustable switches and circuit-breaker trip ranges.

3.06 CLEANING

A. Clean dirt and debris from controller enclosures and components according to manufacturer's instructions.

B. Repair scratched or marred exterior surfaces to match original factory finish.

3.07 CLOSEOUT ACTIVITIES

A. See Section 01 78 00 - Closeout Submittals, for closeout submittals.

B. Demonstration: Demonstrate proper operation of controllers to Owner, and correct deficiencies or make adjustments as directed.

C. Training: Train Owner's personnel on operation, adjustment, and maintenance of enclosed controllers and associated devices.
1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
2. Provide minimum of four (4) hours of training.
3. Instructor: Manufacturer's authorized representative.

4. Location: At project site.
5. Schedule training with at least seven (7) days advance notice.

3.08 PROTECTION

A. Protect installed enclosed controllers from subsequent construction operations.

END OF SECTION

SECTION 262923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Variable frequency controllers (VFC).

1.02 REFERENCE STANDARDS

A. ASTM C1107/C1107M - Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink); 2014a.

B. IEEE 519 - IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems; 2014.

C. NEMA ICS 2 - Industrial Control and Systems Controllers, Contactors and Overload Relays Rated 600 Volts; 2000, with Errata (2008).

D. NEMA ICS 7.1 - Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable-Speed Drive Systems; 2014.

E. NEMA ICS 7 - Industrial Control and Systems: Adjustable-Speed Drives; 2014.

F. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2014.

G. NEMA MG 1 - Motors and Generators; 2017.

H. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.

I. NFPA 70 - National Electrical Code; 2017.

1.03 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.

C. Shop Drawings:
   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. Include the following:
      a. Each installed unit's type and details.
      b. Nameplate legends.
      c. Short-circuit current rating of integrated unit.
      d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.
   2. Wiring Diagrams: Power, signal, and control wiring for VFCs. Provide schematic wiring diagram for each type of VFC.

D. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs where pipe and ducts are prohibited. Show VFC

layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

E. Qualification Data: For manufacturer and testing agency.

F. Field Quality-Control Test Reports: Submit reports documenting the activities performed. These reports are to be submitted two weeks after startup is completed.

G. Training Reports: Submit reports on training documenting dates and attendance.

H. Operation Data: NEMA ICS 7.1. Include instructions for starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.

I. Maintenance Data: NEMA ICS 7.1. Include routine preventive maintenance schedule.

1.04 QUALITY ASSURANCE

A. Conform to requirements of NFPA 70.

B. Manufacturer Qualifications: Award the work to a single firm that specializes in the production of variable frequency drives, with not less than 5 years experience in the production of variable frequency drives similar in design and performance to those required for the Project, and whose work has resulted in a history of successful in-service performance. The manufacturer shall have sufficient production capacity, and have organized quality control and testing procedures, to be capable of producing the equipment required for the Project without causing a delay in the Work. The manufacturer shall maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

C. Products: Listed, classified, and labeled as suitable for the purpose intended.

D. 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 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.

E. Source Limitations: Obtain all VFCs required for the Project through one source from a single manufacturer.

F. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

G. Regulatory Requirements: Comply with the National Electrical Code, including requirements for components and installation.

H. Comply with IEEE 519-1992, "Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems."

1.05 COORDINATION

A. Coordinate layout and installation of VFDs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances, including clearances required for maintenance, and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Deliver setting templates in time to allow casting of anchor-bolt inserts into bases.

C. Coordinate features of VFDs, installed units, and accessory devices with pilot devices and control circuits to which they connect.

D. Coordinate features, accessories, and functions of each VFD and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.06 COORDINATION WITH ENERGY MANAGEMENT SYSTEM

A. General: The equipment specified in this Section is required to be interfaced with the Energy Management System (EMS) as specified in Division 23 Section "Building Automation System." Provide all devices, hardware, programming, startup and commissioning required to establish the interface.

B. Coordinate with EMS supplier for their review and acceptance of the communications interface to be provided. Include evidence of the coordination and review process with the required submittals for this Section.

C. Provide a list of all read/write and read-only points available through the user interface. Provide software, hardware or paperwork that the contractor installing the EMS will require in order to accomplish the interface.

D. The equipment supplier is solely responsible for the proper performance of their equipment provided the correct information is provided through the communications interface.

E. Provide a pre-functional checklist, startup checklist and demonstration report to the Engineer, Commissioning Agent, or Owner’s Authorized Representative for acceptance of system.

F. Provide a startup technician on-site during the establishment of the interface. Coordinate this activity with the EMS installer.

G. BACNet compliant manufacturer-provided controls
   1. Provide any information necessary to allow the BACNet compliant device to be directly connected to the existing network, and send/receive information to the system installed under Division 23 sections.
   2. The EMS shall then read and present the information made available by the equipment manufacturer, and transmit information receivable by the equipment manufacturer. This shall be accomplished by user configuration of point information, but shall not require recompiling or downloading of control programs.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store VFCs in manufacturer's original protective packaging, with original labels detailing contents intact. Store VFCs indoors, off of ground, under cover, in clean, dry location with uniform temperature and humidity to prevent condensation. Protect VFCs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to components, enclosure, and finish.

1.08 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components or equipment that fail in materials or workmanship within the specified warranty period. Manufacturer's warranty shall include parts, labor, travel costs, and living expenses incurred by the manufacturer in providing on-site service and repair or replacement.
   1. Warranty Period: Three years from the date of Preliminary Acceptance.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Design - Environmental: Equipment shall be rated for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:
   1. Temperature Range, Ambient: 32 deg F to 105 deg F.
   2. Relative Humidity: Less than 90 percent (noncondensing).
   3. Altitude: Not exceeding 3300 feet.
   4. Conditions: Winter: -10 deg F DB; Summer: 95 deg F DB / 75 deg F WB.

B. Noise: The VFC shall not produce motor noise in excess of the manufacturers published noise standards for 60 Hz operation.

2.02 MANUFACTURERS

A. Variable Frequency Motor Controllers:
   1. ABB Power
   2. Danfoss
   3. Rockwell Automation, Inc.; Allen-Bradley Products
   4. Siemens Industry, Inc
   5. Toshiba International Corp.
   6. Yaskawa

2.03 DESCRIPTION

A. Variable Frequency Controllers: Enclosed controllers suitable for operating the indicated loads, in conformance with requirements of NEMA ICS 7. Select unspecified features and options in accordance with NEMA ICS 3.1.
   1. Provide unit suitable for operation of premium-efficiency motor as defined by NEMA MG 1.

B. Enclosures: NEMA 250, Type 1, suitable for equipment application in places restricted to persons employed on the premises.

C. All PWM AC Variable Frequency Drives of 40 hp and above shall be equipped with harmonic mitigation equipment to prevent power system problems resulting from high levels of reflected harmonic distortion. Provide harmonic mitigation for drives less than 40 hp where required to meet IEEE 519.
   1. The harmonic mitigation equipment shall treat all of the characteristic low frequency harmonics generated by a 3-phase, diode bridge rectifier load (5th, 7th, 11th, 13th, etc.).
   2. The characteristic harmonics shall be suppressed without the need for individual tuning or the requirement to phase shift against other harmonic sources.

3. Harmonic mitigation shall be by passive inductor/capacitor network or internal phase shifting transformer. Active electronic components shall not be used.
4. Power factor shall be 0.98 lagging to 0.95 leading in operating range from full to half load.
5. To ensure compatibility with engine generators, the harmonic mitigation equipment must never introduce a capacitive reactive power (KVAR) that is greater than 15% of its kVA rating.
6. The harmonic mitigation equipment shall not resonate with system impedances or attract harmonic currents from other harmonic sources.
7. The harmonic mitigation equipment in combination with the Variable Frequency Drive shall meet all requirements of IEEE 519 for individual and total harmonic voltage and current distortion. The Point of Common Coupling (PCC) for all voltage and current harmonic calculations and measurements shall be the input terminals to the harmonic mitigation equipment.
8. Total Harmonic Voltage Distortion (THVD) shall meet the requirements of Table 10.2 of IEEE 519 by not exceeding 5% and by limiting the individual harmonic voltage distortion to less than 3%. These limits shall apply while operating on either utility supply or generator supply when applicable. The harmonic mitigation equipment vendor shall not be responsible for pre-existing voltage distortion caused by other harmonic sources.
9. Total Demand Distortion (TDD) of the current at the input terminals of the harmonic mitigation equipment shall not exceed the limits as defined in Table 10.3 of IEEE 519 . For Isc/Il ratio < 20, TDD must be less than 5%. For all other Isc/Il ratios, the TDD must not exceed 8% even when Table 10.3 allows for more relaxed limits. For single-phase applications, the TDD must not exceed 12%.
10. The full load efficiency of the harmonic mitigation equipment / VFD combination shall be greater than 96%. The harmonic mitigation equipment itself shall have efficiency no less than 99%.

D. Design and Rating: Match load type such as fans, blowers, and pumps, and type of connection used between motor and load, such as direct or through a power-transmission connection.

2.04 OPERATING REQUIREMENTS

A. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.

B. Input ac voltage ranges of 208 V, plus or minus 10 percent or 480 V, plus or minus 10 percent as indicated on equipment schedules.

C. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.

D. Minimum Efficiency: 96 percent at 60 Hz, full load.

E. Minimum Displacement Primary-Side Power Factor: 96 percent.

F. Overload Capability: 1.2 times the base load current for 60 seconds; 1.8 times the base load current for 3 seconds.

G. Starting Torque: 100 percent of rated torque or as indicated.

H. Speed Regulation: Plus or minus 1 percent.

2.05 COMPONENTS AND FEATURES

A. Isolated Control Interface: To allow controller to follow control signal over an 11:1 speed range.
1. Electrical Signal: 4 to 20 mA at 24 V.

B. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.

2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 2 to a minimum of 22 seconds.
4. Deceleration: 2 to a minimum of 22 seconds.
5. Current Limit: 50 to a minimum of 110 percent of maximum rating.

C. Self-Protection and Reliability Features:
1. Input transient protection by means of surge suppressors.
2. Under- and overvoltage trips; inverter over-temperature, overload, and overcurrent trips.
3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class 10 performance.
4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
5. Instantaneous line-to-line and line-to-ground overcurrent trips.
6. Loss-of-phase protection.
7. Reverse-phase protection.
8. Short-circuit protection.
9. Motor over temperature fault where motor is equipped with RTD.

D. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.

E. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

F. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.

G. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

H. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

I. Input Line Conditioning: dc bus link reactors, isolation transformers, active and passive harmonic filters, and phase shifting transformers.

J. VFD Output Filtering: Line inductors, output limit filters, sine wave filters, and motor termination filters shall be provided where the motor to drive conductor lengths exceed manufacturer's recommended lengths.

K. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

L. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

M. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
   1. Output frequency (Hz).
   2. Motor speed (rpm).
   3. Motor status (running, stop, fault).
   4. Motor current (amperes).
   5. Motor torque (percent).
   6. Fault or alarming status (code).
   7. PID feedback signal (percent).
   8. DC-link voltage (VDC).
   9. Set-point frequency (Hz).
   10. Motor output voltage (V).

N. Control Signal Interface:
   1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
   2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the EMS or other control systems:
      a. 0 to 10-V dc.
      b. 0-20 or 4-20 mA.
      c. Potentiometer using up/down digital inputs.
      d. Fixed frequencies using digital inputs.
      e. RS485.
      f. Keypad display for local hand operation.
   3. Output Signal Interface:
      a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
         1) Output frequency (Hz).
         2) Output current (load).
         3) DC-link voltage (VDC).
         4) Motor torque (percent).
         5) Motor speed (rpm).
         6) Set-point frequency (Hz).
   4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
      a. Motor running.
      b. Set-point speed reached.
      c. Fault and warning indication (overtemperature or overcurrent).
      d. PID high- or low-speed limits reached.

O. Communications: Provide an RS485 interface allowing VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via EMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.

P. Integral Disconnecting Means: NEMA AB 1, molded-case switch with lockable handle.

Q. Operation and Maintenance Features:
   1. Current-Voltage-Frequency Indicating Devices: Mount meters or digital readout device and selector switch flush in controller door and connect to indicate controller output.
   2. Manual Bypass: Magnetic contactor arranged to safely transfer the motor from the controller to the power line, or from the line to the controller while the motor is at zero speed. Include VFC-bypass selector switch and indicator lights to indicate mode selection. The operator shall have full control of the bypass starter by operation of the selector switch.

3. Integral Main Disconnect: Circuit breaker connected to shut down all power to both the controller and the bypass. Interlock breaker with cabinet door.
4. Auxiliary Motor Contactors: Electrically interlocked. One contactor connected between the controller output and the motor, controlled by the controller regulator; and one between the bypass power line and the motor, providing across-the-line starting capability in the bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either mode.
5. Isolating Circuit Breaker: Arranged to electrically isolate the variable-speed controller to permit safe trouble-shooting and testing of the controller, both energized and de-energized, while the motor is operating in the bypass mode.
6. Form C output contacts for run and fault conditions.
7. Terminal strip for N.C. safety shutdown contacts.
8. N.C. input for remote start/stop control in Auto mode.

R. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

S. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

T. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

U. Standard Displayed information, display shall be interchangeable for all VFDs installed:
1. Output frequency (Hz).
2. Set-point frequency (Hz).
3. Motor current (amperes).
4. DC-link voltage (VDC).
5. Motor torque (percent).
6. Motor speed (rpm).
7. Motor output voltage (V).
8. Fault history with analytical data.

V. Historical Logging Information and Displays:
1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

W. Non shrink, Nonmetallic Grout: Factory-packaged, non-staining, noncorrosive, nongaseous grout complying with ASTM C1107/C1107M.

2.06 FINISH

A. Finish: Manufacturer's standard paint finish, applied to factory-assembled and -tested VFCs.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that surface is suitable for controller installation.

B. Do not install controller until building environment can be maintained within the service conditions required by the manufacturer.

C. Examine areas, surfaces, and substrates to receive VFDs for compliance with requirements, installation tolerances, and other conditions affecting performance.

D. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

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

3.02 PREPARATION

A. Harmonic Analysis: Obtain the electrical system one-line diagram from the contract document, provide a harmonic analysis demonstrating that the proposed VFDs (along with harmonic mitigation equipment provided) conform with IEEE 519.

3.03 SELECTION

A. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFDs, minimum clearances between VFDs, and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

B. Select features of each VFD to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.

C. Select horsepower rating of controllers to suit motor controlled.

3.04 INSTALLATION

A. Install in accordance with NEMA ICS 7.1 and manufacturer's instructions.

B. Tighten accessible connections and mechanical fasteners after placing controller.

C. Anchor each VFD assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface.

D. Install VFDs on concrete bases where indicated to be installed on the floor. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

E. VFD's are not to be installed inside air handlers or air plenums due to the potentially high humidity or temperatures.

F. Install wiring between VFCs and remote devices according to Division 26 sections. Power and control wiring shall not be run in the same conduit and shall follow manufacturer's recommendations.

G. Bundle, train, and support wiring in enclosures.

H. Connect hand-off-automatic switch and other automatic-control devices where applicable.
   1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
   2. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

I. Install conduit and ground equipment in accordance with Division 26 sections.

3.05 ADJUSTING

A. Make final adjustments to installed controller to assure proper operation of load system. Obtain performance requirements from installer of driven loads.

B. Set field-adjustable switches and circuit-breaker trip ranges.

3.06 CONTRACTOR STARTUP AND REPORTING

A. Prepare for acceptance tests as follows:
   1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

B. Reports: Prepare written reports certified by testing organization of tests and observations. Report defective materials and workmanship and unsatisfactory test results. Include records of repairs and adjustments made. Harmonic compliance shall be verified with on-site field measurements of both the voltage and current harmonic distortion at the input terminals of the harmonic mitigating equipment with and without the equipment operating. A recording type Fluke 41 or equivalent harmonics analyzer displaying individual and total harmonic currents and voltages must be utilized.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
   1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
   2. Assist in field testing of equipment including pretesting and adjusting of solid-state controllers.
   3. Prepare written reports.

D. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
   1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS. Certify compliance with test parameters.
   2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.07 DEMONSTRATION AND COMMISSIONING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air handling units.
   1. Train Owner's maintenance personnel on procedures and schedules for starting up and shutting down, troubleshooting, servicing, and maintaining the equipment. The training will occur after the startup report has been provided to the Owner and the trainer will provide two (2) Installation and Operations manuals for the use of the Owner's personnel during training.
   2. Review data in maintenance manuals. Refer to Section 01 78 00 - Closeout Submittals. All required and recommended maintenance will be reviewed as well as operational troubleshooting. If the IOM does not include a written troubleshooting guide one shall be provided.
   3. Schedule training with Owner, through Architect/Engineer of Record, with at least seven days' advance notice.

B. Demonstrate proper operation of equipment to commissioning agent or Owner's designated personnel. The scope of the demonstration will include functional performance requirements under both local and building automation control as well as any commissioning requirements in Divisions 01 and 23 sections.

END OF SECTION

SECTION 264113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1- GENERAL REQUIREMENTS

1.1 WORK INCLUDES

A. Base Bid:
1. Electrical Contractor:
a. The Contractor shall provide all material and labor for the installation of a complete Lightning Protection System for all of the building(s) included in this project. This specification addresses the requirements of Lightning Protection Systems for buildings only.
b. Special consideration:
1) If this contract includes the construction of a building or buildings that are physically connected to an existing building or are additions to existing structures, then the Lightning Protection System(s) for the new construction shall comply with the standards stated above. The delivery of the L.P.I. Certification and the Underwriters' Laboratories Master Label shall not be required. In place of this certification or label the procedures of each program shall be followed to deliver partial or qualified certification outlined by either organization.

1.2 RELATED WORK

A. Specified elsewhere:
1. Section 26 05 26 "Grounding and Bonding."

1.3 REFERENCES

A. LPI: Lightning Protection Institute.

B. NRTL: National recognized testing laboratory.

1.4 SUBMITTALS

A. Product Data: For air terminals and mounting accessories.

B. Shop Drawings: Detail lightning protection system layout and details, including air-terminal locations, conductor routing and connections, and bonding and grounding provisions. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.

C. Catalog Data with complete description of material components

D. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include data on listing or certification by an NRTL or LPI.

E. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply membrane roofing material.

F. Field inspection reports indicating compliance with specified requirements.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who is an NRTL or who is certified by LPI as a Master Installer/Designer.

B. Compliance Requirements:
1. System Design: NFPA 780, latest edition.
2. Component Design: UL 96 Standard, latest edition, L.P.I. 175.
3. Certification: Lightning Protection Institute Certified System and Underwriters' Laboratories 96A Master Label, Lightning Protection Institute certification

1.6 COORDINATION

A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

B. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Harger Lightning Protection, Inc (IL).
2. Automatic Lightning Protection.
3. ERICO International Corporation.
4. Heary Bros. Lightning Protection Co. Inc.
5. Independent Protection Co.
6. Robbins Lightning Inc.
7. Thompson Lightning Protection, Inc.

2.2 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. Comply with UL 96.

B. System to be designed and installed by a L.P.I. Certified Master Installer/Designer in good standing with the Lightning Protection Institute.

C. System to consist of groundings, down conductors, air terminals, interconnecting conductors and bonding, designed to appear as a part of the building.

D. Design to be complete per current NFPA 780 requirements.
   1. Class II Aluminum materials required.
   2. Class II Copper materials required.
   3. Aluminum Lightning Protection materials not to be embedded in concrete or masonry or installed on or below copper surfaces.
   4. Copper Lightning Protection materials not to be installed on aluminum surfaces.
   5. Grounding shall be suitable for the soil conditions per NFPA 780, this may include:
      a. Ground loop only (full size cable) 2/0 buried 18 in. deep.
      b. Ground loop combined with ¾ x 10 ft. rods buried 18 in. deep.
   6. Strike termination devices (air terminals) required as follows, unless the area in question is located under a zone of protection.
      a. Minimum 10 in. projection above the object projected.
      b. Maximum 20 ft. spacing on roof ridges or edges.
      c. Maximum 24 in. distance from ridge ends or roof edges & outside corners.
      d. Penthouses, Protrusions and Mechanical roof top equipment, same guidelines.
      e. Strike termination devices required on eaves of sloping roofs, when the eave is over 50 ft. in height.
      f. Mid-roof areas are to be provided with Strike termination devices at either 50 ft. spacing or provided with Strike termination devices of sufficient quantity & height, to ensure the entire roof area is covered by a “zone of protection” as afforded by a 150 ft. radius sphere (per NFPA 780).
      g. Strike termination safety devices to be provided in mid-roof areas and high traffic areas. Material to be the same as, or an alloy of, the point and base and to be one of the following:
         1) Safety tipped point
   7. Bonding is required in strict accordance with NFPA 780
      a. Ground level potential equalization; below the 12 ft. elevation of the structure all grounded media to be interconnected.
      b. Ground loop required for structures 60 ft. in height.
      c. Lightning surge suppressors to be provided on electrical and communication service entrances and on communication antenna lead-ins

E. Roof-Mounting Air Terminals: NFPA Class I copper, solid, unless otherwise indicated.

   1. Single-Membrane, Roof-Mounting Air Terminals: Designed for single-membrane roof materials.

F. Stack-Mounting Air Terminals: Solid copper.

G. Ground Rods, Ground Loop Conductors, and Concrete-Encased Electrodes: Comply with Division 26 Section "Grounding and Bonding for Electrical Systems" and with standards referenced in this Section.

H. Cable straps and supports: Cable straps shall be aluminum single-hole or two-hole with screws or fasteners. Cable holders for use with hot pitch roofing compound or commercial adhesive on built-up roof where holes for anchoring cable strap/holders are not allowed.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install lightning protection components and systems according to UL 96A and NFPA 780.

B. L.P.I. Certified Master Installer required with a minimum of five (5) years experience.

C. Complete per requirements of NFPA 780.

D. Neat and inconspicuous manner.

E. All mounting & penetration of roof surface shall be coordinated with roofing contractor to assure maximum roofing guarantee.

F. All through-roof penetration flashings to be furnished, sealed and guaranteed by the roofing contractor.

G. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops.

H. Conceal the following conductors:

1. System conductors.
2. Down conductors.
3. Interior conductors.
4. Conductors within normal view from exterior locations at grade within 200 feet of building.
5. Notify Architect at least 48 hours in advance of inspection before concealing lightning protection components.

I. Cable Connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components, except those above single-ply membrane roofing.

J. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's written instructions.

K. Bond extremities of vertical metal bodies exceeding 60 feet in length to lightning protection components.

L. A counterpoise installation based on requirements in Division 26 Section "Grounding and Bonding " may be used as a ground loop required by NFPA 780, provided counterpoise conductor meets or exceeds minimum requirements in NFPA 780.

1. Bond ground terminals to counterpoise conductor.
2. Bond grounded metal bodies on building within 12 feet of ground to counterpoise conductor.
3. Bond grounded metal bodies on building within 12 feet of roof to counterpoise conductor.

M. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at 60-foot intervals.

N. Fasteners:
   1. At 3 ft. centers, maximum, on exposed conductor runs.
   2. As necessary to maintain position and hold permanently in place on concealed runs of conductor.

3.2 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.3 FIELD QUALITY CONTROL AND FINAL ACCEPTANCE

A. Provide an inspection by an inspector certified by LPI to obtain an LPI certification.

B. Procurement of L.P.I. Certification includes jobsite verification and completion of:
   1. Witness of Grounding System & Grade bonding (Stage I)
   2. Inspection of concealed equipment between roof & grade (Stage II)
   3. Final inspection of exposed equipment on roof (Stage III)

C. Procurement of Underwriters' Laboratories Master Label indicating completion of;
   1. Show owner or his representative the type and manner of placing groundings and receiving his record of review.
   2. Completion of application form and submission to Underwriters' Laboratories for issuance of certification.

D. Installation of Installer's Nameplate at location designated on UL application form.

E. Any components or methods found to be not in accordance with this specification shall be repaired or replaced without cost to the owner.

END OF SECTION 264113

SECTION 26 43 00 - SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Surge protective devices for service entrance locations.

B. Surge protective devices for distribution locations.

C. Surge protective devices for branch panelboard locations.

1.02 ABBREVIATIONS AND ACRONYMS

A. EMI/RFI: Electromagnetic Interference/Radio Frequency Interference.

B. SPD: Surge Protective Device.

1.03 REFERENCE STANDARDS

A. National Electrical Code.

B. IEEE 1100 - IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment; 2005.

C. IEEE C62.41.1 - IEEE Standard Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits; 2002 (Reaffirmed 2008).

D. IEEE C62.45 - Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits; 2002.

E. MIL-STD-220 - Method of Insertion Loss Measurement; Revision C, 2009.

F. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2014.

G. NEMA WD 6 - Wiring Devices - Dimensional Specifications; 2016.

H. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems; 2017.

I. UL 1283 - Standard for Electromagnetic Interference Filters; Current Edition, Including All Revisions.

J. UL 1449 - Standard for Surge Protective Devices; Current Edition, Including All Revisions.

K. UL 486A-486B - Wire Connectors; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination: Coordinate size and location of overcurrent device compatible with the actual surge protective device and location to be installed. Notify Architect/Engineer of Record of any conflicts or deviations from the contract documents to obtain direction prior to ordering equipment.

B. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner's Representative or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
   1. Notify Architect/Engineer of Record and Owner's Representative not less than seven (7) days in advance of proposed utility interruptions.
   2. Do not proceed with utility interruptions without Architect's/Engineer of Record and Owner's Representative written permission.

1.05 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Include detailed component information, voltage, surge current ratings, repetitive surge current capacity, voltage protection rating (VPR) for all protection modes, maximum continuous operating voltage (MCOV), nominal discharge current (I-n), short circuit current rating (SCCR), connection means including any required external overcurrent protection, enclosure ratings, outline and support point dimensions, weight, service condition requirements, and installed features.
   1. SPDs with EMI/RFI filter: Include noise attenuation performance.

C. Shop Drawings: Include wiring diagrams showing all factory and field connections with wire and circuit breaker/fuse sizes.

D. Certificates: Manufacturer's documentation of listing for compliance with the following standards:
   1. UL 1449.
   2. UL 1283 (for Type 2 SPDs).

E. Field Quality Control Test Reports.
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Failed test results and corrective action taken to achieve requirements.

F. Manufacturer's Installation Instructions: Include application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

G. Operation and Maintenance Data: Include information on status indicators and recommended maintenance procedures and intervals.

H. Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.

I. Project Record Documents: Record actual connections and locations of surge protective devices.

1.06 QUALITY ASSURANCE

A. Comply with City of National Electric Code.

B. Comply with IEEE 1100, IEEE C62.41.1 and test devices according to IEEE C62.45.

C. Comply with UL 1449

D. Permanently affix surge ratings to the unit.

E. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

F. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum five years documented experience.
   1. Manufacturer shall be certified ISO 9001 or 9002.

G. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

H. Electrical Components, Devices, and Accessories: Listed and labeled as defined in National Electrical Code, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.07 DELIVERY, STORAGE, AND PROTECTION

A. Store in a clean, dry space in accordance with manufacturer's written instructions.

1.08 FIELD CONDITIONS

A. Deliver SPD in original factory shipping cartons, with manufacturer's labels intact.

B. Store SPD indoors in clean, dry space, protected from weather, with uniform temperature and humidity to prevent condensation. Protect SPD from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. Handle SPD in accordance with manufacturer's instructions and to avoid damage.

1.09 WARRANTY

A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.

B. Manufacturer's Warranty: Provide minimum ten (10) year warranty covering repair or replacement of surge protective devices showing evidence of failure due to defective materials or workmanship.

C. Special Warranty for Cord-Connected, Plug-in Surge Suppressors: Manufacturer's standard form in which manufacturer agrees to repair or replace electronic equipment connected to circuits protected by surge suppressors.

D. Exclude surge protective devices from any clause limiting warranty responsibility for acts of nature, including lightning, stated elsewhere.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Field-installed, Externally Mounted Surge Protective Devices:
   1. ABB/GE: www.geindustrial.com/#sle.
   2. Advanced Protection Technologies, Inc (APT): www.aptsurge.com.
   3. Current Technology; a brand of Thomas & Betts Power Solutions: www.tnbpowersolutions.com.
   4. Schneider Electric; Square D Brand Surgelogic Products: www.surgelogic.com.
   5. Cutler-Hammer, Inc.; Eaton Corporation: www.eaton.com.
   6. LEA International: www.powerlogics.com/lea-international
   7. Liebert Corporation; a division of Emerson: Emerson.com

8. Siemens: www.siemens.com

B. Factory-installed, Internally Mounted Surge Protective Devices:
1. Same as manufacturer of equipment containing surge protective device, to provide a complete listed assembly including SPD.

C. Source Limitations: Furnish surge protective devices produced by a single manufacturer and obtained from a single supplier.

2.02 SURGE PROTECTIVE DEVICES - GENERAL REQUIREMENTS

A. Description: Factory-assembled surge protective devices (SPDs) for 60 Hz service; listed, classified, and labeled as suitable for the purpose intended; system voltage as indicated on the drawings.

B. Protected Modes:
1. Wye Systems: L-N, L-G, N-G, L-L.
2. Delta Systems: L-G, L-L.
3. Single Split Phase Systems: L-N, L-G, N-G, L-L.
4. High Leg Delta Systems: L-N, L-G, N-G, L-L.

C. UL 1449 Voltage Protection Ratings (VPRs):
1. 208Y/120V System Voltage: Not more than 1,000 V for L-N, L-G, and N-G modes and 1,200 V for L-L mode.
2. 240/120V System Voltage: Not more than 1,000 V for L-N, L-G, and N-G modes and 1,200 V for L-L mode.
3. 480Y/277V System Voltage: Not more than 1,500 V for L-N, L-G, and N-G modes and 2,000 V for L-L mode.
4. 480V Delta System Voltage: Not more than 1,800 V for L-G mode and 3,000 V for L-L mode.

D. UL 1449 Maximum Continuous Operating Voltage (MCOV): Not less than 115% of nominal system voltage.

E. Operating Frequency: 47 to 63 Hertz.

F. Integral OCPD for Suppression: The unit shall require the associated switchgear assembly to have an integral OCPD as a means of disconnecting the suppression/filter system for maintenance and/or test purposes without interruption of power to the facility's distribution system. The OCPD shall be 3-pole for three-phase applications and shall be padlockable.

G. Refer To Section 26 05 53 - Identification for Electrical Systems for labeling requirements.

H. Enclosure Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
1. Indoor clean, dry locations: Type 1.
2. Outdoor locations: Type 3R.

I. Mounting for Field-installed, Externally Mounted SPDs: Unless otherwise indicated, as specified for the following locations:
1. Provide surface-mounted SPD where mounted in non-public areas or adjacent to surface-mounted equipment.
2. Provide flush-mounted SPD where mounted in public areas or adjacent to flush-mounted equipment.

J. Equipment Containing Factory-installed, Internally Mounted SPDs: Listed and labeled as a complete assembly including SPD.
   1. Switchboards: See Section 26 24 13 - Switchboards.
   2. Panelboards: See Section 26 24 16 - Panelboards.

2.03 SURGE PROTECTIVE DEVICES FOR SERVICE ENTRANCE LOCATIONS

A. Unless otherwise indicated, provide field-installed, externally mounted or factory-installed, internally mounted SPDs.

B. Type 1 as defined by UL 1449.

C. Short Circuit current rating complying with UL 1449, and matching or exceeding short circuit current value available at the point of connection.

D. Voltage Protection Rating shall be in compliance with test and evaluation procedures described in UL 1449.

E. Provide SPDs utilizing field-replaceable modular or non-modular protection circuits.

F. Surge Current Rating: Not less than 100kA per mode / 200 kA per phase minimum..

G. UL 1449 Nominal Discharge Current (I-n): 20 kA.

H. EMI/RFI Filtering: Provide EMI/RFI filter to attenuate electrical noise; listed as complying with UL 1283 for Type 2 SPDs (UL 1283 listing not available for Type 1 SPDs).
   1. Noise Attenuation: Not less than 40 dB at 100 kHz using MIL-STD-220 insertion loss test method.

I. Fabrication using bolted compression lugs for internal wiring.

J. Integral disconnect switch or circuit breaker.

K. Redundant suppression circuits.

L. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.

M. Diagnostics:
   1. Protection Status Monitoring: Provide indicator lights to report the protection for each phase.
   2. Alarm Notification: Provide indicator light and audible alarm to report alarm condition. Provide button to manually silence audible alarm.
   3. Remote Status Monitoring: Provide Form C dry type contacts (normally open and normally closed) for remote annunciation of status.
   4. Surge Counter: Provide surge event counter with manual reset button, surge count retention upon power loss, and six digit LCD display that indicates quantity of surge events.

N. Provide surge rated integral disconnect switch for SPDs not connected to a dedicated circuit breaker or fused switch or not direct bus connected.

O. All primary transient path wiring shall be of copper minimum size as required by the manufacturer but not less than No. 2 AWG, or via bus bar of equivalent capacity to provide equal impedance interconnection between phases. No plug-in modules, components or printed circuit boards shall be used in surge carrying path.

P. Connection Means: Permanently wired, integral to the switchboard or externally mounted adjacent to the switchboard.

Q. VPR (Voltage Protection Rating) under UL 1449, 6kV 3000A testing should fall within:
1. 120V system 700-800V L-N,L-G, 600-800V N-G and 1000-1,200V L-L.
2. 277V system 1,000-1,200V L-N, N-G, 1,200V L-G and 1,800-2,000V L-L.
3. 480V Delta system 1,500-2,500V L-L, L-G

2.04 SURGE PROTECTIVE DEVICES FOR DISTRIBUTION LOCATIONS

A. Unless otherwise indicated, provide field-installed, externally mounted or factory-installed, internally mounted SPDs.

B. List and label as complying with UL 1449, Type 1 or Type 2.

C. Distribution locations include SPDs connected to distribution panelboards, motor control centers, and busway.

D. Provide SPDs utilizing field-replaceable modular or non-modular protection circuits.

E. Surge Current Rating: Not less than 80 kA per mode/160 kA per phase.

F. Repetitive Surge Current Capacity: Not less than 3,500 impulses.

G. UL 1449 Nominal Discharge Current (I-n): 20 kA.

H. UL 1449 Short Circuit Current Rating (SCCR): Not less than the available fault current at the installed location as indicated on the drawings.

I. EMI/RFI Filtering: Provide EMI/RFI filter to attenuate electrical noise; listed as complying with UL 1283 for Type 2 SPDs (UL 1283 listing not available for Type 1 SPDs).
1. Noise Attenuation: Not less than 40 dB at 100 kHz using MIL-STD-220 insertion loss test method.

J. Diagnostics:
1. Protection Status Monitoring: Provide indicator lights to report the protection status for each phase.
2. Alarm Notification: Provide indicator light and audible alarm to report alarm condition. Provide button to manually silence audible alarm.
3. Remote Status Monitoring: Provide Form C dry type contacts (normally open and normally closed) for remote annunciation of status.
4. Surge Counter: Provide surge event counter with manual reset button, surge count retention upon power loss, and six digit LCD display that indicates quantity of surge events.

K. Provide surge rated integral disconnect switch for SPDs not connected to a dedicated circuit breaker or fused switch or not direct bus connected.

L. Integral disconnect switch when required by contract documents.

M. Voltage Protection Rating shall be in compliance with test and evaluation procedures described in UL 1449.

N. Fabrication using bolted compression lugs for internal wiring.

O. Redundant suppression circuits.

P. Arrangement with wire connections to phase buses, neutral bus, and ground bus.

2.05 SURGE PROTECTIVE DEVICES FOR BRANCH PANELBOARD LOCATIONS

A. Unless otherwise indicated, provide field-installed, externally mounted or factory-installed, internally mounted SPDs.

B. List and label as complying with UL 1449, Type 1 or Type 2.

C. Provide SPDs utilizing field-replaceable modular or non-modular protection circuits.

D. Surge Current Rating: Not less than 50 kA per mode/100 kA per phase.

E. Repetitive Surge Current Capacity: Not less than 2,000 impulses.

F. UL 1449 Nominal Discharge Current (I-n): 20 kA.

G. UL 1449 Short Circuit Current Rating (SCCR): Not less than the available fault current at the installed location as indicated on the drawings.

H. EMI/RFI Filtering: Provide EMI/RFI filter to attenuate electrical noise; listed as complying with UL 1283 for Type 2 SPDs (UL 1283 listing not available for Type 1 SPDs).
   1. Noise Attenuation: Not less than 40 dB at 100 kHz using MIL-STD-220 insertion loss test method.

I. All primary transient path wiring shall be of a No, 6 AWG copper minimum or via bus bar of equivalent capacity to provide equal impedance interconnection between phased. No plug-in modules, components, or printed circuit boards shall be in use in surge carrying paths.

J. Diagnostics:
   1. Protection Status Monitoring: Provide indicator lights to report the protection status.
   2. Alarm Notification: Provide indicator light and audible alarm to report alarm condition. Provide button to manually silence audible alarm.
   3. Remote Status Monitoring: Provide Form C dry type contacts (normally open and normally closed) for remote annunciation of status.
   4. Surge Counter: Provide surge event counter with manual reset button, surge count retention upon power loss, and six digit LCD display that indicates quantity of surge events.

K. Provide surge rated integral disconnect switch for SPDs not connected to a dedicated circuit breaker or fused switch or not direct bus connected.

L. Integral disconnect switch when required by contract documents.

M. Voltage Protection Rating shall be in compliance with test and evaluation procedures described in UL 1449.

N. Nominal Discharge Current Rating: 10 kA minimum as determined by the actual Nominal Discharge Current test.

O. Fabrication using bolted compression lugs for internal wiring.

P. Redundant suppression circuits.

Q. Arrangement with wire connections to phase buses, neutral bus, and ground bus.

R. The system protection modules shall contain an array of metal oxide varistors (MOV). The SPD shall be listed in accordance with UL 1449.

S. Provide visible status indicator mounted on the front of the panel or a glass window shall be installed on the enclosing cabinet to make indicators on the modules visible.

2.06 PLUG-IN SURGE SUPPRESSORS

A. Description: Non-modular, plug-in suppressors with at least four 15-A, 120-V ac, NEMA WD 6, Configuration 15-15R receptacles, suitable to plug into a NEMA WD 6, Configuration 15-15R receptacle; with the following features and additional accessories:
   1. LED indicator lights for reverse polarity and open outlet ground.
   2. Circuit breaker and thermal fusing. When protection is lost, circuit opens and cannot be reset.
   3. Close-coupled direct plug-in.
   4. Rocker-type on-off switch, illuminated when in the on position.
   5. One RJ11/12C telephone line protector, suitable for modem connection. Maximum clamping voltage 220 peak on pins No. 3 and No. 4.

B. Peak Single-Impulse Surge Current Rating: 33 kA per phase.

C. Protection modes and UL 1449 VPR shall be as follows:
   1. Line to Neutral: 475 V.
   2. Line to Ground: 475 V.
   3. Neutral to Ground: 475 V.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that field measurements are as indicated.

B. Verify that the service voltage and configuration marked on the SPD are consistent with the service voltage and configuration at the location to be installed.

C. Verify that electrical equipment is ready to accept connection of the SPD and that installed overcurrent device is consistent with requirements of drawings and manufacturer's instructions.

D. Verify system grounding and bonding is in accordance with Section 26 05 26 - Grounding and Bonding for Electrical Systems, including bonding of neutral and ground for service entrance and separately derived systems where applicable. Do not energize SPD until deficiencies have been corrected.

E. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. Installation shall be in accordance with the NEC 280 & 285.

C. Unless indicated otherwise, connect service entrance surge protective device on load side of service disconnect main overcurrent device.

D. Provide conductors with minimum ampacity as indicated on the drawings, as required by the National Electrical Code, and not less than manufacturer's recommended minimum conductor size.

E. Install conductors between SPD and equipment terminations as short and straight as possible, not exceeding manufacturer's recommended maximum conductor length. Breaker locations may be reasonably rearranged in order to provide leads as short and straight as possible. Twist conductors together to reduce inductance. Installation of leads shall avoid sharp and unnecessary bends. Terminals shall be provided for all necessary power and ground connections.
   1. Where SPD cannot be mounted within five (5) feet of the panel at the service entrance, an internal SPD mounting shall be utilized.
   2. Where SPD cannot be mounted within eighteen (18) inches of the panelboard, an internal SPD mounting shall be utilized.

F. Install devices for panelboard and auxiliary panels with conductors or buses between SPD and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
   1. Comply with manufacturer's written recommendation for conductor and circuit-breaker size for connecting SPD to distribution system. Match circuit-breaker size to conductor size. Coordinate with Drawings.
   2. Provide multipole, 30-A circuit breaker as a dedicated disconnect for SPD if mounted exterior to the switchboard or panelboard, unless otherwise indicated.
   3. Where SPD cannot be mounted within 18-inches of the panel, high performance, low impedance cable as recommended by the manufacturer may be provided to eliminate any potential degradation of voltage protection.

G. Do not energize SPD until bonding of neutral and ground for service entrance and separately derived systems is complete in accordance with Section 26 05 26 - Grounding and Bonding for Electrical Systems where applicable. Replace SPDs damaged by improper or missing neutral-ground bond.

H. Disconnect SPD prior to performing any high potential testing. Replace SPDs damaged by performing high potential testing with SPD connected.

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

J. System shall not require removal and replacement for warranty and/or other repairs. All internal component replacements shall be capable of being completed by a licensed electrician.

3.03 FIELD QUALITY CONTROL

A. See Section 01 40 00 - Quality Requirements, for additional requirements.

B. Inspect and test in accordance with NETA ATS, except Section 4.

C. Perform inspections and tests listed in NETA ATS Section 7.19.1.

D. Procure services of a qualified manufacturer's representative to observe installation and assist in inspection, testing, and adjusting. Include manufacturer's reports with field quality control submittals.

3.04 CONTRACTOR START UP AND REPORTING

A. Verify that electrical wiring installation complies with manufacturer's written installation requirements.

B. Do not energize or connect service entrance equipment, panelboards, control terminals or data terminals to their sources until surge protection devices are installed and connected.

C. Testing: Perform the following field tests and inspections and prepare test reports:
   1. After installing surge protection devices, but before electrical circuitry has been energized, test for compliance with manufacturer's requirements.
   2. Complete startup checks according to manufacturer's written instructions.
   3. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.

D. Remove and replace malfunctioning units and retest as specified above.

3.05 CLEANING

A. Repair scratched or marred exterior surfaces to match original factory finish.

B. Do not used compressed air for cleaning.

END OF SECTION

SECTION 26 5100 - INTERIOR LIGHTING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Interior lighting fixtures, lamps, and drivers.
2. Emergency lighting units.
3. Exit signs.
4. Lighting fixture supports.

B. Related Sections:

1. Division 26 Section "Lighting Control" for automatic control of lighting, including time switches, photoelectric relays, occupancy sensors, and multiple lighting relays and contactors.
2. Division 26 Section "Wiring Devices" for manual wall-box dimmers.

1.3 REFERENCES

A. National Fire Protection Association (NFPA):

B. NFPA 70, “National Electrical Code”, (NEC)

C. Illuminating Engineering Society of North America (IESNA):

1. IES Approved Method for Life Performance Testing of General Lighting Incandescent Filament Lamps, LM-49.
2. IES Approved Method for Electrical and Photometric Measurements of General Service Incandescent Filament Lamps, LM-45.
3. IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products, LM-79.
4. IES Approved Method for Measuring Lumen Maintenance of LED Light Sources, LM-80.
5. IES Approved Method for Characterization of LED Light Engines and LED Lamps for Electrical and Photometric Properties as a Function of Temperature, LM-82.
6. IES Projecting Long Term Lumen Maintenance of LED Products, TM-21-11

D. American National Standards Institute (ANSI):

1. ANSI C78.377, Specifications for the Chromaticity of Solid State Lighting Products.
2. ANSI C81 Series, Electric Lamp Bases and Holders.

E. National Electric Manufacturer’s Association (NEMA):

1. NEMA FA1, “Outdoor Flood Lighting Equipment”.
2. NEMA SH5, “Tubular Steel, Aluminum and Prestressed Concrete Roadway Lighting Poles”.

F. Underwriter’s Laboratories (U.L.) Standards.

G. Codes: Materials and installations shall be in accordance with the latest revision of the National Electrical Code and any applicable Federal, State and local codes and regulations.

H. Listing: All luminaires shall be manufactured in strict accordance with the appropriate and current requirements of the National Electrical Code as verified by Underwriters' Laboratories, Inc. (U.L.), or tested to UL standards by other nationally recognized testing agency as acceptable to Building Officials and Code Administrators International (BOCAI); the International Conference of Building Officials (ICBO); or other relevant code authority recognized by the jurisdiction within which the project is being constructed. Such a listing shall be provided for each luminaire type, and the appropriate label or labels shall be affixed to each luminaire in a location as required by code or law.

1.4 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color-rendering index.

C. LED: Light-emitting Diode

D. Lumen: Measured output of lamp and luminaire, or both.

E. Luminaire: Complete lighting fixture, including driver and lamp.

F. LED Light Engine: a combination of an LED module and the associated control gear (driver).

1.5 SUBMITTALS

A. Product Data: For each type of lighting fixture, arranged in order of fixture designation. Include data on features, accessories, finishes, and the following:

1. Physical description of lighting fixture including dimensions.
2. Emergency lighting units including battery and charger.
3. Energy-efficiency data.
4. Life, output (lumens, CCT, and CRI), and energy-efficiency data for lamps.
5. Photometric data and adjustment factors based on laboratory tests, complying with IESNA Lighting Measurements Testing & Calculation Guides, of each lighting fixture type. The adjustment factors shall be for lamps, ballasts, and accessories identical to those indicated for the lighting fixture as applied in this Project.

    a. Testing Agency Certified Data: For indicated fixtures, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining fixtures shall be certified by manufacturer.
    b. Manufacturer Certified Data: Photometric data shall be certified by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings: For nonstandard or custom lighting fixtures. 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.

C. Samples: For each lighting fixture indicated in the Interior Lighting Fixture Schedule. Each Sample shall include the following:

1. Lamps and drivers, installed.
2. Cords and plugs.
3. Pendant support system.

D. Installation instructions.

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

1. Lighting fixtures.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extends to within 12 inches (305 mm) of the plane of the luminaires.
4. Ceiling-mounted projectors.
5. Structural members to which suspension systems for lighting fixtures will be attached.
6. Other items in finished ceiling including the following:

    a. Air outlets and inlets.
    b. Speakers.
    c. Sprinklers.
    d. Smoke and fire detectors.
    e. Occupancy sensors.
    f. Access panels.

7. Perimeter moldings.

F. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.

G. Product Certificates: For each type of ballast for bi-level and dimmer-controlled fixtures and/or LED light engine from manufacturer.

H. Field quality-control reports.

I. Operation and Maintenance Data: For lighting equipment and fixtures to include in emergency, operation, and maintenance manuals.

1. Provide a list of all lamp types used on Project; use ANSI and manufacturers' codes.

J. Warranty: Sample of special warranty.

1.6 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910, complying with the IESNA Lighting Measurements Testing & Calculation Guides.

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 NFPA 70.

D. FM Global Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

E. LED Luminaires shall be photometrical tested in accordance with IESNA LM-79 Standard

F. Life and operation of LED modules shall be tested in accordance with IESNA LM-80 Standard

G. White LEDs shall be binned to a minimum chromaticity in accordance with ANSI/NEMA/ANSLG C78.377-2015 Standard

1.7 COORDINATION

A. Coordinate layout and installation of lighting fixtures and suspension system with other construction that penetrates ceilings or is supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.

1.8 WARRANTY

A. Luminaire and lamp vendors shall provide warranty and level of support consistent with industry practice and expectations regardless of point of actual sale and/or chain of sale. Vendor shall provide warranty against loss of performance and defects in materials and workmanship for the period as indicated in the following sections. All warranties shall commence on the date the installation is turned over to the project owner.

1. Warranty for LED Luminaires: Entire LED luminaire shall be provided with a minimum 5-Year Manufacturer's warranty unless otherwise noted in the lighting fixture schedule. The Warranty shall commence on the date the LED luminaire installation is turned over to the project owner.

2. 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.

3. Warranty Period for Emergency Lighting Unit Batteries: 10 years from date of Substantial Completion. Full warranty shall apply for first year, and prorated warranty for the remaining nine years.

1.9 ATTIC STOCK

A. For all fixtures electrical contractor to provide:

1. Minimum of 5% of total installed quantity per fixture type, minimum of 1 and maximum of 5.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide product indicated in the Lighting Fixture Schedule in the drawings.

2.2 GENERAL REQUIREMENTS FOR LIGHTING FIXTURES AND COMPONENTS

A. Recessed Fixtures: Comply with NEMA LE 4 for ceiling compatibility for recessed fixtures.

B. Incandescent Fixtures: Comply with UL 1598. Where LER is specified, test according to NEMA LE 5A.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.

E. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

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.

G. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

H. Diffusers and Globes:

1. Acrylic Lighting Diffusers: 100 percent virgin acrylic plastic. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

a. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
b. UV stabilized.

2. Glass: Annealed crystal glass unless otherwise indicated.

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. Factory-Applied Labels: Include recommended lamps and drivers. 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. "USE ONLY" and include specific lamp type and wattage.
b. CCT and CRI for all luminaires.

2.3 LED LUMINAIRES AND DRIVERS

A. LED luminaire shall be constructed and heat-sinked to maintain LED performance as reported by LED manufacturer and exhibited in IESNA LM-79 and LM-80 test reports.

B. LEDs shall be of the color temperature and Color Rendering Index (CRI) as specified on the drawings. Minimum LED performance shall be 70% lumen maintenance at 50,000 hours operation at a forward current up to 700mA with junction temperature maintained at or below 135° C.

C. LED drivers shall be integral or remote type as specified on the drawings and shall provide continuous current matched to LED array requirements. Driver shall be High Power Factor (HPF) with <20% total harmonic distortion (THD) full load, Driver performance shall comply with the requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR Part 15.

2.4 EXIT SIGNS

A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.

B. Internally Lighted Signs:

1. Lamps for AC Operation: LEDs, 50,000 hours minimum rated lamp life.

2. Self-Powered Exit Signs (Battery Type): Integral automatic charger in a self-contained power pack.

    a. Battery: Sealed, maintenance-free, nickel-cadmium type.
    b. Charger: Fully automatic, solid-state type with sealed transfer relay.
    c. Operation: Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
    d. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
    e. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
    f. 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.
    g. 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 EMERGENCY LIGHTING UNITS

A. General Requirements for Emergency Lighting Units: Self-contained units complying with UL 924.

1. Battery: Sealed, maintenance-free, lead-acid type.
2. Charger: Fully automatic, solid-state type with sealed transfer relay.
3. 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.
4. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
5. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
6. 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.

2.6 LIGHTING FIXTURE SUPPORT COMPONENTS

A. Comply with Division 26 Section "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 (13-mm) steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.

C. Twin-Stem Hangers: Two, 1/2-inch (13-mm) steel tubes with single canopy designed to mount a single fixture. Finish same as fixture.

D. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage.

E. Hook Hangers: Integrated assembly matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

PART 3 EXECUTION

3.1 INSTALLATION

A. Lighting fixtures:

1. Set level, plumb, and square with ceilings and walls unless otherwise indicated.
2. Install lamps in each luminaire.

B. Temporary Lighting: If it is necessary, and approved by Architect, to use permanent luminaires for temporary lighting, install and energize the minimum number of luminaires necessary. When construction is sufficiently complete, remove the temporary luminaires, disassemble, clean thoroughly, install new lamps, and reinstall.

C. Remote Mounting of Drivers/Power Supplies: Distance between the driver/power supply and fixture shall not exceed that recommended by ballast/power supply manufacturer. Verify, with driver/power supply manufacturers, maximum distance between ballast/driver/power supply and luminaire.

D. Lay-in Ceiling Lighting Fixtures Supports: Use grid as a support element.

1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each fixture. Locate not more than 6 inches (150 mm) from lighting fixture corners.
2. Support Clips: Fasten to lighting fixtures and to ceiling grid members at or near each fixture corner with clips that are UL listed for the application.
3. Fixtures of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two 3/4-inch (20-mm) metal channels spanning and secured to ceiling tees.
4. Install at least one independent support rod or wire from structure to a tab on lighting fixture. Wire or rod shall have breaking strength of the weight of fixture at a safety factor of 3.

E. Suspended Lighting Fixture Support:

1. Pendants and Rods: Where longer than 48 inches (1200 mm), brace to limit swinging.
2. Stem-Mounted, Single-Unit Fixtures: Suspend with twin-stem hangers.
3. Continuous Rows: 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 grid as support for pendant luminaires. Connect support wires or rods to building structure.

F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.2 IDENTIFICATION

A. Install labels with panel and circuit numbers on concealed junction and outlet boxes. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.3 FIELD QUALITY CONTROL

A. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery and retransfer to normal.

B. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.4 STARTUP SERVICE

A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner. Burn-in LED lamps/luminaires intended to be dimmed, for at least 100 hours at full voltage.

END OF SECTION

SECTION 26 5600 - EXTERIOR LIGHTING

PART 1 GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Exterior luminaires with lamps and ballasts.
2. Luminaire-mounted photoelectric relays.
3. Poles and accessories.
4. Luminaire lowering devices.

B. Related Sections:

1. Division 26 Section "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.3 REFERENCES

A. National Fire Protection Association (NFPA):

B. NFPA 70, “National Electrical Code”, (NEC)

C. Illuminating Engineering Society of North America (IESNA):

1. IES Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products, LM-79.
2. IES Approved Method for Measuring Lumen Maintenance of LED Light Sources, LM-80.
3. IES Approved Method for Characterization of LED Light Engines and LED Lamps for Electrical and Photometric Properties as a Function of Temperature, LM-82.
4. IES Projecting Long Term Lumen Maintenance of LED Products, TM-21-11

D. American National Standards Institute (ANSI):

1. ANSI C78.377, Specifications for the Chromaticity of Solid State Lighting Products.
2. ANSI C81 Series, Electric Lamp Bases and Holders.

E. National Electric Manufacturer’s Association (NEMA):

1. NEMA FA1, “Outdoor Flood Lighting Equipment”.
2. NEMA SH5, “Tubular Steel, Aluminum and Prestressed Concrete Roadway Lighting Poles”.

F. Underwriter’s Laboratories (U.L.) Standards.

G. Codes: Materials and installations shall be in accordance with the latest revision of the National Electrical Code and any applicable Federal, State and local codes and regulations.

H. Listing: All luminaires shall be manufactured in strict accordance with the appropriate and current requirements of the National Electrical Code as verified by Underwriters’ Laboratories, Inc. (U.L.), or tested to UL standards by other nationally recognized testing agency as acceptable to Building Officials and Code Administrators International (BOCAI); the International Conference of Building Officials

(ICBO); or other relevant code authority recognized by the jurisdiction within which the project is being constructed. Such a listing shall be provided for each luminaire type, and the appropriate label or labels shall be affixed to each luminaire in a location as required by code or law.

1.4 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color-rendering index.

C. LED: Light-emitting Diode

D. Lumen: Measured output of lamp and luminaire, or both.

E. Luminaire: Complete lighting fixture, including ballast/driver and lamp.

F. LED Light Engine: a combination of an LED module and the associated control gear (driver).

G. Pole: Luminaire support structure, including tower used for large area illumination.

H. Standard: Same definition as "Pole" above.

I. EPA rating: Outdoor wind load value associated with pole-mounted luminaires

1.5 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 (2224 N), 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. Basic wind speed for calculating wind load for poles exceeding in height is 125 mph.

a. Wind Importance Factor: 1.0.
b. Minimum Design Life: 50 years.
c. Velocity Conversion Factors: 1.0.

1.6 SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:

1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
2. Details of attaching luminaires and accessories.
3. Details of installation and construction.
4. Luminaire materials.
5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, LED modules, ballasts, drivers, and accessories.

a. Testing Agency Certified Data: For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.

b. Manufacturer Certified Data: Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

6. Photoelectric relays.
7. Ballasts and/or drivers, including energy-efficiency data.
8. Lamps and/or LED modules, including life, output, CCT, CRI, lumens, and energy-efficiency data.
9. Materials, dimensions, and finishes of poles.
10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
11. Anchor bolts for poles.
12. Manufactured pole foundations.

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. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
3. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.
4. Wiring Diagrams: For power, signal, and control wiring.

C. Samples: For products designated for sample submission in the Exterior Lighting Device Schedule. Each Sample shall include the following:

1. Lamps and ballasts, installed.
2. Cords and plugs.
3. Specified support system.

D. Installation Instructions.

E. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations by a professional engineer.

F. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.

G. Field quality-control reports.

H. Operation and Maintenance Data: For luminaires and poles luminaire lowering devices to include in emergency, operation, and maintenance manuals.

I. Warranty: Sample of special warranty.

1.7 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.

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 IEEE C2, "National Electrical Safety Code."

D. Comply with NFPA 70.

E. FM Global Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

F. LED Luminaires shall be photometrical tested in accordance with IESNA LM-79 Standard

G. Life and operation of LED modules shall be tested in accordance with IESNA LM-80 Standard

H. White LEDs shall be binned to a minimum chromaticity in accordance with ANSI/NEMA/ANSLG C78.377-2015 Standard

1.8 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay-resistant-treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.

D. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.9 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

1. Warranty for LED Luminaires: Entire LED luminaire shall be provided with a minimum 5-Year Manufacturer’s warranty unless otherwise noted in the lighting fixture schedule. The Warranty shall commence on the date the LED luminaire installation is turned over to the project owner.

1.10 ATTIC STOCK

A. For all fixtures electrical contractor to provide:

1. Minimum of 5% of total installed quantity per fixture type, minimum of 1 and maximum of 5.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide products indicated on Drawings.

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.

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.

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 indicated on plans or 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.

    a. Color: As indicated on plans or as selected by Architect from manufacturer's full range.

2.3 LED LUMINAIRES AND DRIVERS

A. LED luminaire shall be constructed and heat-sinked to maintain LED performance as reported by LED manufacturer and exhibited in IESNA LM-79 and LM-80 test reports.

B. LEDs shall be of the color temperature and Color Rendering Index (CRI) as specified on the drawings. Minimum LED performance shall be 70% lumen maintenance at 50,000 hours operation at a forward current up to 700mA with junction temperature maintained at or below 135° C.

C. LED drivers shall be integral or remote type as specified on the drawings and shall provide continuous current matched to LED array requirements. Driver shall be High Power Factor (HPF) with <20% total harmonic distortion (THD) full load, Driver performance shall comply with the requirements of the Federal Communications Commission (FCC) rules and regulations, Title 47 CFR Part 15.

2.4 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 (65 by 130 mm), 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 Division 03 Section "Cast-in-Place Concrete."

F. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4-M.

2.5 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. Shape: As indicated on drawings.
2. 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 (13-mm) threaded lug, complying with requirements in Division 26 Section "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. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.

1. As indicated on drawings.
2. Finish: Same as luminaire.

F. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

G. 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. As scheduled on drawings.

a. Color: As indicated in the Lighting Fixture schedule or by Architect from manufacturer’s full range.

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.

C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

D. Remote Mounting of Drivers/Power Supplies: Distance between the driver/power supply and fixture shall not exceed that recommended by power supply manufacturer. Verify, with driver/power supply manufacturers, maximum distance between driver/power supply and luminaire.

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 (1520 mm).
2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet (3 m.
3. Trees: 15 feet (5 m)] 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 Division 03 Section "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- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

3.3 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Division 26 Section "Raceway and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.4 GROUNDING

A. Ground metal poles and support structures according to Division 26 Section "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 Division 26 Section "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.

3.5 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.

1. Verify operation of photoelectric controls.

C. Illumination Tests:

1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IESNA testing guide(s):

a. IESNA LM-5, "Photometric Measurements of Area and Sports Lighting Installations."
b. IESNA LM-64, "Photometric Measurements of Parking Areas."
c. IESNA LM-72, "Directional Positioning of Photometric Data."

D. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.6 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain luminaire lowering devices.

3.7 STARTUP SERVICE

A. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by Owner. Burn-in LED lamps/luminaires intended to be dimmed, for at least 100 hours at full voltage.

END OF SECTION

SECTION 265613 - LIGHTING POLES AND STANDARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Poles and accessories for support of luminaires.

2. Luminaire-lowering devices.

1.3 DEFINITIONS

A. EPA: Equivalent projected area.

B. Luminaire: Complete luminaire.

C. Pole: Luminaire-supporting structure, including tower used for large-area illumination.

D. Standard: See "Pole."

1.4 ACTION SUBMITTALS

A. Product Data: For each pole, accessory, and luminaire-supporting and -lowering device, arranged as indicated.

1. Include data on construction details, profiles, EPA, cable entrances, materials, dimensions, weight, rated design load, and ultimate strength of individual components.

2. Include finishes for lighting poles and luminaire-supporting devices.

3. Anchor bolts.

4. Manufactured pole foundations.

B. Shop Drawings:

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

2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

3. Detail fabrication and assembly of poles and pole accessories.

4. Foundation construction details, including material descriptions, dimensions, anchor bolts, support devices, and calculations, signed and sealed by a professional engineer licensed in the state of installation.

5. Anchor bolt templates keyed to specific poles and certified by manufacturer.

6. Method and procedure of pole installation. Include manufacturer's written installations.

C. Samples: For each exposed lighting pole, standard, and luminaire-supporting device and for each color and texture specified.

1.5 INFORMATIONAL SUBMITTALS

A. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements according to AASHTO LTS-6-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations signed and sealed by a professional engineer.

B. Qualification Data: For Installer and testing agency.

C. Seismic Qualification Data: For poles, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Material Test Reports:

1. For each foundation component, by a qualified testing agency.

2. For each pole, by a qualified testing agency.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranty: Manufacturer's standard warranty.

H. Soil test reports

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For poles and luminaire-lowering devices to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include pole inspection and repair procedures.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Pole repair materials.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM C 1093 for foundation testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay-resistant skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch (6 mm) deep. Do not apply tools to section of pole to be installed below finished grade.

D. Retain factory-applied pole wrappings on fiberglass and laminated wood poles until right before pole installation. Handle poles with web fabric straps.

E. Retain factory-applied pole wrappings on metal poles until right before pole installation. Handle poles with web fabric straps.

1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of pole(s) and luminaire-lowering device(s) that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within a specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs from special warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

2. Warranty Period for Corrosion Resistance: Five years from date of Substantial Completion.

3. Warranty Period for Color Retention: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

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

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

1. The term "withstand" means "the system will remain in place without separation of any parts when subjected to the seismic forces specified and the system will be fully operational after the seismic event."

2. Component Importance Factor: 1.5.

C. Structural Characteristics: Comply with AASHTO LTS-6-M.

D. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied according to AASHTO LTS-6-M.

E. Live Load: Single load of 500 lbf (2200 N) distributed according to AASHTO LTS-6-M.

F. Ice Load: Load of 3 lbf/sq. ft. (145 Pa), applied according to AASHTO LTS-6-M for applicable areas on the Ice Load Map.

G. Wind Load: Pressure of wind on pole and luminaire, calculated and applied according to AASHTO LTS-6-M.

1. Basic wind speed for calculating wind load for poles exceeding 50 feet (15 m) in height is 100 mph (45 m/s).

a. Wind Importance Factor: 1.0.

b. Minimum Design Life: 50 years.

c. Velocity Conversion Factor: 1.0.

2. Basic wind speed for calculating wind load for poles 50 feet (15 m) high or less is 100 mph (45 m/s).

a. Wind Importance Factor: 1.0.

b. Minimum Design Life: 25 years.

c. Velocity Conversion Factor: 1.0.

H. Strength Analysis: For each pole, multiply the actual EPA of luminaires and brackets by a factor of **1.1** to obtain the EPA to be used in pole selection strength analysis.

I. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

2.2 STEEL POLES

A. Refer to Lighting Fixture Schedule shown on the drawings.

B. Source Limitations: Obtain poles from single manufacturer or producer.

C. Source Limitations: For poles, obtain each color, grade, finish, type, and variety of pole from single source with resources to provide products of consistent quality in appearance and physical properties.

D. Poles: Comply with ASTM A 500/A 500M, Grade B carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.

1. Shape: Round, tapered, Round, straight, Square, tapered, Square, straight as indicated in the lighting fixture schedule.

2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

E. Poles: Comply with ASTM A 240/A 240M, stainless steel with a minimum yield of 55,000 psig (379 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.

1. Shape: Round, tapered, Round, straight, Square, tapered, Square, straight as indicated in the lighting fixture schedule.

2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

F. Steel Mast Arms: Single-arm type, continuously welded to pole attachment plate. Material and finish same as plate.

G. Brackets for Luminaires: Detachable, cantilever, without underbrace.

1. Adaptor fitting welded to pole, allowing the bracket to be bolted to the pole-mounted adapter, then bolted together with stainless-steel bolts.

2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match pole material and finish.

H. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

I. Fasteners: Stainless steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.

1. Materials: Compatible with poles and standards as well as the substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.

2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

J. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size indicated, and accessible through handhole.

K. Steps: Fixed steel, with nonslip treads.

1. For climbing positions, install at 15-inch (381-mm) vertical spacing, alternating on opposite sides of pole, oriented 180 degrees from each other; first step shall be at an elevation 10 feet (3 m) above finished grade.

2. For working positions, install steps on opposite side of pole, oriented 180 degrees from each other at the same elevation.

L. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.

M. Intermediate Handhole and Cable Support: Weatherproof, 3-by-5-inch (76-by-130-mm) handhole located at midpoint of pole, with cover for access to internal welded attachment lug for electric cable support grip.

N. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported load multiplied by a 5.0 safety factor.

O. Platform for Lamp and Ballast Servicing: Factory fabricated of steel, with finish matching that of pole.

P. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

Q. Galvanized Finish: After fabrication, hot-dip galvanize according to ASTM A 123/A 123M.

R. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces according to SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.

2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.

3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high gloss, high-build polyurethane enamel.

a. Color: As selected by Architect from manufacturer's full range.

S. Powder-Coat Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces according to SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair powder coat bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.

2. Powder Coat: Comply with AAMA 2604.

a. Electrostatic-applied powder coating; single application and cured to a minimum 2.5- to 3.5-mils dry film thickness. Coat interior and exterior of pole for equal corrosion protection.

b. Color: As selected by Architect from manufacturer's full range.

2.3 ALUMINUM POLES

A. Refer to Lighting Fixture Schedule shown on the drawings.

B. Poles: Seamless, extruded structural tube complying with ASTM B 221, Alloy 6063-T6, with access handhole in pole wall.

1. Shape: Round, tapered, Round, straight, Square, tapered, Square, straight as indicated in the lighting fixture schedule.

2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

C. Mast Arms: Aluminum Single-arm type, continuously welded to pole attachment plate. Material and finish same as plate.

D. Brackets for Luminaires: Detachable, cantilever, without underbrace.

1. Adaptor fitting welded to pole, allowing the bracket to be bolted to the pole-mounted adapter, then bolted together with stainless-steel bolts.

2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire. Match pole material and finish.

E. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

F. Grounding and Bonding Lugs: Bolted 1/2-inch (13-mm) threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

G. Fasteners: Stainless steel, size and type as determined by manufacturer. Corrosion-resistant items compatible with support components.

1. Materials: Compatible with poles and standards as well as to substrates to which poles and standards are fastened and shall not cause galvanic action at contact points.

2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.

H. Handhole: Oval shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.

I. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

J. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.

3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I clear coating of 0.018 mm or thicker), complying with AAMA 611.

4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.

K. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.

2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.

3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

a. Color: As selected by Architect from manufacturer's full range.

L. Powder-Coat Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1 to remove dirt, oil, grease, and other contaminants that could impair powder coat bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, according to SSPC-SP 5/NACE No. 1 or SSPC-SP 8.

2. Powder coat shall comply with AAMA 2604.

a. Electrostatic applied powder coating; single application with a minimum 2.5- to 3.5-mils dry film thickness; cured according to manufacturer's instructions. Coat interior and exterior of pole for equal corrosion protection.

b. Color: As selected by Architect from manufacturer's full range.

2.4 POLE ACCESSORIES

A. Duplex Receptacle: Ground-fault circuit interrupter type, 120 V ac, 20 A in a weatherproof assembly. Comply with requirements in Section 262726 "Wiring Devices."

1. **Recessed** 12 inches (300 mm) above finished grade.

a. NEMA 250, **Type 4X**, nonmetallic polycarbonate plastic or reinforced fiberglass, enclosure with cover; color to match pole.

b. Lockable hasp and latch complying with OSHA lockout and tag-out requirements.

B. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.

C. Base Covers: Manufacturers' standard metal units, finished same as pole, and arranged to cover pole's mounting bolts and nuts.

D. Transformer-Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and to accept **indicated accessories**. Include removable flanged access cover secured with bolts or screws.

E. Decorative accessories, supplied by decorative pole manufacturer, include the following:

2.5 MOUNTING HARDWARE

A. Anchor Bolts: Manufactured to ASTM F 1554, Grade 55, with a minimum yield strength of 55,000 psi (380,000 kPa).

1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C.

2. Bent rods 18 in length.

3. Threading: Uniform National Coarse, Class 2A.

B. Nuts: ASTM A 563, Grade A, Heavy-Hex

1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C.

2. Four nuts provided per anchor bolt , shipped with nuts pre-assembled to the anchor bolts.

C. Washers: ASTM F 436, Type 1.

1. Galvanizing: Hot dip galvanized according to ASTM A 153, Class C.

2. Two washers provided per anchor bolt.

2.6 GENERAL FINISH REQUIREMENTS

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Appearance of Finished Work: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine poles, luminaire-mounting devices, lowering devices, and pole accessories before installation. Components that are scratched, dented, marred, wet, moisture damaged, or visibly damaged are considered defective.

C. Examine roughing-in for foundation and conduit to verify actual locations of installation.

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

3.2 POLE FOUNDATION

A. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123 M; and with top-plate and mounting bolts to match pole-base flange and strength required to support pole, luminaire, and accessories. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

B. Pre-Cast Foundations: Factory fabricated, with structural steel complying with ASTM 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. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-Place Concrete."

C. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM 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.

1. Baseplate: Stamped with manufacturer's name, date of production, and cable entry.

D. Direct-Buried Foundations: Install to depth indicated on Drawings, but not less than one-sixth of pole height. Add backfill in 6-inch (150-mm) to 9-inch (230-mm) layers, tamping each layer before adding the next. To ensure a plumb installation, continuously check pole orientation with plumb bob while tamping.

E. Direct-Buried Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height. To ensure a plumb installation, continuously check pole orientation with plumb bob while tamping.

1. Make holes 6 inches (150 mm) in diameter larger than pole diameter.

2. Fill augered hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi (20 MPa) at 28 days and finish in a dome above finished grade.

3. Use a short piece of 1/2-inch (13-mm) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

4. Cure concrete a minimum of 72 hours before performing work on pole.

F. Anchor Bolts: Install plumb using manufacturer-supplied [steel] [plywood] template, uniformly spaced.

G. Extend concrete pole foundation base a minimum of 36” above finished grade with chamfered edges where pole is located within 48” from any vehicular parking or driveways for pole protection.

3.3 POLE INSTALLATION

A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on drawing.

1. Fire Hydrants and Water Piping: 60 inches (1520 mm).

2. Water, Gas, Electric, Communications, and Sewer Lines: 10 feet (3 m.

3. Trees: 15 feet (5 m) 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 according to pole manufacturer's written instructions.

1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.

2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.

3. Install base covers unless otherwise indicated.

4. Use a short piece of 1/2 -inch (13-mm) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Poles and Pole Foundations Set in Concrete-Paved Areas: Install poles with a minimum 6-inch- (150-mm-) wide, unpaved gap between the pole or pole foundation and the edge of the adjacent concrete slab. Fill unpaved ring with pea gravel. Insert material to a level 1 inch (25 mm) below top of concrete slab.

F. Raise and set pole using web fabric slings (not chain or cable) at locations indicated by manufacturer.

3.4 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum using insulating fittings or treatment.

B. Steel Conduits: Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50-percent overlap.

3.5 GROUNDING

A. Ground Metal Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole unless otherwise indicated.

2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

B. Ground Nonmetallic Poles and Support Structures: Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole.

2. Install grounding conductor and conductor protector.

3. Ground metallic components of pole accessories and foundation.

3.6 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Special Inspections: Engage a qualified special inspector to perform the following special inspections:

1. Inspect poles for nicks, mars, dents, scratches, and other damage.

2. System function tests.

END OF SECTION

SECTION 268000 - ELEVATOR ELECTRICAL REQUIREMENTS

PART I - GENERAL

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

A. Coordination: All electrical equipment placement and installation shall be coordinated with the elevator contractor and shall not be located until elevator equipment is installed or coordination has been arranged with elevator contractor's equipment placement.

B. Contractor shall comply with the latest Elevator Code (ASME A17.1, Safety Code for Elevators and Escalators) including Chapter 30 of the International Building Code.

C. NEMA 4 : All electrical equipment, located less than 1225 mm (48 in.) above the pit floor, shall:

   a. Be weatherproof (NEMA 4).

   b. Have wiring identified for use in wet locations in accordance with the requirements in NFPA 70.

D. GFI Receptacles: 20 amp, NEMA 5-20R GFI receptacles in a separate dedicated 20 amp branch circuit shall be provided in all elevator machine rooms, machinery spaces and elevator pit areas as per ASME A17.1 NEC, 620.23(C) & 620.24(C).

E. Building Emergency Power to Elevator Machine Room and Elevator Car Lighting: Emergency power shall be provided to all elevator machine room lighting and to all elevator car lighting disconnects located in the elevator machine rooms.

   1. Emergency Power to Elevator Machine Room HVAC Unit: If elevator is to operate on building emergency power, the HVAC unit (if applicable) shall also be provided with building emergency power so to provide proper temperature environment for the elevator controller.

F. Lighting Required in Elevator Machine Rooms: Provide 4' long, linear LED light fixture in elevator machine rooms (and machinery spaces when present). The lighting fixture(s) within the elevator machine room shall be on a separate dedicated 20 amp branch circuit per NEC 620.23. Lighting shall be adequate to work on all equipment without shadowing. Refer to ASME A17.1.

G. Lighting Required in Elevator Pits: Provide a 4' long, NEMA 4, gasketed linear LED light fixture in all elevator pits, at every other elevator floor landing within the hoistway and and at top of elevator shaft. The lighting fixtures within the elevator pit/hoistway shall be on a separate dedicated 20 amp branch circuit. The location shall be determined after coordination with the elevator contractor so that the light fixture is located out of the way of all elevator equipment. Refer to ASME A17. When fire-fighters' emergency operation is active, the entire height of the hoistway shall be illuminated at not less than 1 foot-candle (11 lux) as measured from the top of the car of each fire service access elevator.

   1. Sub-Pit Light fixture and Light Switches (when present): If there is more than one level of an elevator pit, a three-way switch shall be provided in both the pit areas to operate a light fixture located in both locations. A light fixture shall be installed in each pit level. Both light

fixtures shall be wired so that they both operate at the same time by light switches at both pit levels.

H. Bulls Eye (Simplex) Receptacles: Bulls eye (simplex) receptacle for Sump pumps (not – GFI) on a designated circuit shall be provided in all elevator pits for the elevator pit sump pump. Provide 120VAC, single-phase, 20 amp dedicated branch circuit in a ¾-inch conduit to each sump pump receptacle.

I. Light Switch Required in Elevator Machine Rooms: Provide a 20 amp, single-pole 120VAC wall mounted line voltage light switch in each elevator machine room. Locate light switch directly adjacent to the jamb side of the machine room entry door. Refer to NEC 620.23, ASME A17.1.

J. Light Switch Required in Elevator Pits: The switch shall be a minimum of 18 inches above the elevator lowest landing doorsill and adjacent to (not behind) the pit access ladder. Refer to NEC 620.24(D), ASME A17.1.

K. Grounding: Grounding shall be supplied from the elevator main line disconnect and controller to the source panelboard or MCC and building ground.

L. Main Line Breaker or Disconnect (lockable, fused or breaker, a listed device): Shall be provided in all elevator machine rooms in sight of elevator motor and controller and adjacent to machine room entry door, one disconnect switch shall be provided for each elevator. A label on the disconnect is required stating location of overcurrent protection device.

M. Hydraulic Elevator Only: Main Line Disconnect Auxiliary Contact for Emergency battery Lowering Operation (when used): This item shall be provided by the electric contractor within the main line disconnect: If an emergency lowering system is utilized on a hydraulic elevator, there shall be an auxiliary contact associated with the main line disconnect that is in compliance with the NEC Section 620-91 (C).

N. Car Lighting Disconnect: Provide a separate branch circuit shall supply the car lights, receptacle(s), auxiliary lighting power source, and ventilation on each elevator car. Provide a lockable fused switch within a nema 1 enclosure in all elevator machine rooms. One disconnect required for each elevator. A label stating the location of the supply side overcurrent protection device is required on the disconnect. Refer to NEC 620.22(A) & 620.51(D).

O. Air Conditioning and/or Heater for Elevator Car (when required, commonly used with parking garage or glass elevators): When air-conditioning unit provided for elevator cab, a dedicated branch circuit shall supply the air-conditioning and heating units on each elevator car. The fused/breaker, lockable disconnect shall be provided and located in the elevator machine room. It shall have a tag stating the location of the supply side overload protecting device on it.

P. Shunt Trip Circuit Breaker Required When Sprinklers are Present: Electric contractor shall provide a shunt trip circuit breaker for the elevator main line power in order to remove power from elevator controls before any sprinkler is activated in the elevator machine room and hoistway overhead. The shunt trip circuit breaker shall be installed in the elevator machine room. Refer to ASME A17.1.

Q. Two Separate Circuits for Elevator Pit: The elevator pit shall be provided with a separate branch circuit supplying pit lighting and receptacle(s) and another circuit for the pit sump pump.

R. Separate Branch Circuit for Machine Room Lighting and Outlets: A separate branch circuit shall supply the elevator machine room space lighting and receptacles.

S. Electrical Component NEC Clearances: Clearances around all electrical equipment in the elevator machine room shall comply with NEC 110-26 electrical clearances requirements. The electrician's work and equipment placement shall be coordinated with the elevator contractor's equipment placement.

T. Electrical Conduit Runs: All electrical conduit runs provided by the electrical contractor and elevator contractor to the elevator equipment shall be run overhead or in a manner which does not restrict access to and around any equipment.

U. Emergency Phone and Data Line: Conduit shall be provided by electrical contractor in all elevator machine rooms to the elevator controller. Electrical contractor shall provide electrical conduit and associated CAT 6 low voltage wiring for both the emergency elevator phone and required data line to the elevator machine room, to the elevator controller, and terminated on the elevator controller with coordination from the elevator contractor.

V. Overhead Machinery Spaces (if present): GFI receptacles, light fixtures, light switches shall be provided within in elevator overhead machinery spaces if overhead machinery space requires "full body entry" (as defined by elevator code).

W. Where an emergency or standby power system is provided to operate an elevator in the event of normal power supply failure, the following requirements shall be complied with:

1. The emergency or standby power system shall be capable of operating the elevator(s) with rated load, at least one at a time, unless otherwise required by the building code.

2. The transfer between the normal and the emergency or standby power system shall be automatic.

3. An illuminated signal marked "ELEVATOR EMERGENCY POWER" shall be provided in the elevator lobby at the designated level to indicate that the normal power supply has failed and the emergency or standby power is in effect.

4. Where the emergency or standby power system is not capable of operating all elevators simultaneously, requirements the following shall be conformed to.

5. A selector switch(es) marked "ELEVATOR EMERGENCY POWER" in red lettering a minimum of 5 mm (0.25 in.) in height, that is key-operated or under a locked cover, shall be provided to permit the selection of the elevator(s) to operate on the emergency or standby power system. The key shall be Group 3 Security.

6. The selector switch(es) positions shall be marked to correspond with the elevator identification number and a position marked "AUTO."

7. The selector switch(es) shall be located at the designated level in view of all elevator entrances, or if located elsewhere means shall be provided adjacent to the selector switch(es) to indicate that the elevator is at the designated level with the doors in the normally open position.

8. When the selector switch is in the "AUTO" position, automatic power selection shall be provided, that will return each elevator that is not on designated attendant operation, inspection operation, or Phase II In-Car Emergency Operation, one or more at a time, to the recall level. Failure of the selected car to move shall cause power to be transferred to another car.

9. The selector switch(es) positions corresponding to the elevator identification numbers shall override the automatic power selection. Operation of the selector switch(es) shall not cause power to be removed from any elevator until the elevator is stopped. NOTE: The selector switch(es) should normally be placed in the "AUTO" position.

10. When the emergency or standby power system is designed to operate only one elevator at a time, the energy absorption means (if required) shall be permitted to be located on the supply side of the elevator power disconnecting means, provided all other requirements of this section are conformed to when operating any of the elevators the power might serve. Other building loads, such as power and lights that can be supplied by the emergency or standby power system, shall not be considered as a means of absorbing the regenerated energy for the purposes of conforming to this section, unless such loads are normally powered by the emergency or standby power system.

END OF SECTION

SECTION 270000 - COMMUNICATION GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. This section used in conjunction with each separate specification section outline the general communications design requirements, administration topics, and installation requirements for Information Technology System (ITS).

B. Reference acoustic AC Drawings series for all conduit penetrations and electrical back box conditions. Contractor to comply with all acoustic requirements.

C. Related Requirements

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
2. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them, including but not limited to the following:
3. This specification covers all general requirements for work under this contract and the following specification sections:

    a. Section 27 05 26 - Bonding and Grounding
    b. Section 27 05 28 - Pathways
    c. Section 27 05 29 - Hangers and Supports
    d. Section 27 05 33 - Conduits and Boxes
    e. Section 27 05 53 - Identification
    f. Section 27 08 00 - Commissioning
    g. Section 27 11 16 - Cabinets Racks and Enclosures
    h. Section 27 11 19 - Termination Blocks and Patch Panels
    i. Section 27 11 23 - Cable Management and Runway
    j. Section 27 13 13 - Copper Backbone Cabling
    k. Section 27 13 23 - Optical Fiber Backbone Cabling
    l. Section 27 13 33 - Coaxial Backbone Cabling
    m. Section 27 13 34 - Coaxial Splicing and Termination
    n. Section 27 15 13 - Copper Horizontal Cabling
    o. Section 27 15 33 - Coaxial Horizontal Cabling
    p. Section 27 15 43 - Faceplates and Connectors
    q. Section 27 16 19 - Patch Cords

4. Reference acoustic AC Drawings series for all conduit penetrations and electrical back box conditions. Contractor to comply with all acoustic requirements.

    a. REFERENCES:

D. Abbreviations:

1. A/E: Architect / Engineer (designer)
2. ACT: Acoustical Ceiling Tile
3. BET: Building Entrance Terminal
4. CBC: Coupled Bonding Conductor
5. CFOI: Contractor Furnished Owner Installed
6. E.E. Electrical Engineer
7. EMI: Electromagnetic Interference

8. GE: Ground Equalizer
9. IDC: Insulation Displacement Contact
10. IDF: Intermediate Distribution Facility
11. I/O: Information Outlet or Work Area Information Outlet
12. LAN: Local Area Network
13. LOMMF: Laser Optimized Multimode Fiber
14. MC: Main Cross-Connect
15. MDF: Main Distribution Facility
16. NIC: Not In Contract
17. OTDR: Optical Time Domain Reflectometer
18. RCDD: Registered Communications Distribution Designer
19. TBB: Telecommunications Bonding Backbone
20. TBC: Telecommunications Bonding Conductor
21. TGB: Telecommunications Ground Bus Bar
22. TMBC: Telecommunications Main Bonding Conductor
23. TMGB: Telecommunications Main Grounding Bus Bar

1.2 REFERENCE STANDARDS & CODES:

A. The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

B. All reference amendments adopted prior to the effective date of this Contract shall be applicable to this Project.

C. The publications listed in this section form a part of this specification. The publications are referred to in the text of applicable specifications by basic designation only.

D. Specific reference in specifications to codes, rules, regulations, standards, manufacturer's instructions, or requirements of regulatory agencies shall mean reference to the latest edition of each as adopted by the projects local AHJ.

E. It shall be the responsibility of the installing contractor to verify the applicable code version for all work performed with the authority having jurisdiction (AHJ).

F. Conflicts:

1. Drawings and specifications are to be used in conjunction with one another and to supplement one another. In general, the specifications determine the nature and quality of the materials and tests, and give characteristics of performance that should be adhered to in the installation of the communications system components, the drawings establish the quantities and details of installation.
2. If there is an apparent conflict between the drawings and specifications, or between specification sections, the items with the greater quantity or quality shall be estimated and installed.
3. Clarification with the Owner and/or Owner's Representative about these items shall be made prior to ordering and installation of components.

G. All materials, installation and workmanship shall comply with the most recently approved applicable reference standards and codes addressed within each specification document.

1. The latest edition of all listed standards as current as of the date that the work is advertised for bids
2. The latest edition of the codes as approved and adopted by the agency/authority having jurisdiction (AHJ) as of the date that the work is advertised for bids, shall apply to the work under the Contract Documents.
3. Codes and Regulations: (Note: Reference Division One for specific code versions governing the work in addition to the information noted below.)

    a. National Electric Code (NEC)
    b. National Electric Safety Code (NESC)

c. National Fire Protection Association (NFPA)
d. Life Safety Code (NFPA 101)
e. Local Municipal Codes

4. IEEE Standards: 1100-1992: Powering and Grounding Sensitive Electronic Equipment
5. ANSI/IEEE 802.12 100Base-TX Ethernet
6. ANSI/IEEE 802.3ab 1000Base-T Ethernet Specification
7. ANSI/IEEE 802.3ae 10Gb/s Ethernet Specifications
8. ANSI/IEEE 802.11 Wireless Ethernet Specifications, including 802.11a, 802.11b, 802.11g, 802.11n, 802.11ac and 802.11ax
9. EIA-310 Cabinets, Racks, Panels and Associated Equipment Standard
10. ANSI/TIA/EIA-455-57 FOTP-57, Preparation and Examination of Optical Fiber End Face for Testing Purposes
11. ANSI/TIA-455-78 FOTP-78, Measurement Methods and Test Procedures – Attenuation
12. ANSI/TIA-455-95 FOTP-95, Absolute Optical Power Testing for Optical Fiber and Cables
13. ANSI/TIA-455-133 FOTP-133, Measurement Methods and Test Procedures – Length Measurement
14. TIA-492AAAD Detail specification for 850-nm laser-optimized, 50-um core diameter/125-um cladding diameter class Ia graded-index multimode optical fibers.
15. TIA-492CAAB Detail Specification for Class lVa Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak
16. ANSI/TIA-526-7 OFSTP-7, Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant
17. ANSI/TIA-526-14 OFSTP-14, Optical Power Loss Measurement of Installed Multimode Fiber Cable Plant
18. ANSI/TIA/EIA-568 Series of Standards for Commercial Building Telecommunications
19. ANSI/TIA-569 Commercial Building Standard for Telecommunications Pathways and Spaces
20. TIA-598 Optical Fiber Color Coding
21. ANSI/TIA-606 Administration Standard for Telecommunications Infrastructure
22. TIA-607 Generic Telecommunications Grounding (Earthing) and Bonding for Customer Premises
23. ANSI/NECA/BICSI 607 Standard for Telecommunications Bonding and Grounding
24. TIA-758 Customer-owned Outside Plant Telecommunications Infrastructure Standard
25. ANSI/TIA-942: Telecommunications Infrastructure for Data Centers
26. ANSI/TIA-1179-2010 “Healthcare Facility Telecommunications Infrastructure Standard”.
27. ANSI/UL1479, “Fire Tests of Through Penetration Firestops”.
28. ASTM E 814, “Fire Tests of Through Penetration Firestops”.
29. BICSI - Telecommunications Distribution Methods Manual
30. BICSI - Information Technology Systems Installation Manual
31. BICSI - Outside Plant Design Reference Manual
32. BICSI - Electronic Safety and Security Design Reference Manual
33. Underwriters Laboratories (UL) Cable Certification and Follow-Up Program.
34. National Electrical Manufacturers Association (NEMA)
35. American Society for Testing Materials (ASTM)
36. Institute of Electrical and Electronic Engineers (IEEE)
37. UL Testing Bulletin
38. Equipment of foreign manufacture must meet U.S. codes and standards. It shall be indicated in the proposal the components that may be of foreign manufacture, if any, and the country of origin.

1.3 SCOPE OF WORK:

A. Work of this section covers a complete installation of both permanent and channel links for a Structured Information Technology Infrastructure utilizing copper and fiber transmission media that includes but is not limited to the following. The Contractor shall:

1. Comply with all Master Specifications documents and requirements for a complete and functioning project installation.
2. It shall be the responsibility of the Division 27 contractor to coordinate with Division 26 and other trades to ensure pathways and all infrastructure are installed to comply with all specifications and contract documents.

a. Verify conduit routing does not cause cabling to exceed specified electrical length, pulling tension, bend radius, or bend quantity.
b. Verify Bonding and grounding from MDF and TR rooms to Grounding Electrode System provided by Division 26 contractor meets Division 27 specifications.

3. Provide a structured cabling system as described hereafter that includes, but is not limited to, supplying, installing, labeling and testing of: fiber and copper riser and backbone cable; fiber and copper horizontal cabling, cable connectors, communications outlets and terminations, and equipment racks/cabinets for networking hardware, patch panels, and patch cords as required to provide a complete and functioning system.
4. Furnish all labor, materials, tools, equipment and services for the installation described herein. Provide add/deduct unit pricing for all components as part of the bid response. Assume an average cable length of 180 linear feet for comparative purposes. All requirements and specifications shall be enforced. Cable pathways and runs to individual outlets are not shown in their entirety, but shall be provided as if shown in their entirety.
5. Follow industry standard installation procedures for communications cable to assure that the mechanical and electrical transmission characteristics of the installed cable plant and equipment are maintained.
6. Verify or provide and install UL-listed firestopping systems in all communication pass-throughs, conduits and cable trays, used in ceiling, wall and floor penetrations in coordination with General Contractor.
7. Provide Submittals prior to commencement of work as outlined later in this specification.
8. Conduct a final document handover meeting with client, consultant, and PM to review, discuss and educate the Owner on the test results and As-Built Drawings.
9. Provide a Manufacturer's Extended Product Warranty and System Assurance Warranty for this structured cabling system.

B. Fire rated cable pathway devices shall be used in fire-rated construction for ALL low-voltage, video, data and voice cabling, optical fiber raceways and certain high-voltage cabling where frequent cable moves, adds and changes may occur. Pathways required for high voltage cabling will be detailed on the prints. Such devices shall:

1. Meet the hourly fire-rating of fire rated wall and or floor penetrated.
2. Be tested for the surrounding construction and cable types involved.
3. Have UL Systems permitting cable loads from; "*Zero to 100% Visual Fill*." This requirement eliminates need for fill-ratio calculations to be made by cable technicians to ensure cable load is within maximum allowed by UL System.
4. Not have inner fabric liner that tightens around and compresses cables tightly together encouraging potential cable damage or interference.
5. Be "Zero-Maintenance", zero-maintenance is defined as; No action required by cabling technician to open and/or close pathway for cable moves, adds or changes, such as, but not limited to:

    a. Opening or closing of doors.
    b. Spinning rings to open or close fabric liner.
    c. Removal and or replacement of any material such as, but not limited to, firestop caulk, putty, pillows, bags, foam muffins, foam, foam plugs, foam blocks, or foam closures of any sort.
    d. Evaluation Services Report (ESR) from an accredited Nationally Recognized Third-party Laboratory certifying compliance with this definition of "Zero-Maintenance" and all relevant codes and standards.

6. Pathways shall be engineered such that two or more devices may be ganged together for larger cable capacities.
7. Pathways shall be engineered to be re-enterable so they can be retrofitted and removed from around existing cables without cutting and re-splicing them.
8. Cable Pathway Devices passing vertically through floors shall have equal F & T Rating.
9. Affix adhesive wall label immediately adjacent to devices to communicate to future cable technicians, authorities having jurisdiction and others the manufacturer of the device and the corresponding UL System number installed.

C. Non rated cable pathway devices shall be used in non-fire-rated construction for ALL low-voltage, video, data and voice cabling, optical fiber raceways and certain high-voltage cabling where frequent cable moves, adds and changes may occur. Pathways required for high voltage cabling will be detailed on the prints. Such devices shall:

1. Limit the movement of smoke and sound of wall and or floor penetrated.
2. Restore the STC Rating of the penetrated assembly.
3. Provide L Ratings of <1 CFM when empty and <2.5 CFM at all other loading up to 100 percent.
4. Accommodate cable loads from; "*Zero to 100% Visual Fill*."
5. Not have inner fabric liner that tightens around and compresses cables tightly together encouraging potential cable damage or interference.
6. Be "Zero-Maintenance", zero-maintenance is defined as; No action required by cabling technician to open and/or close pathway for cable moves, adds or changes, such as, but not limited to:

    a. Opening or closing of doors.
    b. Spinning rings to open or close fabric liner.
    c. Removal and or replacement of any material such as, but not limited to, firestop caulk, putty, pillows, bags, foam muffins, foam, foam plugs, foam blocks, or foam closures of any sort.

7. Furnish letter from manufacturer certifying compliance with this definition of "Zero-Maintenance". Pathways shall be engineered such that two or more devices may be ganged together for larger cable capacities.
8. Pathways shall be engineered to be re-enterable so they can be retrofitted and removed from around existing cables without cutting and re-splicing them.
9. Affix adhesive wall label immediately adjacent to devices to communicate to future cable technicians, authorities having jurisdiction and others the manufacturer of the device and the corresponding UL System number installed.

D. As an alternate to using a fire-rated or non-rated cable pathway device for single low voltage cables (up to 0.27 in. (7 mm) O.D) penetrating one or two-hour, gypsum board/stud wall assemblies or non-rated assemblies, either as a through-penetration or as a membrane-penetration, a fire-rated cable grommet may be substituted. The product shall consist of a molded, two-piece, plenum-rated grommet having a foam fire and smoke sealing membrane that conforms to the outside diameter of the individual cable. The grommet product shall be capable of locking into place to secure the cable penetration within the wall assembly. The grommet shall be UL Classified and tested to the requirements of ASTM E814 (UL1479) and CAN/ULC S115.

E. Where non-mechanical pathways must be utilized, such as sealing (caulking) around single or grouped conduits, provide products that upon curing do no re-emulsify, dissolve, leach, breakdown or otherwise deteriorate over time from exposure to atmospheric moisture, sweating pipes, ponding water or other forms of moisture characteristic during or after construction. Provide letter from manufacturer certifying compliance with this section.

F. Cable pathway shall replace conduit sleeves in walls and floors, and;

1. When installed individually in floors, devices shall pass through core-drilled opening utilizing tested floor plates.
2. When multiple units are ganged in floors, devices shall be anchored by means of a tested grid.
3. When installed individually in walls, devices shall pass through core drilled opening utilizing tested wall plates or integrated flanges.
4. When multiple units are ganged in walls, devices shall be anchored by means of a tested grid.

G. Cable tray shall terminate at each barrier and resume on the other side such that cables pass independently through devices. Cable tray shall be properly supported on each side of the barrier.

1.4 PRODUCTS AND WORK BY OTHERS (NIC) INCLUDES:

A. The Owner may separately purchase and/or provide certain equipment and miscellaneous items that will be installed during the course of the installation process. Such items may not be indicated in the project documents. Contractor shall coordinate with the Owner to ensure the ITS is built factoring:

1. Provision and installation of phone systems, computer hardware, and related networking software and equipment.
2. Provision and installation of UPS in communications rooms.
3. Communications grounding busbars and bonding conductors connecting to the main building electrode system.
4. Dedicated power panels, ground busbars, circuits and utility outlets.
5. Installation and finishing of plywood backboards.
6. Building mechanical ductwork, cooling/heating system, and environmental control sensors.
7. Communication pathway devices such as, but not limited to, cable tray and flex-tray in corridors, office spaces and open areas, conduits, conduit sleeves, and penetrations in walls and floors.

1.5 MEASUREMENT PROCEDURES:

A. The Contractor shall

1. Verify dimensions in areas of installation by field measurements before fabrication and indicate measurements and scale on shop drawings.
2. Coordinate fabrication schedule with construction progress to avoid delaying the project.
3. Where field measurements cannot be made without delaying the project, establish dimensions and coordinate with the General Contractor, and when approved, proceed with fabricating units without field measurements.
4. Coordinate supports, adjacent construction, and fixture locations to ensure actual dimensions correspond to established dimensions.
5. Immediately notify the Project Team of any discrepancies before and during construction.

1.6 ALTERNATES:

A. If an alternate material is proposed that is equal to or exceeds specified requirements, Contractor shall provide manufacturers' specifications in writing for Owner approval prior to purchase and installation.

B. Substitutions of material by the Contractor shall be in writing complete with written manufacturers' specifications. The material substituted shall not void, alter or change manufacturers' structured cabling system warranty.

C. Contractor shall:

1. Provide a complete cabling ITS infrastructure according to the project written specifications and drawings.
2. Respond to these changes with a complete material list, including pricing, labor, and taxes in writing presented to the Owner's Representative for approval.
3. Not proceed with additional scope of work without a signed approval by the Owner.

D. Any additional work performed by the Contractor without signed approval of these changes shall be at the contractors own risk. Contractor will submit a copy of signed change order upon billing.

1.7 SUBSTITUTION PROCEDURES

A. Substitution may be considered when a product becomes unavailable through no fault of the Contractor.

B. Document each request with complete data substantiating compliance of proposed substitution with Contract Documents. Include in each request for substitution:

1. Product identification, manufacturer's name and address.
2. Product Data: Description, performance and test data, reference standards, finishes and colors.
3. Samples: Finishes
4. Complete and accurate drawings indicating construction revisions required (if any) to accommodate substitutions.
5. Data relating to changes required in construction schedule.
6. Cost comparison between specified and proposed substitution.
7. Product specification cut sheets.

C. Substitutions will not be considered when they are indicated or implied on shop drawing or product data submittals without separate written request, or when acceptance will require revision to the Contract Documents.

D. The Owner will be the final judge of acceptability, with review by Owner's Representative and the distribution of the acceptance by the Architect. No substitute shall be ordered, installed or utilized without the Architect's prior written verification of acceptance from the Owner.

1.8 SYSTEM DESCRIPTION:

A. The objective of this project is to provide a complete ITS infrastructure installation including, but not limited to, fiber backbone, riser system, horizontal data and voice cabling with associated terminations, mounting equipment, cable pathway and management systems, testing and other items/materials, as specified in drawings, these specifications, and contract documents.

1.9 SUBMITTALS:

A. The Contractor:

1. Shall submit a minimum of six (6) weeks prior to the commencement of any work all shop drawings, product data, or samples for approval by the Owner's Representative. Such work shall be in accordance with the requirements of all specification sections related to the work.

    a. Shop drawings as required by the owner or as a minimum to include an electronic set of plan view and elevations of all work to be installed. The Contractor shall make any corrections required by the owner or the owner's representative or consultant team, file corrected copies and furnish such other copies as may be needed. The consultant's approval of such drawings or schedules shall not relieve the Contractor from responsibility for deviations from drawings or specifications, unless the Contractor has in writing called the Architect's attention to such deviations at the time of submission, nor shall it relieve the Contractor from responsibility for errors of any sort in shop drawings or schedules.

2. Shall not perform any portion of the work that would disqualify any part or all of the ITS installation from the Manufacturer's warranty qualification.

B. The Contractor shall provide a copy of the Certified Test Data Sheet, available from the delivering distribution warehouse for either a full run or cut piece from the Master Reel of the fiber cable to be installed:

1. The Certified Test Data Sheet shall include the Master Reel number, cable description, a passing test result with details, test equipment description, date certified, and a certificate of compliance stamp, and shall be included in the O&M Manual as a component of the final deliverables submittal package.
2. Contractor shall also include a copy of their acceptance test performed prior to installing the delivered optical fiber.

C. The Contractor shall provide the appropriate documentation from the certifying manufacturer showing the project is registered and qualified for the System Assurance Warranty. All subsequent work shall be in accordance with approved submittals.

D. The Contractor's BICSI Registered Communications Distribution Designer (RCDD) supervisor shall review, approve and stamp all documents prior to submitting. The Contractor's RCDD shall warrant in writing that 100% of the installation meets the requirements specified herein upon completion of all work.

E. Product Certificates shall be signed by manufacturers of cables, connectors, and terminal equipment certifying that products furnished comply with requirements.

F. Contractor shall submit the required Field Test Reports in the format and media specified, upon completion of testing the installed system.

G. Contractor shall deliver manufacturer's signed long-term Warranty of installed cabling system to include all components that comprise the complete cabling system. Delivery to be affected within two weeks of the time of final punch list review. Failure of any component to pass system component tests shall be promptly corrected, repaired or replaced to meet standards compliance. Contractor shall coordinate with manufacturer for warranty paperwork and procedures prior to the start of the project.

H. Cable Commissioning Plan:

1. The Contractor shall:

    a. Provide a complete and detailed commissioning plan for approval of the cabling system specified herein, including a complete list of test equipment for copper and fiber optic components and accessories prior to beginning cable testing. The following minimal items shall be submitted for review:
    b. Comply with all testing procedures and methods as listed in Specification 27 08 00 Communication Commissioning.
    c. Provide product data for test equipment.
    d. Provide certifications and qualifications of all persons conducting the testing.

2. Calibration certificates indicating that equipment calibration meets National Institute of Standards and Technology (NIST) standards and has been calibrated at least once within the previous year of the testing date.

    a. Include validation, and testing. Owner will require that the communications cabling system installed by the Contractor be fully certified to meet all necessary requirements to be compliant with referenced IEEE and TIA standards, specifications, and vendor's warranty.
    b. Will determine the source/cause of test failure readings and correct malfunctioning component and/or workmanship within each channel or permanent link and retest to demonstrate compliance until corrected failure produces a passing result.

I. Cable Testing Reports: The Contractor shall submit cable test reports as follows:

1. Submit certified test reports of Contractor-performed tests.

    a. The tests shall clearly demonstrate that the media and its components fully comply with the requirements specified herein.
    b. One (1) set of electronic version of test reports shall be submitted together and clearly identified with cable identification.
    c. Include software required to read test reports.

2. Cable inventory data shall be submitted for all fiber, copper, and coaxial cabling and termination equipment. Submit data electronically on CD-ROM, listing products furnished, including:

    a. Manufacturer's name.
    b. Manufacturer's part numbers.
    c. Cable numbers.
    d. Location and riser assignments.

e. Product Data:

3. Equipment and materials shall be standard products of a manufacturer regularly engaged in the manufacture of communications cabling products and shall be the manufacturer's latest standard design in satisfactory use for at least one year prior to bid opening.

J. Shop Drawings:

1. The Contractor shall:

a. Submit catalogue cut-sheets that include manufacturer, trade name, and complete model number for each product specified. Model number shall be marked with an arrow, highlighted, or underlined to indicate exact selection.
b. Identify applicable specification section reference for each product performance for each component specified for approval prior to purchase and installation.
c. Submit for approval diagrams showing room layouts, rack layouts (including elevations), riser layouts, etc.
d. Submit sample floor plan demonstrating outlet administration, clearly identifying each outlet with correct nomenclature, and legibly located on drawing.

K. Qualifications:

1. The Contractor shall provide the appropriate documentation to comply with the requirements described in SECTION 1.12- QUALITY ASSURANCE, included with, and at the time of bid submittal.

L. Closeout Submittals (As-built Drawings):

1. As-Built drawings are to be supplied to the Architect to prepare the Record Drawings.
2. As-Built drawings shall be in AutoCAD format, same version as used by Architect and consultant. Dimensions and scale of the drawing sheets submitted shall match the size of the drawing used for the contract documents, and shall include the cable numbers labeled in accordance with this document.
3. Utilize industry recognized drafting procedures that match Architect and consultant guidelines, methodology, and symbols.
4. The As-Built drawings shall incorporate all changes made to the building identified in, but not limited to, addendum, change notices, site instructions or deviations resulting from site conditions.
5. Contractor shall:

a. Clearly identify any resubmitted drawing sheets, documents or cut sheets either by using a color to highlight or cloud around resubmitted information.
b. Maintain drawing numbering, and graphic symbol consistency as per drawings issued by Architect

6. Provide dimensioned plan and elevation views of networking components, showing:

a. All communications data/voice outlet locations complete with outlet/cable labeling.
b. Cable routing paths of communications cables to identified infrastructure pathways.
c. All rack and cabinet locations and labeling thereof.
d. Standard or typical installation details of installations unique to Owner's requirements.

1.10 QUALITY ASSURANCE

A. Regulatory Requirements:

1. Contractor shall supply all city, county, and state communication cabling permits required by appropriate governing agency.
2. Contractor shall be state-licensed and/or bonded as required for communications/low voltage cabling systems.

B. Certifications:

1. Contractor shall submit an up-to-date and valid certification verifying qualifications of the Contractor and installers to perform the work specified herein at time of bid submission.
2. Contractor shall have a complete working knowledge of low voltage cabling applications such as, but not limited to data, voice and video network systems.
3. Contracting firm shall have installed similar-sized systems in at least ten (10) other projects in the last five years prior to this bid and be regularly engaged in the business of installation of the types of systems specified in this document. Certification shall include, but not be limited to, items such as name and location of project contacts and numbers, total square footage, total number of cables/drops, types of media, etc.
4. Contractor shall provide certificates for the appropriate insurance coverage as defined in contract documents.
5. All installer personnel that will be assigned to this project shall be listed in the qualification questionnaire document. 25% shall have a minimum of 3 years' experience in the installation of the types of systems, equipment, and cables specified in this document prior to this bid. Any personnel substitutions shall be noted in writing to Owner prior to commencement of work.
6. Contractor shall provide a registered BICSI Technician who shall act as the on-site Foreman throughout the duration of the project.
7. Contractor shall submit evidence of compliance with these requirements prior to beginning work on the project.
8. Cabling installers shall be trained and certified by the connectivity/cable manufacturer for communication cabling installations and maintenance of said materials. Refer also to General Conditions.

C. Products/Systems: Provide firestopping systems that comply with the following requirements:

1. Firestopping tests are performed by a qualified, testing and inspection agency. A qualified testing and inspection agency is UL, or another agency performing testing and follow-up inspection services for firestop system acceptable to authorities having jurisdiction.
2. Firestopping products bear the classification marking of qualified testing and inspection agency.
3. Installer Qualifications: Experience in performing work of this section who is qualified by the firestopping manufacturer as having been provided the necessary training to install firestop products in accordance with specified requirements.

1.11 ADMINISTRATIVE REQUIREMENTS AND COORDINATION:

A. The Contractor shall:

1. Provide a specified contact person (name and contact number) for coordination to attend project meetings with the communication consultant, the Owner and others.
2. Install and coordinate the communications cabling work in cooperation with other trades installing interrelated work. Before installation, make proper provisions to avoid interference in a manner accepted by the A/E. Any repairs or changes made necessary in the contract work, caused by the contractors' neglect, shall be made by the contractor at their own expense
3. Coordinate work of this section with Owner's telephone system specifications, workstations, equipment suppliers, and installers.
4. Coordinate installation work with other crafts (examples include ceiling grid contractors, HVAC and sheet metal contractors, etc.) to resolve procedures and installation placement for cable trays and cable bundle pathways. The goal of this coordination will be to establish priority pathways for critical structured cabling infrastructure, materials, associated hardware, as well as mitigate delays to the project and to allow service access for communications and HVAC components. Damage by Contractor to the craftwork of others will be remedied at the Contractor's expense in a timely manner.
5. Exchange information and agree on details of equipment arrangements and installation interfaces. Record agreements reached in meetings and distribute record to other participants, Owner and communication consultant.
6. Adjust arrangement and locations of distribution frames, patch panels, and cross-connect blocks in equipment rooms and racks to accommodate and optimize arrangement and space requirements of any service provider

equipment, telephone system, and LAN equipment. Tasks shall be coordinated with Owner or his representative, and other trades' installation representatives.

7. Where installed, confirm exact locations and method of mounting outlets in modular furniture. Follow furniture manufacturers' written instructions for installing cable and devices in modular partitions. Obtain modular furniture and power pole locations from the General Contractor. Cabling locations noted in plans along walls or in floors for modular furniture are approximate and will have to be determined by Contractor at time of installation. Field condition adjustments for installation shall be made and coordination efforts with the electrical contractor for pathway must take place early on in the project to comply with maximum 40% conduit fill ratio requirements.
8. When requested by Owner or Owner's representative, furnish extra materials that match specified products and that are factory packaged with protective covering for storage and identified with labels describing contents.

B. Related Documents:

1. Drawings and General provisions of the contract, including Uniform General Conditions, Supplementary General Conditions, architectural plans and specifications, requirements of Division 01, electrical, mechanical, plumbing, audio visual, security and communications specifications and plans apply to the communications section, and shall be considered a part of this section. The Contractor shall read all sections in their entirety and apply them as appropriate for work in this section.
2. Contract Documents and the overall construction schedule must be carefully reviewed to determine all required interfacing and timing of the work. All such documents shall be available through the General Contractor or Construction Manager.
3. The Contractor will respect and protect the privacy and confidentiality of Owner, its employees, processes, products, and intellectual property to extent necessary, consistent with the legal responsibilities of the Owner's policies.
4. When required the contractor shall sign a non-disclosure agreement and abide by the requirements to keep confidential all information concerning bid documents and this project.
5. Use of Subcontractors: Successful bidder shall inform the Owner's contact and General Contractor in writing about the intention to use Subcontractors and the scope of work for which they are being hired. The Owner or Owner's designated contact must approve the use of Subcontractors in writing prior to the Subcontractor's hiring and start of any work.
6. The Contractor's designated project manager will be recognized as the single point of contact. The Project manager shall oversee all work performed to ensure compliance with specifications as outlined in bid documents (which includes all specifications and drawings) to ensure a quality installation.

1.12 CONTRACT ADMINISTRATION:

A. Change orders shall be submitted to the Owner/Project Manager complete with price breakdown and description for approval before any work is done.

B. Owner's Representative will provide job field reports upon inspection of Contractor's installation, materials, supporting hardware, coordination with other trades and progress to schedule to the client.

C. Job Field Report outline:

1. General installation progress in relation to scheduled work made by the Contractor up to that date.
2. All deficiencies noted in the cable installation to be corrected by the Contractor.

D. Pre-Installation Meetings - Contractor shall:

1. Attend and/or arrange a scheduled pre-installation conference prior to beginning any work of this section.

    a. Agenda: This venue is to ask and clarify questions in writing related to work to be performed, scheduling, coordination, etc. with consultant and/or project manager/Owner representative.

b. Attendance: Communications project manager/supervisor shall attend meetings arranged by General Contractor, Owner's representatives, and other parties affected by work of this document.
c. All individuals who will supervise installers of communication cables and equipment on-site, including project managers and lead installers, shall be required to attend the pre-installation conference. Individuals who do not attend the conference will not be permitted to supervise the installation of communications cables on the project.

E. Post-Installation Meetings:

1. At the time of substantial completion, or shortly thereafter, the Contractor shall call and arrange for a post-installation meeting to present and review all submittal documents to include, but not limited to as-built drawings, test reports, warranty documentation, etc. Attendees shall be Owner staff, Owner's Representative, General Contractor, and others that the General Contractor deems appropriate.
2. At this meeting the Contractor shall present and explain all documentation, and asking for feedback on its completeness. Any discrepancies or deviations noted by and agreed to by participants shall be remedied by Contractor and resubmitted within one week of meeting.

1.13 DELIVERY, STORAGE, AND HANDLING:

A. Coordination with delivery companies, drivers, site address, and contact person(s) will be the responsibility of the Contractor.

B. Contractor Shall:

1. Be responsible for prompt material deliveries to meet contracted completion date.
2. Coordinate deliveries and submittals with the General Contractor to ensure a timely installation.
3. No equipment materials shall be delivered to the job site more than three weeks prior to the commencement of its installation.
4. Equipment shall be delivered in original packages with labels intact and identification clearly marked.
5. Equipment shall not be damaged in any way and shall comply with manufacturer's operating specifications.
6. Equipment and components shall be protected from the weather, humidity, temperature variations, dirt, dust, or other contaminants. Equipment damaged prior to system acceptance shall be replaced at no cost to the Owner.
7. Contractor shall be responsible for all handling and control of equipment. Contractor is liable for any material loss due to delivery and storage problems.

C. Owner/General Contractor shall supply a list of security requirements for Contractor to follow.

1.14 PROJECT/SITE CONDITIONS

A. For all environmental recommendations, refer to master Architectural section.

B. For all security recommendations, refer to related Division 01.

C. After completing system installation, including outlet fittings and devices, inspect exposed finish. Contractor will remove burrs, dirt, and construction debris. If applicable, the Contractor will repair damaged finishes, including chips, scratches, and abrasions.

D. Contractor shall provide daily a clean work environment, free from dust, trash/rubbish accumulated during and after cabling installation.

E. Communication spaces shall be maintained in a dust/debris free manner at all times.

F. Contractor shall keep all liquids (drinks, sodas, etc.) off finished floors, carpets, and tiles. If any liquid or other detriment (cuts, soils, stains, etc.) damages the above finishes, Contractor shall provide professional services to clean or repair scratched/soiled finishes, at Contractor's expense.

G. Contractor shall coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.

H. Contractor shall coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.

I. Contractor shall schedule installation of firestopping after completion of penetrating item installation but prior to covering or concealing of openings.

1.15 WARRANTY

A. Twenty-Five (25) Year Extended Product Warranty

1. The 25 Year Extended Product Warranty shall ensure against product defects, that all approved cabling components exceed the specifications of TIA/EIA 568A and ISO/IEC IS 11801, exceed the attenuation and NEXT requirements of TIA/EIA TSB 67 and ISO/IEC IS 11801 for cabling links/channels, that the installation will exceed the loss bandwidth requirements of TIA/EIA TSB 67 and ICO/IEC 11801 for fiber links/channels, for a twenty-five (25) year period. The end-to-end passive product shall be capable of delivering 1Gb/s half-duplex mode/2Gb/s full-duplex mode to the workstation.
2. The Twenty-Five (25) Year Extended Product Warranty shall cover the replacement or repair of defective product(s) and labor for the replacement or repair of such defective product(s) for a twenty-five (25) year period.

B. Twenty-Five (25) Year Application Assurance

1. The Twenty-Five (25) Year Application Assurance shall cover the failure of the wiring system to support the application which it was designed to support, as well as additional applications(s) introduced in the future, up to 1Gb/s parallel transmission schemes, by recognized standards or user forums that use the TIA/EIA or ISO/IEC IS 11801 component and link/channel specifications for cabling, for a twenty-five (25) year period.

C. System Certification: Upon successful completion of the installation and subsequent inspection, the Owner shall be provided with a numbered certificate, from the manufacturer, registering the installation.

1.16 MAINTENANCE

A. Support Availability: The Contractor shall commit to make available local support for the product and system maintenance during the Warranty or Extended Warranty period.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Comply with specifications for each specific Division 27 section for acceptable products.

B. All materials shall be UL and/or ETL listed and labeled in accordance with NFPA 70 for all products where labeling service normally applies.

C. Materials and equipment requiring UL 94, 149 or 1863 listing shall be so labeled. Modification of products that nullifies UL labels is not permitted.

D. The installed systems shall not generate nor be susceptible to any harmful electromagnetic emission, radiation, or induction that degrades, or obstructs any equipment.

E. All material and equipment as provided should be the standard Commercial-Off-The-Shelf (COTS) products of a manufacturer engaged in the manufacturing of such products. All shall be typical

commercial designs that comply with the requirements specified. All material and equipment shall be readily available through manufacturers and/or distributors.

F. Coordinate the features of materials and equipment so they form an integrated system. Match components and interconnections for optimum future performance and backward compatibility.

G. Expansion Capability: Unless otherwise indicated, provide spare positions in patch panels, cross connects, and terminal strips, and space in cable pathways and backboard layouts to accommodate 20% future increase in campus distribution and active workstations.

H. Backward Compatibility: The provided solution shall be backward compatible with lower category ratings such that if higher category components are used with lower category components, the basic link and channel measures shall meet or exceed the lower channel's specified parameters.

I. Component Compliance: The provided solution's components shall each meet the minimum transmission specifications listed herein such that no individual component will be less than specifications for permanent link and channel, regardless of the fact that tests for link and channel ultimately meet required specifications.

J. In the event of a breach of the representations and warranties contained herein, the Contractor, at their own expense, shall take all measures necessary to make the cabling system work and comply with the applicable manufacturer written technical recommendations and standards.

PART 3 - EXECUTION

3.1 INSTALLATION CONTRACTOR

A. Provide and pay for all labor, supervision, tools, equipment, test equipment, tests and services to provide and install a complete inside and outside plant fiber and copper infrastructure system. Pay all required sales, gross receipts, and other taxes.

B. A BICSI RCDD shall be employed as the Project Manager and approve all on-site work as a recognized member of the Contractor's installation team. All installation team members must demonstrate knowledge and compliance with all BICSI, TIA, UL, and NEC methods, standards and codes.

3.2 EXAMINATION:

A. Field Measurements: Verify dimensions in areas of installation by field measurements before fabrication and indicate measurements on shop drawings. Coordinate fabrication schedule with construction progress to avoid delaying the work.

B. Established Dimensions: Where field measurements cannot be made without delaying the work, establish dimensions and proceed with fabricating units without field measurements. Coordinate supports, adjacent construction, and fixture locations to ensure actual dimensions correspond to established dimensions.

3.3 PREPARATION:

A. Contractor's RCDD Project Manager shall review, approve and stamp all shop drawings, coordination drawings As Built Drawings and submittal documents.

B. Pre-installation inspection

1. The Contractor shall visually inspect all cables, cable reels, and shipping cartons to detect possible cable damage incurred during shipping and transport. Visibly damaged goods are not acceptable and shall be replaced by the contractor at no additional cost to the Owner.

3.4 INSTALLATION:

A. General

1. Contractor shall install work following specifications, drawings, manufacturer's instructions and approved submittal data.
2. Allowable Cable Bend Radius and Pull Tension:

a. In general, communications cable cannot tolerate sharp bends or excessive pull tension during installation. Refer to cable manufacturer's bend radius recommendations for the maximum allowable limits.
b. After installation, exposed cable and other surfaces must be cleaned free of lubricant residue. Use only lubricants specifically designed for high performance cable installation.

B. Cable Bundles

1. Bundling of cables is to be avoided; where bundling is necessary bundles shall be limited to no more than 24 cables.
2. Allow cables to lay naturally in cable tray and runways whenever possible.
3. Cables shall be neatly dressed from the point of emergence from vertical cable managers to the point of termination.

C. Pull Strings:

1. Horizontal Cable

a. Provide pull strings in all new conduits, including all conduits with cable installed as part of this contract.
b. Pull string shall have a rated average breaking strength of 200 pounds.
c. Data and video cables can be pulled in tandem with pull strings. During pulling sessions, pull strings must move freely to prevent cable jacket/cable damage.

D. Conduit Fill:

1. Reference manufacturer's Design Installation Guidelines manual.
2. Comply with all applicable Listed Firestop Assembly requirements.

E. Firestop Procedures:

1. Install and seal penetrations (conduit, sleeves, slots, chases) into or through fire-rated barriers created by or made for or on the behalf of the Contractor to prevent the passage of smoke, fire, toxic gas, or water through the penetrations.
2. All through penetrations in a fire rated surface require a sleeve, regardless of penetration diameter or penetrating cable count.
3. Provide listed fire-resistant materials to restore originally-designed fire-ratings to all wall, floor, and ceiling penetrations used in the distribution and installation for communications cabling system. Coordinate firestopping procedures and materials with General Contractor. Following the pathway of others through compliant and non-compliant penetrations does not remove the requirement to maintain code-compliant firestopping.
4. Provide and install intumescent systems in floor chases in an approved fashion in all openings.
5. Shall supply Owner with training manuals with instructions on methods of adding or removing cabling to/from firestopped sleeves and chases.
6. Provide manufacturer's UL Listed Assembly Sheet for rated protection for all fire barrier penetrations.
7. Shall laminate and permanently affix adjacent to chases the following information:

a. Manufacturer of firestop system.
b. Date of installation/repair.
c. Listed Assembly number of system.

8. Solutions and shop drawings/submittals for firestop materials and systems shall be presented to the General Contractor for written approval of materials/systems prior to purchase and installation.
9. Materials shall be installed per manufacturer instructions, be UL-listed for intended use, and meet NEC and local codes for fire stopping measures.
10. The material chosen shall be distinctively colored to be clearly distinguishable from other materials, adhere to itself, and maintain the characteristics for which it is designed to allow for the removal and/or addition of communication cables without the necessity of drilling holes in the material.
11. Closeout ~~documentation~~ shall include digital photographs of all firestops related to communication cables.

F. Labeling

1. Cable Labels: Self-adhesive vinyl or vinyl-cloth wraparound tape markers, machine printed with alphanumeric cable designations.
2. Flat-surface labels: Self-adhesive vinyl or vinyl-cloth labels, machine printed with alphanumeric cable designations.
3. Contractor shall:

a. Coordinate with Owner correct nomenclature for all labeling.
b. Provide and install transparent plastic label holders, and 4-pair marked colored labels, according to the type of field as per ANSI/TIA-606-B color code designations.
c. Use the ANSI/TIA-606 designation strip color-code guidelines for voice, data, cross-connect, riser, and backbone fields.

G. Site Tests:

1. Upon completion of the communications infrastructure systems, including all pathways and bonding, the Contractor shall test the system.

a. Cables and termination modules/connectors shall be affixed, mounted or installed to the designed/specified permanent location prior to testing. Any removal and reinstallation of any component in the circuit shall require retesting of that circuit.
b. If the Contractor is found to have manipulated any failing test result for any reason (without written notice and approval of the Owner), the Contractor shall be required to employ a Third-Party Testing Agent selected by the Owner to retest the complete cable plant and shall be required to pay all costs associated with this retesting.

2. These specifications will be strictly enforced. The Contractor shall verify that the requirements of the specifications are fully met through testing with an approved tester (rated for testing the cable type in use), and documentation as specified below. This includes confirmation of requirements by demonstration, testing and inspection. Demonstration shall be provided at final walk-through in soft copy test data.
3. Notification of the likelihood of a cable exceeding standardized lengths must be made prior to installation of the cable. Without contractor's prior written notice and written approval by the Owner, testing that shows some or all pairs of cable not meeting specifications, shall be replaced at Contractor's expense (including respective connectors).
4. With the Owner's written approval, the over-length cable(s) may be excluded from requirements to pass standardized tests and shall be explicitly identified.
5. Testing is still required for non-compliant cabling. The tests shall be for wire-mapping, opens, cable-pair shorts, and shorts-to-ground. The test results must be within acceptable tolerances and shall be submitted with the Owner's acceptance document.
6. Third-Party testing of the completed cable infrastructure is an Owner option that can be implemented and completed after (1) all Contractor testing is complete and submitted, and (2) Contractor certifies that cable

plant meets or exceeds test result requirements as specified in these and ANSI/TIA test standards. Third-Party testing can be implemented at the Owner's discretion by:

a. The Owner's preference to independently confirm the submitted Contractor's standards-compliant testing results.
b. Payment of all Third-Party testing shall be by the Owner if the Third-Party testing is requested for confirming Contractor 's complete and standards-compliant test results.
c. Third-Party shall pick a randomized sample of 15% of total installed cable plant. Prior to testing, this party shall develop and submit a test schedule for approval by Owner.
d. Third-Party testing processes will adhere to the testing protocols delineated in this document under Section 1.10 and Specification Section 27 08 00
e. All Third-Party tested cables that test as failed shall be retested by the Third Party to confirm failure.
f. If Third-Party tests show a failure rate of 2% or greater of tests of all completed cabling, this shall force the retesting of the complete cable plant by the Third-Party at the Contractor's expense.
g. All confirmed failures shall be promptly corrected and retested by Contractor and Third-Party under the same testing protocols and guidelines.
h. Payment of all Third-Party testing shall be by Contractor from Contractor's original accepted bid if Third-Party testing is required.
i. Third-Party shall retest 100% of the total installed cable plant. Prior to testing, this party shall develop and submit a test schedule for approval by Owner.
j. All Third-Party tested cables that test as failed shall be retested by the Third Party to confirm failure.
k. All confirmed failures shall be promptly corrected the installing contractor and retested by Third-Party under the same testing protocols and guidelines.
l. Contractor will complete all work and documentation according to manufacturer guidelines to ensure manufacturer's warranty remains in effect. Contractor shall obtain certificates from manufacturer attesting to warranty being in effect and include certificates with other deliverables due at the completion of the project.
m. Owner reserves the right to be present during any or all testing.

3.5 CLEANING

A. Work areas will be kept in a broom clean condition throughout the duration of the installation process.

B. Remove all unnecessary tools and equipment, unused materials, packing materials, and debris from each area where Work has been completed unless designated for storage.

C. The Contractor will damp clean all surfaces prior to final acceptance by Owner.

3.6 ACCEPTANCE

A. Once all work has been completed, test documentation has been submitted, and Owner is satisfied that all work is in accordance with contract documents, the Owner shall notify Contractor in writing of formal acceptance of the system.

B. Contractor must warrant in writing that 100% of the installation meets the requirements specified herein (Standards Compliance & Test Requirements).

C. Acceptance shall be subject to completion of all work, successful post-installation testing which yields 100% PASS rating, and receipt of full documentation soft and hard copies as described herein.

3.7 RE-INSTALLATION

A. No additional burden to Owner regarding costs, network down-time and/or end user interruption shall result from the re-installation of specified components. Scheduling for re-installation work shall be coordinated, in writing, with Owners Representative prior to beginning the work.

3.8 CLOSEOUT ACTIVITIES

A. Contractor shall provide documentation of all communications system components under this section utilized throughout the site for review and reference by Owners Representative and A/E team.

B. Contractor to submit all as-built drawings and test documentation required prior to acceptance by Owners Representative.

C. Issues and deficiencies identified in field reports and punch lists shall have been resolved. Final as-built drawings shall have been submitted, reviewed and found to meet the requirements of the specifications.

D. Contractor shall provide written notice of substantial completion of the telecom infrastructure. Upon receipt, the Owner's Representative will review/observe the completed installation. Once the Owner's Representative is satisfied that all work is in accordance with the Contract Documents, the Contractor will be notified in writing.

E. Contractor's RCDD shall warrant in writing that 100% of the installation meets the requirements of all project specifications.

END OF SECTION

SECTION 270526 - COMMUNICATION BONDING AND GROUNDING

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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 DESCRIPTION

A. The work covered by this Specification Section includes all labor necessary to perform and complete such construction, materials not provided by the Owners Representative, equipment incorporated or to be incorporated in such construction, and all services, facilities, tools and equipment necessary or used to perform and complete such construction.

1.3 SECTION INCLUDES

A. Telecommunications Busbars

B. Bonding Conductors and Components

1.4 REFERENCE STANDARDS AND CODES

A. Refer to Section 27 00 00 Communications for list of Reference Standards, Codes, and Documents. PART 1.3

1. Specific standards may be referenced throughout this section.

1.5 SCOPE

A. Bonding of all metallic components within ITS spaces, such as, but not limited to, building steel, ladder rack, cable runway, cable tray, racks, cabinets, and conduits.

B. Testing of all bonding connections shall be conducted under the requirements of this specification.

1.6 SUBMITTALS

A. Refer to Section 27 00 00 Communications. - PART 1.10

1.7 QUALITY ASSURANCE

A. Refer to Section 27 00 00 Communications. - PART 1.11

1.8 CONTRACT ADMINSTRATION

A. Refer to Section 27 00 00 Communications. – PART 1.12 – 1.13

PART 2 - PRODUCTS

2.1 ALTERNATES AND SUBSTITUTIONS

A. Refer to Section 27 00 00 Communications. PART 1.7 – 1.8

2.2 BUSBAR ASSEMBLY:

A. Manufacturer

1. Harger Lightning & Grounding

2. ERICO International Corporation

3. Cooper Industries

4. NO Substitutions Allowed

B. TMGB: 1/4-inch-thick by 4 inches high of variable length pre-drilled with TIA standard hole patterns and spacing. Number of required connections determines length of busbar.

C. TGB: 1/4-inch-thick by 2 inches high of variable length pre-drilled with TIA standard hole patterns and spacing. Number of required connections determines length of busbar.

D. When Isolated Ground is required:

1. Rack mounted busbar: solid ~~copper~~ aluminum busbar 1/8-inch-thick by 2 inches wide and threaded 10-32. Varying height

E. Insulators: The busbar shall be insulated from its support.

F. Wall mounting brackets shall provide a minimum 2" separation from the wall to the back of the busbar

G. Busbars shall be UL Listed as bonding and grounding equipment.

2.3 BONDING CONDUCTORS AND COMPONENTS

A. Manufacturer

1. USA Wire and Cable

2. CERRO

3. Southwire

4. Harger

5. Burndy

6. Cooper Industries

B. Copper Bonding Conductors

1. Bare or Insulated and green in color

2. Sized in accordance with TIA-607-B (2 kcmil per linear foot of conductor length)

3. Minimum size bonding conductor shall be 6 AWG

4. Maximum size bonding conductor shall be 3/0 AWG

a. For example: A conductor 25 feet in length shall be 2 AWG (66,360 cmil)

b. A bonding conductor 100 feet in length shall be 3/0 AWG

5. Insulation shall be rated for the environment in which installed.

C. Bolt-On Connector Lugs

1. Lugs for connecting to the TMGB and TGB shall be UL Listed two-hole, long barrel, electro tin-plated compression lugs with inspection port.

2. Compression lugs shall have two holes spaced on 5/8-inch (15.8 mm) or 1-inch (25.4 mm) centers, as stated below, to allow secure two bolt connections to busbars.

3. Compression lugs shall be sized to fit a specific size conductor, sizes #6 to 3/0, as stated below.

4. Antioxidant joint compound, shall be applied as required to the contact areas.

5. Lugs shall be secured to the ground bars with ¼" minimum stainless-steel hex head cap screws with stainless steel washers, lock washers and nuts.

D. Exothermic Welded Connections

1. Exothermic Welded connections shall be Ultraweld by Harger.

2. Weld types BE shall be made to the ground bars using appropriate size weld metal.

3. Weld types VA, VD, or VU shall be made to structural steel framework

E. Shield Bond Connector

1. Shield bonding assembly, with base and top members made of tin-plated tempered brass, slightly curved to exert a continuous spring force on sheath and shield after clamping, and two securing lock nuts. Designed to make a stable, low resistance electrical connection between the shield of a communications cable and a bonding conductor.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Check actual site conditions prior to start of any work. Ensure all preceding trade work associated with the telecommunications system is accurate and complete before proceeding with installation or use of products specified in this section.

3.2 INSTALLATION

A. Wall-Mount Busbars

1. The telecommunications main grounding bar (TMGB) is a dedicated extension of the building grounding electrode system for the telecommunications system. The TMGB should be located near the telecommunications service entrance and the electric service entrance in the MDF. All other spaces shall have a TGB.

2. Only One (1) busbar shall be installed in any space.

3. All Telecommunications Busbars shall be mounted above the cable runway in the space they serve.

4. Busbars shall be located to minimize the length of bonding conductors within the telecommunications space.

5. Attach busbars to the wall with appropriate hardware per the manufacturer's installation instructions.

6. Each lug shall be attached with stainless steel hardware after preparing the bond per manufacturer recommendations and treating the bonding surface on the busbar with antioxidant to help prevent corrosion at the bond.

7. Each wall-mount busbar shall be bonded to ground as part of the overall Telecommunications Bonding and Grounding System.

B. Racks and Cabinets

1. Every rack and cabinet shall be bonded to the closest T(M)GB.

2. Minimum bonding connection to racks and cabinets shall be made with an irreversible 2-hole lug sized to fit the conductor and rack and installed per ANSI/NECA/BICSI 607-2011, BICSI Best Practices, and manufacturer recommendations.

3. Remove paint between rack/cabinet and bonding lug, clean surface and use antioxidant between the rack and the bonding lug to help prevent corrosion at the bond.

C. Bonding to Structural Steel of a Building

1. All bonding conductors and connectors for bonding the metal frame of a building shall be listed for the purpose intended by a NRTL.

2. In buildings where metal frames (structural steel) are effectively grounded, each T(M)GB shall be bonded to the structural steel within the room using a properly sized bonding conductor and connection method.

3. Connections to the structural steel frame shall be made by exothermic welding or by Harger No. 217 or Harger No. 223T electro tin-plated bronze bonding plates. The area of contact on the steel frame shall be cleaned to bare metal removing all paint and mill scale. The contact area shall be protected from corrosion using Harger series HAAJC antioxidant joint compound.

4. Where the structural steel is external to the room and readily accessible the structural steel shall be bonded to the T(M)GB with a properly sized bonding conductor.

5. Steel bars of a reinforced concrete building are not required to be bonded to the T(M)GB.

D. Conduits and Cable Trays

1. All metal conduits and raceways for telecommunications cabling located within the telecommunications space as the busbar shall be bonded to the busbar.

2. Metal cable trays shall be bonded to the busbar.

E. Telecommunications Backbone (TBB)

1. The telecommunications backbone (TBB) is a conductor that originates at the TMGB and extends throughout the building interconnecting all telecommunications grounding busbars (TGBs) with the TMGB.

2. The TBB shall be a copper conductor. The minimum size of the conductor shall be 6 AWG. The size of the conductor shall be increased 2 kcmil per linear foot as the length of the TBB increases to a maximum of 3/0 AWG. For example: A TBB 25 feet in length shall be 2 AWG (66,360 cmil). A TBB 100 feet in length shall be 3/0 AWG.

3. The TBB conductors should be installed without splices. Where splices are necessary, the number of splices should be minimized and located in accessible telecommunications spaces. Splices shall be made using exothermic welding, listed irreversible compression connectors or equivalent.

4. The building water piping system shall not be used as a TBB.

5. Metallic cable shields or metallic conduits shall not be used as a TBB.

6. The TBB shall not rely on connections to any TGB for continuity to another TGB.

F. Grounding Equalizer (GE)

1. Where there are multiple telecommunications rooms or spaces with multiple TBBs, the TBBs shall be interconnected with a Grounding Equalizer (GE) conductor at the TGBs.

2. The GE shall be sized as specified for the TBB.

3. Connections of the GE to the TGBs shall be made by exothermic welding or by listed two-hole compression lugs.

G. Shield Bond Connector Installation

1. The Contractor shall provide a shield bond connector to the shield of each fiber optic and copper riser cable in order to make a stable, low-resistance connections between the shield and a bonding conductor.

2. The bonding jumper at the shield bond connector end shall have a single hole standard barrel lug with a 6 AWG conductor. The other end of the bonding jumper shall be a 2-hole long barrel compression for bonding at the T(M)GB.

H. Testing

1. The Telecommunications Bonding and Grounding System shall be tested with an Earth Ground Resistance Tester using the Two Point Test Method.

2. The following shall be required to test the bonding and grounding.

    a. An Earth Ground Resistance Tester with the attachments.

    b. All testing should be done with the entire building in operation. Nothing needs to be shut down to test the bonding and grounding with this tester.

    c. If the resistance value is less than 0.1 Ohm between the two test points the bonding is adequate.

3. Tests to be conducted:

    a. The installer / technician conducting these tests must be certified

    b. Test between the TMGB and the service equipment (power) ground.

    c. Test between the TMGB and each TGB in the system.

    d. Test between the TGB and:

        1) Data racks

        2) Cable tray

        3) Telecommunication conduit

        4) Caging

        5) Electronic equipment

4. Tests shall be conducted with the systems in operation.

5. Tests shall be recorded and submitted to the Owner's Representative.

3.3 RE-INSTALLATION

A. Refer to Section 27 00 00 Communications. - PART 3.7

3.4 CLOSEOUT ACTIVITIES

A. Refer to Section 27 00 00 Communications. - PART 3.8

END OF SECTION

SECTION 270528 - COMMUNICATION PATHWAYS

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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 DESCRIPTION

A. The work covered by this Specification Section includes all labor necessary to perform and complete such construction, materials not provided by the Owners Representative, equipment incorporated or to be incorporated in such construction, and all services, facilities, tools and equipment necessary or used to perform and complete such construction.

1.3 SECTION INCLUDES

A. Cable Pathway Systems

B. Sleeves for Pathways and Cables

C. Backbone Cable Routing

D. Horizontal Cable Routing

1.4 REFERENCE STANDARDS AND CODES

A. Refer to Section 27 00 00 Communications for list of Reference Standards, Codes, and Documents. PART 1.3

1. Specific standards may be referenced throughout this section.

1.5 SCOPE

A. This section includes the minimum requirements for communications cable pathway installations.

1. Backbone Cable Routing
2. Horizontal Cable Routing
3. Products
4. Common Requirements for Communications Installations
5. Separation from EMI Sources
6. Wire Mesh Cable Tray
7. Sleeve Installation for Communications Penetrations
8. Penetration of Building Surfaces
9. Cutting and Patching
10. Retrofit-Cutover

1.6 SUBMITTALS

A. Refer to Section 27 00 00 Communications. - PART 1.10

1.7 QUALITY ASSURANCE

A. Refer to Section 27 00 00 Communications. - PART 1.11

1.8 CONTRACT ADMINISTRATION

A. Refer to Section 27 00 00 Communications. – PART 1.12 – 1.13

PART 2 - PRODUCTS

2.1 ALTERNATES AND SUBSTITUTIONS

A. Refer to Section 27 00 00 Communications. PART 1.7 – 1.8

1. No Substitution without pre-approval

2.2 CABLE PATHWAY SYSTEMS

A. Cable Support: NRTL labeled and tested to prevent degradation of cable performance and pinch points that could damage cable. Also, to be installed independently of "Other Trades" support system.

1. Wire mesh cable tray
2. Support brackets with cable tie slots for fastening cable ties to brackets.
3. Basket style cable trays are the preferred method of installation. Telecommunications cable shall be installed in "saddle bags" type of pathways from the point of departing from main cable trays.
4. Straps and other devices.

B. Approved manufacturers:

1. Snake Tray
2. Cooper Industries
3. Middle Atlantic Products
4. Chatsworth Products, Inc (CPI)
5. Wiremold

2.3 SLEEVES FOR PATHWAYS AND CABLES

A. Steel Pipe Sleeves: EMT with plastic bushings, or as required to meet UL Listed firestop assembly requirements.

B. Sleeves shall not extend more than six (6) inches from penetrated barrier surface.

2.4 FIRESTOPPING

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

1. Hilti Firestop Systems
2. 3M, Electrical Products Division
3. Specified Technologies Inc

B. Provide materials classified by UL to provide fire barrier equal to time rating of construction being penetrated.

C. Provide asbestos free materials that comply with applicable Codes and have been tested in accordance with UL 1479 or ASTM E 814.

D. Fire Rated Cable Pathways: Device modules comprised of steel raceway with intumescent foam pads allowing 0 to 100 percent cable fill, the following products are acceptable:

1. Specified Technologies Inc. (STI) EZ-PATH™ fire rated pathway

E. Or equivalent product from different manufacturer, after approval by owner.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Check actual site conditions prior to start of any work. Ensure all preceding trade work associated with the telecommunications system is accurate and complete before proceeding with installation or use of products specified in this section.

3.2 BACKBONE CABLE ROUTING

A. Adequate riser sleeve/slot space shall be available with the ability to ingress the area at a later date in all telecommunications rooms, such that no drilling of additional sleeves/slots are necessary.

B. The backbone cables shall be installed in a star topology, emanating from the main cross-connect to each telecommunications room. An intermediate cross-connect may be present between the main cross-connect and the horizontal cross-connect.

C. Backbone pathways shall be installed or selected such that the minimum bend radius and pulling tension of backbone cables is kept within cable manufacturer specifications both during and after installation.

3.3 HORIZONTAL CABLE ROUTING

A. All horizontal cables shall not exceed 90 m (295 ft) from the telecommunications outlets in the work area to the horizontal cross connect.

B. Cable Bundles

1. Bundling of cables is to be avoided; where bundling is necessary bundles shall be limited to no more than 24 cables.

2. Allow cables to lay naturally in cable tray and runways whenever possible.

3. Cables shall be neatly dressed from the point of emergence from vertical cable managers to the point of termination.

C. Consolidation points shall not be used.

D. Horizontal pathways shall be installed or selected such that the minimum bend radius of horizontal cables is kept within manufacturer specifications both during and after installation.

E. In ACT type ceiling cabling, cable supports shall be provided by means that is structurally independent of the suspended ceiling, its framework, or supports. These supports shall be spaced no more than 1.5 m (5 ft) apart.

F. For voice or data applications, 4-pair copper balanced twisted-pair cables shall be run using a star topology from the telecommunications room serving that floor to every individual information outlet. The Owner prior to installation of the cabling shall approve all cable routes.

G. The Contractor shall observe the bend radius and pulling strength requirements of the 4 pair copper balanced twisted-pair optic cable during handling and installation.

H. Each run of 4-pair copper twisted-pair cable between horizontal portions of the cross-connect in the telecommunication closet and the information outlet shall not contain splices.

I. In an ACT type ceiling environment, a minimum of 75 mm (3 in) shall be observed between the cable supports and the ACT.

J. Continuous conduit runs installed by the contractor should not exceed 30.5 m (100 ft) or contain more than two (2) 90-degree bends without utilizing appropriately sized pull boxes.

K. All horizontal pathways shall be designed, installed and grounded to meet applicable local and national building and electrical codes.

L. The number of horizontal cables placed in a cable support or pathway shall be limited to a number of cables that will not cause a geometric shape of the cables to be altered. Under no circumstances should cables in the horizontal pathway be bundled. This is to minimize “alien” cross talk.

M. Maximum conduit pathway capacity shall not exceed a 40 percent fill. However, perimeter and furniture fill ratio is limited to 60% fill for moves, adds, and changes.

1. Horizontal distribution cables shall not be exposed in the work area or other locations with public access.

3.4 SEPARATION FROM EMI SOURCES:

A. Comply with TIAEIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.

B. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

1. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.

2. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.

3. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.

C. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

1. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.

2. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.

3. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.

D. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

1. Electrical Equipment Rating Less Than 2 kVA: No requirement.

2. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.

3. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.

E. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or higher: A minimum of 48 inches.

F. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.5 WIRE MESH CABLE TRAY

A. Provide all components of the tray system (tray, supports, splices, fasteners, and accessories) from a single manufacturer.

B. Supports will be sized at minimum to match the width of the wire mesh cable tray that is supported. The support may be wider than wire mesh cable tray.

C. Wire mesh cable tray shall be secured independently to the structural ceiling, building truss system, wall or floor using manufacturer's recommended supports and appropriate hardware as defined by local code or the authority having jurisdiction (AHJ).

D. When the pathway is overhead, wire mesh cable tray shall be installed with a minimum clearance of 12 inches above the tray. Leave 12 inches in between the tray and ceiling/building truss structure. Multiple tiers of wire mesh cable tray shall be installed with a minimum clearance of 12 inches in between the trays. When located above an acoustical drop ceiling, wire mesh cable tray shall be installed a minimum of 3 inches above the drop ceiling tiles.

E. When installed under a raised floor, wire mesh cable tray shall be installed with a minimum ¾ inch clearance between the top of the tray and the bottom of the floor tiles or floor system stringers, whichever are lower in elevation. Maintain a 3-inch clearance between trays wherever trays cross over.

F. Wire mesh cable tray shall be supported by manufacturer's specifications. Support wire mesh cable tray on both sides of every change in elevation.

G. Wire mesh cable tray shall be labeled with a sign along its side (6 inches by 12 inches) that states the Telecommunications Room that it serves and shall point to the direction of the nearest telecommunications room that it serves, spaced at intervals of every 25 feet with footage markers showing the total footage in reference to the Telecommunications Room that it serves.

H. Secure wire mesh cable tray to each support with a minimum of one fastener. Follow the manufacturers' recommended assembly, splice and intersection-forming practices.

I. Use installation tools recommended by the manufacturer to field fabricate wire mesh cable tray intersections and changes in elevation. Use shear cutters to cut wire mesh cable tray. Use a bending tool to form the ends of cut sections downward at 90° to allow easy drop-in installation with approved supports.

J. Wire mesh cable tray shall be bonded to the Telecommunications Grounding Busbar (TGB) using an approved ground lug on the wire basket tray and a minimum #6 grounding wire or as recommended by the AHJ. Verify bonds at splices and intersections between individual cable tray sections and supports. Cable pathway should be electrically continuous through bonding and attached to the TGB.

K. The quantity of cables within the tray will not exceed a whole number value equal to 50 percent of the interior area of the tray divided by the cross-sectional area of the cable. Cable fill will not exceed the depth of the cable tray's side rail (2, 4 or 6 inches).

L. The combined weight of cables within the tray will not exceed stated load capacity in manufacturer's specifications.

M. Separate different media type within the tray. Treat each type of media separately when determining cable fill limits.

N. When pathways for other utilities or building services are within 2 feet of the wire mesh cable tray, cover the tray after cables are installed.

3.6 SLEEVE INSTALLATION FOR COMMUNICATIONS PENETRATIONS

A. Communications penetrations occur when pathways, cables, wireways, or cable trays penetrate framed wall assemblies, concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Each pipe sleeve, horizontal or vertical, shall have a plastic type "end-bushing" on both ends to protect cables from abrasion when pulled through sleeves. The "end-bushing" shall be installed prior to install cables through sleeve.

E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

F. Cut sleeves to length for mounting flush with both surfaces of walls with respect to plastic "end-bushings". The plastic "end-bushing" shall be plenum rated if applied in plenum space.

G. Extend sleeves installed in floors 2 inches above finished floor level with respect to plastic "end-bushings". The plastic "end-bushing" shall be plenum rated if applied in plenum space.

H. Size pipe sleeves to provide ¼-inch annular clear space between sleeve and pathway or cable, unless indicated otherwise.

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint.

K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pathway and cable penetrations. Install sleeves and seal pathway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

L. Roof-Penetration Sleeves: Weather seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.

3.7 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

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

C. Provide sleeves for new conduit and cable penetrations of building construction.

1. Openings to accept sleeves in new building construction will be formed in building construction by the Contractor for General Construction work. Openings to accept sleeves in existing building construction shall be provided under this division of the Specifications. Refer to, CUTTING AND PATCHING in this Section.

2. Use galvanized rigid conduit sleeves for penetrations through exterior masonry/concrete walls and foundations, concrete floor slabs on grade and above grade, and concrete-filled decks.

3. Use only fire-rated listed assemblies for the type of sleeve being installed through CMU walls or gypsum walls for communications penetrations. Sleeve type shall be galvanized rigid conduit.

D. Where conduits are installed before building construction being penetrated, install sleeves loose around conduits. Split, fit, and weld steel sleeves over existing conduits, with respect to anything flammable in the surrounding environment.

E. Secure sleeves firmly in place using filling and patching materials (grout) that match with surrounding construction.

F. In floor penetrations, extend sleeve 4 inches above finished floor unless noted otherwise. In wall penetrations, cut sleeves flush with wall surface and use metal escutcheon plates in finished interior areas.

G. Seal voids between sleeves and building construction with joint sealants. Make allowances for and coordinate the Work with installation of firestopping, conduit insulation, and waterproofing as applicable.

H. The Contractor shall be fully responsible for final and correct location of sleeves. Sleeves which are omitted or incorrectly located in existing building construction, shall be corrected and provided by the Communications Contractor, at no additional costs to the Owner.

3.8 PENETRATION OF BUILDING SURFACES

A. Above Grade Level or Non-waterproof Areas

1. Seal each annular space between conduits or cable and building surfaces. Pack space with oakum, other rope packing, or backer rod materials and cover with fire-resistant sealant or other protection materials.

2. Provide sleeves as specified in article, sleeve-seal installation in this section for conduit and cable penetrations. Seal each space between conduit or cable and sleeve. Sealing shall be as specified in above paragraph.

B. Waterproof areas (above and below grade)

1. In new and existing construction for penetrations through concrete below grade, ground water level, or in other waterproof areas, provide through-wall and floor seals having galvanized fittings, sealing assemblies, and sleeves as specified.

2. In existing construction when core bore drilled openings are used for conduit penetrations below grade, ground water level, or in other waterproof areas, provide sealing.

C. Fire-resistant areas

1. Provide through-penetration firestop systems for penetrations through fire-rated walls, floors, and other partitions of building construction. Comply with requirements in division 07 section "penetration firestopping".

2. In walls or partitions with 2-hour or less fire ratings, provide only metallic outlet or device boxes installed per UL fire resistance director, NEC, and other national building code requirements.

3.9 CUTTING AND PATCHING

A. Provide openings, cutting, coring, and patching of openings in existing building construction as required. Patching includes openings and voids left in existing construction as a result of demolition.

B. The Work shall include necessary assemblies and materials to maintain required fire ratings.

C. Perform cutting as to not impair structural stability of building construction and systems. Do not drill holes or weld attachments to beams and other structural members without prior written approval from the Owner's Representative. Contact the Engineer-of-Record for guidance.

D. The Work shall be done by a craftsperson skilled in the particular trades affected.

E. Patching materials shall match existing materials in type and quality. Patching shall be done in a manner to match appearance of adjacent surfaces.

3.10 RETROFIT-CUTOVER

A. Furnish equipment, materials, labor and services, and perform operations required to retrofit/cutover existing cabling systems. Removals shown are general indications and may not indicate full extent of removals which may be required to complete Work.

B. Furnish equipment, materials, labor and services, and performing operations required to enable continued functioning of existing system until cutover to new system.

C. Remove wiring, punch blocks, cabinets, outlets, raceways, and equipment not required for new system.

1. Abandon flush mounted device and junction boxes and cover with blank plate to match the current room decor.

2. Remove surface telecommunications outlets and pathways unless said removal will damage the existing finish on surfaces, or physically damage the structure.

3. Remove wiring from abandoned conduits and raceways from the work area outlet back to the corresponding termination point in the telecommunication room. Place a trailer string in vacated conduits and raceways.

4. Remove labeling at both ends for abandoned cables/wiring.

5. The collected abandoned cables/wiring shall be collected and removed from site by contractor.

D. Perform the work in neat and workmanlike manner in accordance with the applicable codes, standards and AHJ.

E. Removal and replacement of existing ceilings:

1. Carefully remove existing ceilings as required to perform the work. Store removed tiles in an area designated by the owner. Modify and augment existing suspension systems as necessary. Restore ceiling systems to their original finish.

2. Repair any damage to ceilings due to modifications, removal, and replacement of same. Replace damaged ceiling tiles, including tiles with holes or openings left as a result of demolition, with materials of like kind.

F. Existing equipment or material shall not be reused without specific approval of the Owner's Representative except as noted below:

1. Existing cable terminal housings may be reused if in good condition.

G. Equipment and materials to be removed and not desired by the Owner shall be removed from site promptly.

H. Equipment and material to be removed and that is desired by the Owner shall be moved to an on-site storage location as directed by the Owner.

3.11 FIRESTOPPING

A. Performance Requirements

1. Fire rated pathway devices shall be the preferred product and shall be installed in all locations where frequent cable moves, add-ons and changes will occur.

2. Where non- mechanical products are utilized, provide products that upon curing do no re-emulsify, dissolve, leach, breakdown or otherwise deteriorate over time from exposure to atmospheric moisture, sweating pipes, ponding water or other forms of moisture characteristic during or after construction.

3. Where it is not practical to use a mechanical device, openings within floors and walls designed to accommodate telecommunications and data cabling shall be provided with re-enterable products that do not cure or dry.

4. Openings for cable trays shall be sealed using re-enterable firestopping pillows.

B. Quality Assurance

1. Products/systems: provide firestopping systems that comply with the following requirements:

2. Firestopping tests are performed by a qualified, testing and inspection agency. A qualified testing and inspection agency is UL or another agency performing testing and follow-up inspection services for firestop system acceptable to authorities having jurisdiction.

3. Firestopping products bear the classification marking of qualified testing and inspection agency.

4. Installer qualifications: experience in performing work of this section who is qualified by the firestopping manufacturer as having been provided the necessary training to install firestop products in accordance with specified requirements.

C. Project Conditions

1. Do not install firestopping products when ambient or substrate temperatures are outside limitations recommended by manufacturer.

2. Do not install firestopping products when substrates are wet due to rain, frost, condensation, or other causes.

3. Maintain minimum temperature before, during, and for a minimum 3 days after installation of materials.

4. Do not use materials that contain flammable solvents.

5. Coordinate construction of openings and penetrating items to ensure that through-penetration firestop systems are installed according to specified requirements.

6. Coordinate sizing of sleeves, openings, core-drilled holes, or cut openings to accommodate through-penetration firestop systems.

7. Schedule installation of firestopping after completion of penetrating item installation but prior to covering or concealing of openings.

3.12 RE-INSTALLATION

A. Refer to Section 27 00 00 Communications. - PART 3.7

3.13 CLOSEOUT ACTIVITIES

A. Refer to Section 27 00 00 Communications. - PART 3.8

END OF SECTION

SECTION 270529 - COMMUNICATION HANGERS AND SUPPORTS

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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 DESCRIPTION

A. The work covered by this Specification Section includes all labor necessary to perform and complete such construction, materials not provided by the Owners Representative, equipment incorporated or to be incorporated in such construction, and all services, facilities, tools and equipment necessary or used to perform and complete such construction.

1.3 SECTION INCLUDES

A. Non-continuous cable supports.

1.4 REFERENCE STANDARDS AND CODES

A. Refer to Section 27 00 00 Communications for list of Reference Standards, Codes, and Documents. PART 1.3

1. Specific standards may be referenced throughout this section.

1.5 SCOPE

A. Provides specifications information for appropriate support in areas where cable tray or conduits are not practical.

1.6 SUBMITTALS

A. Refer to Section 27 00 00 Communications. - PART 1.10

1.7 QUALITY ASSURANCE

A. Refer to Section 27 00 00 Communications. - PART 1.11

1.8 CONTRACT ADMINISTRATION

A. Refer to Section 27 00 00 Communications. – PART 1.12 – 1.13

PART 2 - PRODUCTS

2.1 ALTERNATES AND SUBSTITUTIONS

A. Refer to Section 27 00 00 Communications. PART 1.7 – 1.8

2.2 NON-CONTINUOUS CABLE SUPPORTS

A. Manufacturer List:

1. ERICO International Corporation
2. Cooper Industries
3. Panduit –J-Mod System
4. Arlington Industries

B. Select support system components capable of supporting the telecommunications cable quantities required for each location. Options are as follows:

1. Support slings
2. Four-inch (4”), two-inch (2”) J-hook supports.

C. Description:

1. Non-continuous cable supports shall be available in multiple sizes, styles and materials. Rigid supports shall be equipped with flared edges and pre-configured bend radius controls.
2. Provide drop wire supports and threaded rod assemblies in areas where structural mounting surfaces are non-functional or inaccessible.
3. Sling assemblies shall provide a bearing surface of sufficient width to comply with required bend radii of high-performance FTP/UTP and optical fiber cables. Support slings shall have a static load limit of 100 lbs.
4. Non-continuous cable supports sized 1 5/16” and larger shall have a cable retainer strap to provide containment of cables within the hanger. The cable retainer strap shall be removable and reusable.
5. Select approved non-continuous cable supports suitable for specific installation environments and/or air handling (plenum) spaces.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Check actual site conditions prior to start of any work. Ensure all preceding trade work associated with the telecommunications system is accurate and complete before proceeding with installation or use of products specified in this section.

3.2 NON-CONTINUOUS CABLE SUPPORT INSTALLATION

A. Process:

1. Follow manufacturer’s instructions and recommended industry standards and guidelines.
2. The installed non-continuous support system must be an independent support structure for the voice/data communication system.
3. The non-continuous support system shall consist of a scalable pathway system of J-hooks. The “J” hook style horizontal station cable support system shall be sized to accommodate a 50% increase in future cable counts.
4. Supporting cables with other structures in the ceiling is unacceptable. Water pipes, ceiling grid, sprinkler system, electrical conduits, cables, or supports, air ducts or any other in-ceiling structure shall not be used for cable support.
5. Contractor installed supports shall be used to supplement the main cable support system when any cabling leaves the main support system or is unsupported for more than four feet (4’-0”).

6. The maximum cable “sag” shall be no greater than six (6) inches below the non-continuous support system.
7. Cable must be routed to follow existing corridors and parallel or 90 degree angles from all walls and the cable tray whenever possible.
8. All directional changes shall be supported with a “J” hook or support sling in addition to those required by normal support spacing.
9. The non-continuous support system should have the following minimum clearances maintained throughout the entire cable length:

    a. Six inches (0’-6”), including cable “sag”, from the ceiling support channels (T-bars) and ceiling panels.
    b. Three inches (0’-3”) of clear vertical space from obstructions above & below.
    c. Three inches (0’-3”) of clear horizontal space from obstructions on each side.
    d. When parallel to electrical pathways a minimum six inches (0’6”) of clearance shall be maintained.

3.3 RE-INSTALLATION

A. Refer to Section 27 00 00 Communications. - PART 3.7

3.4 CLOSEOUT ACTIVITIES

A. Refer to Section 27 00 00 Communications. - PART 3.8

END OF SECTION

SECTION 270533 - COMMUNICATION CONDUITS AND BOXES

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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 DESCRIPTION

A. The work covered by this Specification Section includes all labor necessary to perform and complete such construction, materials not provided by the Owners Representative, equipment incorporated or to be incorporated in such construction, and all services, facilities, tools and equipment necessary or used to perform and complete such construction.

1.3 SECTION INCLUDES

A. Telecom conduits and boxes.

1.4 REFERENCE STANDARDS AND CODES

A. Refer to Section 27 00 00 Communications for list of Reference Standards, Codes, and Documents. PART 1.3

1. Specific standards may be referenced throughout this section.

1.5 SCOPE

A. Provides specifications for conduit pathways, back boxes and pull box enclosures utilized for the distribution and housing of telecommunications cabling and components:

1.6 SUBMITTALS

A. Refer to Section 27 00 00 Communications. - PART 1.10

1.7 QUALITY ASSURANCE

A. Refer to Section 27 00 00 Communications. - PART 1.11

1.8 CONTRACT ADMINISTRATION

A. Refer to Section 27 00 00 Communications. – PART 1.12 – 1.13

PART 2 - PRODUCTS

2.1 ALTERNATES AND SUBSTITUTIONS

A. Refer to Section 27 00 00 Communications. PART 1.7 – 1.8

1. No Substitution without pre-approval

2.2 TELECOM CONDUITS AND BOXES

A. Conduit

1. UL Listed of domestic manufacture

B. Pull boxes

1. UL Listed of domestic manufacture

C. Back Boxes

1. Randl
2. Siemon

PART 3 - EXECUTION

3.1 EXAMINATION

A. Check actual site conditions prior to start of any work. Ensure all preceding trade work associated with the telecommunications system is accurate and complete before proceeding with installation or use of products specified in this section.

3.2 TELECOM CONDUITS AND BOXES

A. Pull Boxes:

1. Install Pull boxes in easily accessible locations.
2. Install Horizontal cabling boxes minimum 6” above suspended ceilings.
3. A pull box should not be used in lieu of a bend.
4. Conduits that enter the pull box from opposite ends with each other should be aligned.
5. For direct access to a box located above inaccessible ceilings provide a suitable, marked, hinged access panel (or equivalent) in the ceiling. This access panel can also serve as the cover for the box.
6. Pull box sizing table:

Conduit Trade Size (in.)	Pull Box Width (in.)	Pull Box Length (in.)	Pull Box Depth (in.)	Pull Box Width Increase for Additional Conduit (in.)
1	4	16	3	2
1 1/4	6	20	3	3
1 1/2	8	27	4	4
2	8	36	4	5
2 1/2	10	42	5	6
3	12	48	5	6
3 1/2	12	54	6	6
4	15	60	8	8

B. Back Boxes:

1. Provide 5” H X 5” W X 2-7/8” D outlet back boxes with integrated cable management at all telecom outlet locations shown on drawings.
2. Provide (1) 1-1/4” conduit from back box to telecom cable tray, except as otherwise noted.
3. Provide single gang plaster/mud ring on all communications outlet back boxes, unless indicated otherwise in the contract drawings.
4. Provide bonding to cable pathways.

C. Conduit Support and Bracing:

1. Coordinate layout and installation of conduits and pull boxes with other trade conditions to ensure adequate clearances, access and cable management.

2. Provide seismic support and bracing for all conduits and pull boxes installed under work of this project per the project's structural requirements. Any proposed reinforcement is the responsibility of the Contractor.

3. Coordinate seismic design with architectural, structural, mechanical, electrical, plumbing, fire protection, and other trades.

4. Structural braces and/or reinforcements are to be attached directly to structural framework and secondary structural members; do not attach braces and/or reinforcements to elements other than structural framework and secondary structural members.

5. Install and provide support for conduits and pull boxes in accordance with the latest edition of the NEC, as well as all state and local codes and requirements. Coordinate installation and location with existing conditions.

6. Install conduits above ceilings at height to provide access to pull boxes and cable access to where conduits terminate to meet up with cable trays. Install conduits and pull boxes level and square and at proper elevations. Ensure adequate clearances, access and cable management.

7. Supporting devices: U channel trapeze assemblies, 3/8" threaded rods, clamps, conduit straps, C-clamps and retainers.

8. Fasteners: Carbon steel expansion anchors with minimum 3" embed into concrete slab for pull box U-channel support attachment. The anchors must be tested and approved under dual load conditions.

9. U-channel systems: 16-gauge steel channels. Provide fittings and accessories that match with the U-channel of the same manufacturer.

10. Use fittings and support devices compatible with conduits and pull boxes and suitable for use and location.

11. Install individual and multiple trapeze hangers and riser clamps as necessary to support the conduits. Provide U-bolts, clamp attachments and other necessary hardware for hanger assemblies and for securing hanger rods and conduits. Space supports for conduits on maximum 10-foot centers.

12. Provide and install expansion or deflection fittings for conduits runs at all instances of seismic or expansion joints to allow for movement in any direction.

D. Conduit Routing, Bends and Radius Guidelines:

1. If the conduit has an internal diameter of 2 inches or less the bend radius must be at least 6 times the internal conduit diameter.

2. If the conduit has an internal diameter of more than 2 inches the bend radius must be at least 10 times the internal conduit diameter.

3. Conduit bends should be smooth, even, and free of kinks or other discontinuities that may have detrimental effects on pulling tension or cable integrity during or after installation.

4. If a conduit run requires more than two 90-degree bends then provide a pull box between sections with two bends or less.

5. If a conduit run requires a reverse bend (between 100 degrees and 180 degrees) then insert a pull point or pull box at each bend having an angle from 100 degrees to 180 degrees.

6. Consider an offset as equivalent to a 90-degree bend.

7. Achieve the best direct route with no bend greater than 90 degrees or an aggregate of bends in excess of 180 degrees between pull points or pull boxes.

8. Contain no continuous sections longer than 100 ft.

9. For runs that total more than 100 ft. in length, pull points or pull boxes should be inserted so that no segment between points/boxes exceeds the 100 ft. limit.

10. Withstand the environment to which they will be exposed.

11. Conduits shall not be routed through areas in which flammable material may be stored or over or adjacent to boilers, incinerators, hot-water lines and steam lines.

12. Maintain 6" separation from parallel runs of steam, hot water pipes or mechanical ductwork so as not to affect cable performance.

E. Conduit Terminations:

1. Join conduits with fittings designed and approved for the purpose. Make the joints tight without protrusions that may damage cable inside the conduits.

2. Where conduits are terminated with locknuts and bushings align the conduit to enter squarely and install the locknuts with dished part against the box. Use two locknuts, one inside and one outside the box.

3. Ream all conduit ends and fit them with an insulated bushing, connector, or coupling to eliminate sharp edges that can damage cables during installation or service.

4. Conduits that enter a telecom room should terminate near the corners to allow for proper cable racking.

5. Terminate conduits that protrude through the structural floor 3 inches above the surface.

6. Maintain the integrity of all fire stop barriers for all floor and wall penetrations.

7. Provide bonding for conduits and pull boxes as indicated by the NEC, ANSI/NECA/BICSI 607-2011, and as instructed by manufacturer.

8. Conduits shall be clearly labeled at both ends designating the opposite locations(s) served. The numbering scheme shall be room number plus a suffix to guarantee uniqueness, e.g., 143-1. Labeling must be machine generated.

F. Conduit Protection:

1. Remove burrs, dirt and construction debris from conduits and pull boxes.

2. Conduits should be left capped for protection.

3. Provide final protection and maintain conditions in a manner acceptable to the Owner's Representative to ensure that coatings, finishes and pull boxes are without damage or deterioration at completion. Repair damage to galvanized finishes with zinc-rich paint recommended by the manufacturer.

3.3 RE-INSTALLATION

A. Refer to Section 27 00 00 Communications. - PART 3.7

3.4 CLOSEOUT ACTIVITIES

A. Refer to Section 27 00 00 Communications. - PART 3.8

END OF SECTION

SECTION 270553 - COMMUNICATION IDENTIFICATION

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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 DESCRIPTION

A. The work covered by this Specification Section includes all labor necessary to perform and complete such construction, materials not provided by the Owners Representative, equipment incorporated or to be incorporated in such construction, and all services, facilities, tools and equipment necessary or used to perform and complete such construction.

1.3 SECTION INCLUDES

A. Labeling and identification.

1.4 REFERENCE STANDARDS AND CODES

A. Refer to Section 27 00 00 Communications for list of Reference Standards, Codes, and Documents. PART 1.3

1. Specific standards may be referenced throughout this section.

1.5 SCOPE

A. Provides specifications information for identification of the various components of the telecommunications infrastructure and pathway system.

1.6 SUBMITTALS

A. Refer to Section 27 00 00 Communications. - PART 1.10

1.7 QUALITY ASSURANCE

A. Refer to Section 27 00 00 Communications. - PART 1.11

1.8 CONTRACT ADMINISTRATION

A. Refer to Section 27 00 00 Communications. – PART 1.12 – 1.13

PART 2 - PRODUCTS

2.1 ALTERNATES AND SUBSTITUTIONS

A. Refer to Section 27 00 00 Communications. PART 1.7 – 1.8

2.2 LABELING AND IDENTIFICATION

A. Manufacturer List:

1. Panduit thermal transfer printer.
2. Brady labeling system.

B. Description:

1. All labels shall be machine-manufactured. Handwritten labels shall not be accepted for final labeling.
2. The intention of the labeling scheme is to be ANSI/TIA-606-B compliant.
3. It is the responsibility of the contractor to acquire, understand, and utilize Owners Representative's labeling scheme for all components of the voice data communications system.
4. It is the responsibility of the contractor to provide labels sized to show Owner's labeling scheme in readable font size while still matching the specified hardware identification dimensions.

C. Indoor Copper and Fiber Optic Cables and Bonding Conductors:

1. The cable sheaths shall be labeled with machine-printed polyester self-laminating wrap-around labels sized to fit Owner's labeling scheme in readable font size.

D. Outside Plant Copper and Fiber Optic Cables:

1. The cable sheaths shall be labeled with non-adhesive thermal transfer marker plates attached to the cables with nylon cable ties. The marker plates shall withstand harsh solvents, oils, and chemicals without over-lamination. Marker plates shall offer crisp, clear legends with superior legibility when printed on a thermal transfer desktop printer utilizing the resin ribbon designated for use and shall meet requirements for MIL-STD-202G, Notice 12 Method 215J sized to fit Owner's labeling scheme in readable font size.

E. Horizontal Cable Outlet Housings and Faceplates:

1. Cable termination connectors at each position on the outlet housing shall be labeled with laser-printed labels inserted into the outlet housing labeling window.

F. Copper Patch Panels:

1. The patch panels shall be labeled on the front and rear top left corner with a laser-printed polyester self-laminating label sequentially identifying the patch panel.

G. Copper Patch Termination Blocks:

1. The termination blocks shall be labeled on the front rows with the termination block designation strip colored per ANSI/TIA-606-B requirements identifying the copper cable pairs.

H. Fiber Optic Termination Panels and Housings (FDU):

1. The panels and housings shall be labeled on the outside front and rear top left corner with a laser-printed polyester self-laminating label sequentially identifying the panel.
2. Cable termination identifier and fiber positions inside the termination panels shall be made using the manufacturer's provided label card behind the plastic panel.

I. Equipment Racks

1. Metal Card Holder bracket attached to rack to runway support bracket. NorCal Metal Fabricators Part no. NC-D1185-11. Or equal.
2. Metal Card Holder (2"W x 12.75"L): NorCal Metal Fabricators Part no. NC-D1180-1.
3. Label card: NorCal Metal Fabricators Part no. NC-D1180-2.
4. Clear plastic cover: NorCal Metal Fabricators Part no. NC-D1180-3.
5. Or equal

J. Equipment Cabinets:

1. Reflective Lettering System Labels shall be adhesive backed individual letters and numbers. Dimension per individual label is 1 ½" X 1". 3M Scotchlite 5005 Reflective Lettering System. Or equal.
2. Individual letters and numbers shall be compiled to match identification for each rack or cabinet location and shall be placed on a Decal Strip Holder attached to front and rear of each equipment rack or cabinet. 3M 5012L Decal Strip Holder. Or equal.

K. Indoor Pull Boxes:

1. Each pullbox shall be labeled on the outside door panel facing and unobstructed view with a reflective lettering system. Labels shall be adhesive backed individual letters and numbers.
2. Dimension per individual label is 1 ½" X 1". 3M Scotchlite 5005 Reflective Lettering System. Or equal.

L. Outdoor Enclosures:

1. Each wall mounted enclosure shall be identified with its individual identifier at the top right of the enclosure door. The Lettering is 1 inch tall solid two-colored injection molded letters held in an aluminum tag/letter holder. The aluminum tag/letter holder shall be attached to the enclosure with appropriate fasteners.
2. AH106 Aluminum tag/letter holder and ELHWK 1 inch tall white on black injection molded letters: Everlast, Makers and Tags, Tech Products, Inc.
3. Or equal, no known equal.

M. Conduit Labeling

1. All conduits smaller than 3" shall be labeled within 12" of termination with a laser-printed polyester self-laminating label sequentially identifying the conduit and its origin and termination end (to and from).
2. All 3" and larger conduits shall be labeled with a stainless-steel marker tag.
3. Stainless steel marker tag shall be machine embossed with a labeling scheme approved by Owners Representative.
4. Stainless steel marker tag shall be secured with stainless steel tie wraps.
5. Marker tags shall be located at each penetration through a wall or floor, and at 50 ft.' intervals on continuous runs.
6. Stainless steel marker tags shall be Panduit MMP350-C316, or equal.
7. Stainless steel tie wraps shall be Panduit MLT-S, or equal.

N. Outside Plant Conduits and Pull Boxes/Manholes/Vaults:

1. Each OSP conduit shall be labeled on the inside of the pull box, manhole or vault with a non-adhesive thermal transfer marker plates attached to the pull box, manhole or vault with

mechanical fasteners. The marker plates shall withstand harsh solvents, oils, and chemicals without over-lamination. Marker plates shall offer crisp, clear legends with superior legibility when printed on a thermal transfer desktop printer utilizing the resin ribbon designated for use and shall meet requirements for MIL-STD-202G, Notice 12 Method 215J sized to fit Owners Representative's labeling scheme in readable font size, sequentially identifying the conduit and its origin and termination end (to and from).

2. Each pull box/manhole/vault shall be identified on the cover plate/lid sequentially identifying the pull box/manhole/vault.

PART 3 - EXECUTION

3.1 LABELING

A. The labeling scheme is intended to comply with ANSI/TIA-606-B standard for labeling and administration of a cable plant. It is the responsibility of the contractor to acquire, understand, and utilize the Owner labeling scheme for all component of the voice data communications systems including, but not limited to:

1. Indoor Horizontal copper and fiber optic cables (Identify at both ends within 6-inches of termination)
2. Indoor copper and fiber optic backbone cables shall be identified at both ends within 12-inches of the point that the cable enters or exits termination panels/blocks, pull boxes, wall and floor sleeves.
3. Outside plant copper and fiber optic backbone cables shall be identified at both ends within 12-inches of the point that the cable enters or exits termination panels/blocks, pull boxes, manholes, vaults and pedestals.
4. Workstation outlets, faceplates and individual outlet connectors.
5. Termination panels and blocks.
6. Racks, cabinets, and equipment enclosures. (front and rear)
7. Indoor and OSP conduit pathways, pull boxes, manholes, and vaults.
8. Bonding conductors and busbars.
9. Label each component with a specified label at an unobstructed view location and where it is accessible for administration.

3.2 EXAMINATION

A. Check actual site conditions prior to start of any work. Ensure all preceding trade work associated with the telecommunications system is accurate and complete before proceeding with installation or use of products specified in this section.

3.3 RE-INSTALLATION

A. Refer to Section 27 00 00 Communications. - PART 3.7

3.4 CLOSEOUT ACTIVITIES

A. Refer to Section 27 00 00 Communications. - PART 3.8

END OF SECTION

SECTION 270800 - COMMUNICATION COMMISSIONING

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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 DESCRIPTION

A. The work covered by this Specification Section includes all labor necessary to perform and complete such construction, materials not provided by the Owners Representative, equipment incorporated or to be incorporated in such construction, and all services, facilities, tools and equipment necessary or used to perform and complete such construction.

1.3 SECTION INCLUDES

A. Copper cable test device

B. Optical fiber test device

C. Coaxial cable test device

1.4 REFERENCE STANDARDS AND CODES

A. Refer to Section 27 00 00 Communications for list of Reference Standards, Codes, and Documents. PART 1.3

1. Specific standards may be referenced throughout this section.

1.5 SCOPE

A. Provides specifications for a certification tester used for end to end testing, certification, and documentation of all test results to confirm the installed connectivity system complies with industry standards and specific category and performance ratings.

1.6 SUBMITTALS

A. Refer to Section 27 00 00 Communications. - PART 1.10

1. Electronic Reports: Submit in CD format. Include necessary software required to view test results. Accompany electronic reports by Certificate signed by authorized representative of Contractor warranting truth and accuracy of electronic report. Certificate: Reference traceable circuit numbers that match electronic record. Contain following information on each row of report: Circuit ID, test specification used, length, date of test, and pass/fail results.

1.7 QUALITY ASSURANCE

A. Refer to Section 27 00 00 Communications. - PART 1.11

1.8 CONTRACT ADMINISTRATION

A. Refer to Section 27 00 00 Communications. – PART 1.12 – 1.13

PART 2 - PRODUCTS

2.1 ALTERNATES AND SUBSTITUTIONS

A. Refer to Section 27 00 00 Communications. PART 1.7 – 1.8

1. No Substitution without pre-approval

2.2 COPPER CABLE TESTER

A. Manufacturer List:

1. Fluke
2. Agilent

B. Description:

1. Must meet or exceed TIA Level IV compliant network cable-testing device certification by an independent laboratory, such as Intertek, for verification of high-performance cables.
2. Copper test equipment must be capable of certifying Category-3, Category-5e, Category-6 and Category-6A UTP and F/UTP links or channels independent of termination hardware configuration (8P8C port or 110-style) for each level of performance.
3. Provide full 2-way Autotest of Category-3, 5E, 6 and 6A twisted pair links.
4. All test equipment shall be capable of storing full frequency sweep data for all tests and printing color graphical reports for all swept measurements.

C. Accessory Products:

1. Interface Adapters
2. Category/Class E permanent link adapters for TIA unshielded and shielded cables.
3. DTX ten (10) Gigabit Kit

2.3 OPTICAL FIBER TESTER

A. Manufacturer List:

1. Fluke
2. Agilent

B. Product Options:

1. Select analyzer to comprehensively certify each optical fiber connection and record results verifying compliance with TIA/EIA performance standards and manufacturer specifications.
2. Tier 2 OptiFiber or Equal Certifying OTDR

C. Description:

1. The optical fiber source shall permit full end to end testing of Multimode, Single-mode and LOMMF optical fiber cabling fully compliant with industry standards and manufacturer recommendations.
2. Available source types and wavelengths shall be as follows:
    a. Multimode - 850nm LED and 1300nm LED.
    b. Single-mode – 1310nm FP Laser and 1550nm FP Laser.
    c. LOMMF – 850nm VCSEL and 1310nm FP Laser.
3. The built-in power meter shall be calibrated to read 850, 1310 and 1550nm wavelengths.
4. All test equipment shall be capable of storing full frequency sweep data for all tests and printing color graphical reports for all swept measurements.

D. Accessory Products:

1. Interface Adapters

a. Fiber Modules including Multimode, Single-mode and LOMMF adapters.

b. Optical Fiber Mandrels.

2.4 COAXIAL CABLE TESTER

A. Manufacturer List:

1. Fluke

2. Agilent

B. Product Options

1. Select analyzer to comprehensively Autotest each connection and record results verifying compliance with industry standards and manufacturer specifications.

a. DTX or Equal Digital Cable Analyzer

C. Description

1. The tester's Autotest function shall test and record cable resistance, length, impedance, insertion loss and propagation delay. Additionally, the tester shall provide a TDR function that provides extended troubleshooting capabilities.

2. All test equipment shall be capable of storing full frequency sweep data for all tests and printing color graphical reports for all swept measurements.

D. Accessory Products:

1. Interface Adapters

a. DTX-Coax Interface Adapters

PART 3 - EXECUTION

3.1 EXAMINATION

A. Check actual site conditions prior to start of any work. Ensure all preceding trade work associated with the telecommunications system is accurate and complete before proceeding with installation or use of products specified in this section.

B. Verify telecommunications cabling is installed and supported, terminated, mounted in an appropriate housing or terminated on the applicable component and labeled prior to certification testing and documentation.

C. Verify certification tester universal interface adapters and manufacturer patch cords that enable permanent link verification are in new condition not indicating any twisting or kinking resulting from incorrect storage of the tester interface adapters.

D. Optical fiber patch cords shall be inspected to ensure connector surfaces are clean and free of defects that may affect testing results.

E. Refer to Section 01 91 00 - General Commissioning Requirements.

F. Refer to Section 27 00 00 – 3.4 and 3.6 for additional requirements.

3.2 TEST INSTRUMENT SUBMITTALS

A. All copper & fiber optic test instruments used on the site shall be capable of storing test data files and downloading these test results as data files. The unique cable/strand number previously approved as per Specification 27 05 53 shall be used as the record identifier for each test.

B. Submit a certificate verifying the model number, serial number, manufacturer, last date of calibration/certification for each test instrument used on the site prior to any testing.

3.3 TEST AND EVALUATION REPORTS:

A. Prior to commencement of full system testing a test sample shall be submitted to Owner's Representative in order to verify correct testing procedures.

1. Sample test reports shall include:

a. Copper tests for one (1) complete 48 port patch panel

b. Optical Fiber tests for 24 consecutive MMF strands

c. Optical Fiber tests for 24 consecutive SMF strands

2. These reports shall be reviewed and accepted by Owner's Representative prior to any additional testing.

3. Should the contractor fail to provide sample test reports prior to full system testing and issues are found with submitted test reports, full retesting of installed cable plant shall be required at the contractors' expense.

B. A complete set of test results verifying the installed link performance parameter results for all cable types shall be presented to the Owner's Representative at least two (2) weeks before the placement of any active electronics in technology rooms and/or spaces.

C. Verification and test results in electronic format saved directly from the testing device software application. Results must be neatly presented and organized according to floor and cable type; OSP, ISP, Category-6A, Category-6, Category-5E, Category-3, and optical fiber cables (backbone and workstation fiber) must be divided into separate sections for each floor. Electronic results shall be presented in the testing device's native file type with a copy of the electronic software used to generate the test results when requested.

3.4 OPTICAL FIBER CABLE TESTING

A. Fiber Testing: Perform on fibers in completed end to end system. Splices not allowed unless clearly defined and pre-approved by Owner's Representative.

1. Testing: Bi-directional end to end power meter test, TIA/EIA 455-53A.

2. Test horizontal multimode fiber at both 850nm and 1300nm, TIA-526-14-A OFSTP-14 Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant - Method B, (1 Jumper Reference)

a. The following loss limits shall apply to Horizontal segments regardless of actual link configuration:

1) Permanent Link 2.0 dB

2) Permanent Link w/ CP 2.8 dB

3) Permanent Link w/MUTOA2.0 dB

4) Centralized Fiber 3.3 dB

5) Centralized Fiber w/ CP 3.3 dB

3. Test backbone multimode fiber at both 850nm and 1300nm, TIA-526-14-A OFSTP-14 Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant - Method A, (2 Jumper Reference)

4. Test all single-mode fiber at both 1310 nm and 1550 nm, TIA/EIA 526-7 OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant - Method A.2 (2 Jumper Reference)

B. Pre-installation Cable Testing: Test fiber optic cable prior to installation of cable.

1. Contractor shall be solely responsible for replacement of cable if found defective at later date.

C. Loss Budget – Backbone Fiber Links: Maximum loss of:

1. (Allowable cable loss per km)*(km's of fiber in link) + (.5dB)*(number of connector pairs) + (.15dB)*(number of splices) = maximum allowable loss

2. Splice Losses from Fusion Splice Pigtail Connectors and Fusion Splice-On Connectors shall not be counted in the Loss Budget. Only the Connector Loss shall be counted for Loss Budget.

3. All test reports exhibiting a Headroom Margin of 0.25 dB or less shall be considered as not meeting requirements of this specification.

4. Bring links not meeting requirements of this specification into compliance, at no charge to Owner.

D. Documentation: Provide native electronic test reports to point of contact, include required software to view electronic results.

3.5 COPPER AND COAXIAL CABLE TESTING

A. Certification test 100% of the installed cabling plant including all backbone and horizontal four (4) pair copper, multi-pair UTP and coaxial connections.

B. Follow manufacturers' instructions and recommended industry standards and guidelines to complete all TIA/EIA testing procedures to verify performance levels.

C. Follow manufacturer requirements for self-calibration procedures.

D. Update tester software to show specific project information including but not limited to:

1. Date and time of testing

2. Project name

3. Field technicians name

4. Cable identification number

5. Cable manufacturer, type and part number

E. REPAIR

1. Any connections failing to meet referenced standards or more stringent performance requirements stated above, must be removed and replaced with connections that prove, in additional testing, to meet or exceed the performance standards set forth.

2. Refer to Section 01 91 00 - General Commissioning Requirements.

3.6 RE-INSTALLATION

A. Refer to Section 27 00 00 Communications. - PART 3.7

3.7 CLOSEOUT ACTIVITIES

A. Refer to Section 27 00 00 Communications. - PART 3.8

END OF SECTION

SECTION 271116 - COMMUNICATION CABINETS RACKS & ENCLOSURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 DESCRIPTION

A. The work covered by this Specification Section includes all labor necessary to perform and complete such construction, materials not provided by the Owners Representative, equipment incorporated or to be incorporated in such construction, and all services, facilities, tools and equipment necessary or used to perform and complete such construction.

1.3 SECTION INCLUDES

A. Equipment Cabinets

B. 2-Post Telecom Racks

1.4 REFERENCE STANDARDS AND CODES

A. Refer to Section 27 00 00 Communications for list of Reference Standards, Codes, and Documents. PART 1.3

1. Specific standards may be referenced throughout this section.

1.5 SCOPE

A. Provides specifications for network cabinets, racks, and telecommunications enclosure components utilized to house various telecommunications infrastructure components within technology distribution spaces.

1.6 SUBMITTALS

A. Refer to Section 27 00 00 Communications. - PART 1.10

1.7 QUALITY ASSURANCE

A. Refer to Section 27 00 00 Communications. - PART 1.11

1.8 CONTRACT ADMINISTRATION

A. Refer to Section 27 00 00 Communications. – PART 1.12 – 1.13

PART 2 - PRODUCTS

2.1 ALTERNATES AND SUBSTITUTIONS

A. Refer to Section 27 00 00 Communications. PART 1.7 – 1.8

2.2 19" EQUIPMENT CABINETS

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

1. B-Line; An Eaton Company.
2. Chatsworth Products Inc.
3. Ortronics; A Legrand Company.
4. Middle Atlantic Products; A Legrand Company.

B. Description:

1. Cabinet dimensions:

a. Forty-five (45) rack units (RU) or as indicated in T-series drawings, marked in a contrasting color.
b. Standard 19" EIA-310-D compliant rack width
c. Depth 42"

2. Equipment cabinet components shall be black in color. Finish shall be powder coat.
3. Rated load for equipment cabinets shall be no less than 2000 pounds.
4. Each cabinet enclosure shall have a rectangular frame with removable top panel, side panels and doors. Installed cabinets shall include thermal, power, and cable management accessories that control airflow through the cabinet and keep network and power cables separate and organized.
5. Provide minimum 20 RU of various configurable size blanking panels for each equipment cabinet.
6. The cabinet frame shall be rectangular with four corner posts, manufactured from steel and aluminum with welded and bolted frame construction. The horizontal frame members shall be aluminum extrusion with grooves that accept captive hardware to allow attachment of equipment mounting rails and thermal, cable and power management accessories. The captive hardware will slide within the groove allowing rails and accessories to be adjusted in depth without removal from the cabinet. The slide extrusions will be marked with a scale that allows easy top-to-bottom alignment of mounting rails and other accessories when adjusted in depth.
7. Each cabinet shall include two pairs of equipment mounting rails. Mounting rails shall bolt to the side of the cabinet frame at the top and bottom of the frame and shall be adjustable in depth to provide front and rear support for equipment.
8. Equipment Mounting Rails shall be spaced horizontally to support 19" wide EIA-310-D compliant rack-mount equipment.
9. AV Cabinets shall have standard 10/32 threaded mounting holes according to the EIA-310-D Universal hole pattern and shall be marked and start at the bottom of the rail.
10. NON-AV Cabinet mounting rails shall be square-punched according to the EIA-310-D Universal hole pattern and shall accept cage nut hardware with various threads. Rack units (RU) shall be marked and start at the bottom of the rail.
11. The cabinet shall include an interchangeable top panel with cable access ports located near the front and rear corners of the frame. Each cable access port shall be plastic with a brush seal to allow easy addition and removal of cables while limiting bypass airflow.
12. The cabinet shall be designed to allow baying with or without side panels installed.
13. The cabinet shall include a single front door with a high air flow perforated metal panel, hidden tamper-resistant hinges with quick-release hinge pins and a swing handle. The door shall be

removable and reversible to open from the right or left. The door shall open a minimum of 120° when the cabinet is bayed with other cabinets. The front door shall have a single-point slam latch with a keyed lock.

14. The cabinet shall include a high flow perforated metal double rear door with a swing handle. The doors shall be removable. The doors shall open a minimum of 120° when the cabinet is bayed with other cabinets. The double rear door shall have a two-point cam latch with a keyed lock.
15. The mounting rails, top panel, side panels and doors shall be mechanically bonded to the cabinet frame. The cabinet frame shall have a prepared location for attaching a grounding lug.
16. The cabinet shall be UL Listed. UL Listing will be stated in the manufacturer's product literature.
17. The cabinet shall include (4) leveling feet, (4) clamps for securing the leveling feet to the floor and a grounding lug for bonding the cabinet frame to the Telecommunications Grounding Busbar. The manufacturer of the cabinet shall sell compatible casters and equipment mounting hardware as an accessory.

2.3 19" 2-POST TELECOM RACKS

A. Manufacturer List:

1. B-Line
2. Chatsworth
3. Ortronics
4. Middle Atlantic Products

B. Description:

1. EIA-310-D compliant 19" open frame rack shall have a self-aligning design to speed field assembly.
2. Overall dimensions of rack shall be 19.62" W x 15.25"D (5.5" deep at top) with a useable rack height of 45 rack units.
3. Weight capacity shall be 800 lbs., evenly distributed with the base securely fastened, and 1600 lbs., evenly distributed with the base of the rack securely fastened and the top of the rack braced to a structural building.
4. Relay rack channels shall be constructed of 11-gauge steel with tapped 12-24, holes in universal EIA-310-D spacing, top angles shall be 0.125" thick aluminum which can be easily field drilled for cable ladder installation.
5. Gusseted foot base shall have taper on feet to allow rack to self-stabilize on uneven floors.
6. Open frame rack shall be finished in a durable black powder coat.

2.4 EXECUTION

2.5 EXAMINATION

A. Check actual site conditions prior to start of any work. Ensure all preceding trade work associated with the telecommunications system is accurate and complete before proceeding with installation or use of products specified in this section.

2.6 GENERAL

A. Prevention of dust, metal filings and debris collection in the equipment during construction is critical to the longevity of the installed equipment. The Contractor shall place and maintain dust protective plastic covers over any electronic equipment that is occupying the space during construction.

2.7 INSTALLATION

A. Cabinets, racks, frames and enclosures shall be located and installed as indicated in the specifications and on the drawings.

B. Follow installation guidelines as per the requirements specified by the manufacturer.

C. Assemble racks per manufacturer's instructions. Verify that equipment mounting rails are sized properly for rack-mount equipment before attaching the rack to the floor.

D. Anchor all racks and cabinets shall be secured to the floor/wall per the structural requirements and cross brace to the cable runway system above.

E. Racks shall be bonded to the TGB using appropriate hardware provided by the contractor.

F. Seismically brace the products indicated in this specification adhering to construction regulations relative to the buildings seismic zone as required by building codes and the recommendations of a licensed structural engineer.

G. Cable runway may be attached to the top of the rack to deliver cables to the rack. The rack should not be drilled to attach cable runway. Use appropriate hardware from the ladder rack manufacturer.

H. Mounting screws not used for installing patch panels and other hardware shall be bagged and left within a well-marked container upon completion of the installation.

I. Attach Wall Mounted racks to the wall so that the swing gate can be opened fully without obstruction by adjacent racks, or other building, storage or architectural components.

J. Follow the manufacturer's assembly and installation instructions when securing the rack to the wall.

K. Wall mounted racks shall be installed on a plywood backboard bolted to a reinforced wall, or attached to a masonry wall. The rack shall not be attached to sheet rock (gypsum wall board).

L. Provide the necessary clearances in the front and rear of all cabinets, racks, frames and enclosures so that the technology hardware and cabling infrastructure is accessible without obstruction by other utilities or architectural components.

2.8 EQUIPMENT CABINETS & 2-POST TELECOM RACKS

A. Installation:

1. Assemble racks according to manufacturer's instructions. Verify that equipment mounting rails are sized properly for rack-mount equipment before attaching the rack to the floor.
2. Anchor all racks and cabinets to the floor/wall per the structural requirements and cross brace to the cable runway system above.
3. Racks shall be bonded to the TGB using appropriate hardware provided by the contractor.
4. Seismically brace the products indicated in this specification adhering to construction regulations relative to the buildings seismic zone as required by building codes and the recommendations of a licensed structural engineer.
5. Cable runway may be attached to the top of the rack to deliver cables to the rack. The rack should not be drilled to attach ladder rack. Use appropriate hardware from the ladder rack manufacturer.

2.9 RE-INSTALLATION

A. Refer to Section 27 00 00 Communications. – PART 3.7

2.10 CLOSEOUT ACTIVITIES

A. Refer to Section 27 00 00 Communications. – PART 3.8

END OF SECTION

SECTION 271119 - COMMUNICATION TERMINATION BLOCKS AND PATCH PANELS

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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 DESCRIPTION

A. The work covered by this Specification Section includes all labor necessary to perform and complete such construction, materials not provided by the Owners Representative, equipment incorporated or to be incorporated in such construction, and all services, facilities, tools and equipment necessary or used to perform and complete such construction.

1.3 SECTION INCLUDES

A. Optical Fiber Termination panels (FDU).

B. Copper horizontal cabling UTP Angled Patch Panels.

C. Telecom room rack to cabinet copper horizontal cabling UTP Patch Panels.

D. Resource Termination Panels

E. Copper backbone cabling Wall-mounted 110 Frame System.

1.4 REFERENCE STANDARDS AND CODES

A. Refer to Section 27 00 00 Communications for list of Reference Standards, Codes, and Documents. PART 1.3

1. Specific standards may be referenced throughout this section.

1.5 SCOPE

A. Provides specifications for wall and rack/cabinet-mounted blocks, termination panels and patch panel components utilized to terminate various telecommunications infrastructure cabling and connectivity.

1.6 SUBMITTALS

A. Refer to Section 27 00 00 Communications. - PART 1.10

1.7 QUALITY ASSURANCE

A. Refer to Section 27 00 00 Communications. - PART 1.11

1.8 CONTRACT ADMINISTRATION

A. Refer to Section 27 00 00 Communications. – PART 1.12 – 1.13

PART 2 - PRODUCTS

2.1 ALTERNATES AND SUBSTITUTIONS

A. Refer to Section 27 00 00 Communications. PART 1.7 – 1.8

1. No Substitution without pre-approval

2.2 OPTICAL FIBER DISTIBUTION UNITS (FDU)

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

1. Berk-Tek/Ortronics a Nexans company.
2. SYSTIMAX Solutions; a CommScope Inc. brand
3. Superior Essex and Leviton Network Solutions

B. Indoor FDU description:

1. 19-inch Rack mountable FDU with minimum 144-positions with integrated splicing for termination inside Telecom rooms.
2. Maximum 4U (Rack Units) height.
3. Single mode termination: Fusion splice both ends of each single mode fiber optic strand onto factory connectorized single mode pigtails mounted in connector housings assembled by the manufacturer of the single mode fiber optic cable.

    a. Fusion Splice-On Connectors or Pigtail Splice is acceptable.

4. Multimode termination: Terminate both ends of each multimode fiber optic strand onto field installable type connectors.

    a. Fusion splice methodology is acceptable.

5. FDU housings shall be provided for cross-connecting or inter-connecting purposes between OSP, Indoor riser backbone, and/or distribution cables and the active network electronic switches, as noted in the T-series drawings.
6. All FDU's shall be complete factory-provided assemblies that contain all components including LC duplex connector adapter panels and internal/external bend radius, strain relief and cable clamp components that are provided in a housing which includes accessible rear access.
7. All FDU trays and associated bulkhead inserts shall have factory numerical labeling included in the design and presentation to the user side of the panel.
8. The FDU bulkheads that house the terminating modules for the fiber backbone cabling and any horizontal optical fiber cabling shall accept ANSI/TIA-568 standard-compliant LC-connectors compatible with the optical fiber strands being terminated.

C. Outdoor FDU description:

1. Outdoor rated, wall mountable FDU with minimum 24-positions with integrated splicing for termination at outdoor locations. Maximum dimensions 13"H x 12"W x 7"D.
2. Single mode termination: Fusion splice both ends of each single mode fiber optic strand onto factory connectorized single mode pigtails mounted in connector housings assembled by the manufacturer of the single mode fiber optic cable.

    a. Fusion Splice-On Connectors or Pigtail Splice is acceptable.

3. Multimode termination: Terminate both ends of each multimode fiber optic strand onto field installable type connectors.

    a. Fusion splice methodology is acceptable.

4. FDU housings shall be provided for cross-connecting or inter-connecting purposes between OSP, Indoor riser backbone, and/or distribution cables and the active network electronic switches, as noted in the TC-series drawings.
5. FDU's shall be complete factory-provided assemblies that contain all components including LC or ST connector adapter panels as required per location and internal/external bend radius strain relief and cable clamp components that are provided in a housing which includes an accessible rear access hatch.
6. All FDU trays and associated bulkhead inserts shall have factory numerical labeling included in the design and presentation to the user side of the panel.
7. FDU bulkheads that house the terminating modules for the fiber backbone cabling and any horizontal optical fiber cabling shall accept ANSI/TIA-568-C standard-compliant connectors compatible with the optical fiber strands being terminated.

2.3 COPPER HORIZONTAL CABLING UTP PATCH PANELS

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

1. Berk-Tek/Ortronics a Nexans company.
2. SYSTIMAX Solutions; a CommScope Inc. brand
3. Superior Essex and Leviton Network Solutions

B. Description:

1. All patch panels are to be rack/cabinet mountable within industry standard TIA/EIA 19" mounting rails unless otherwise noted.
2. All patch panels are to provide adequate space for individual port labeling on the front and cable/connector labeling on the back.
3. All installed UTP patch panels shall consist of twenty-four (24) or forty-eight (48) port patch panels with ports for each cable as indicated in the TC-series drawings.
4. The performance criteria for the UTP patch panels must meet or exceed the performance parameters for frequency, attenuation, near end cross-talk (NEXT), attenuation to cross-talk ratio (ACR), power sum NEXT (PS-NEXT), power sum ACR (PS-ACR), equal level far end cross-talk (ELFEXT), power sum far end cross-talk (PS-FEXT), and return loss (RL) as set forth in ANSI/TIA-568 Category-6 and Category-6A standards.

C. Accessory Products:

1. Patch panel cable management bars shall be provided to support cable routing to each termination panel.
2. Provide any accessory products related to the UTP patch panels to provide a complete and functional infrastructure system.
3. Provide complete with all required mounting hardware, fittings and cables needed to form a bonded (grounded) system including manufacturer provided star washers.

2.4 TELECOM ROOM RACK TO CABINET COPPER UTP PATCH PANELS AND FDU's

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

1. Berk-Tek/Ortronics a Nexans company.
2. SYSTIMAX Solutions; a CommScope Inc. brand.
3. Superior Essex and Leviton Network Solutions.

B. Description:

1. All patch panels are to be rack/cabinet mountable within industry standard TIA/EIA 19" mounting rails unless otherwise noted.
2. All patch panels mounted in equipment cabinets shall be flat.
3. All patch panels are to provide adequate space for individual port labeling on the front and cable/connector labeling on the back.

4. All installed copper UTP patch panels shall be twenty-four (24) or forty-eight (48) port patch panels as indicated in the T-series drawings.
5. Optical Fiber FDU's shall be a maximum 144 Strand or as indicated in the T-series drawings.
6. The performance criteria for the UTP patch panels must meet or exceed the performance parameters for frequency, attenuation, near end cross-talk (NEXT), attenuation to cross-talk ratio (ACR), power sum NEXT (PS-NEXT), power sum ACR (PS-ACR), equal level far end cross-talk (ELFEXT), power sum far end cross-talk (PS-FEXT), and return loss (RL) as set forth in ANSI/TIA-568-C Category-6 and Category-6a standards.

C. Accessory Products:

1. Patch panel cable management bars shall be provided to support cable routing to each termination panel.
2. Provide any accessory products related to the patch panels to provide a complete and functional infrastructure system.
3. Provide complete with all required mounting hardware, fittings and cables needed to form a bonded (grounded) system.
4. Cabling connecting each telecom room rack to cabinet patch panels shall be 4-pair UTP Category-6 and Category-6a rated cable. Furnish and install 4-pair UTP Category-6 and Category-6a rated horizontal cable as indicated.

2.5 COPPER BACKBONE CABLING WALL-MOUNTED 110 FRAME SYSTEM

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

1. Berk-Tek/Ortronics a Nexans company.
2. SYSTIMAX Solutions; a CommScope Inc. brand
3. Superior Essex and Leviton Network Solutions

B. Description:

1. All wall-mounted voice field termination blocks shall be fifty (50), one hundred (100), three hundred (300), or nine hundred (900) pair tower frame assemblies with 110-style insulation

displacement contact (IDC) type termination and connector blocks installed to terminate the voice pairs and outside plant cable, plus 25 percent spare, as indicated in the T-series drawings.

2. The wiring blocks shall be fire retardant, molded plastic consisting of horizontal index strips for terminating twenty-five (25) pairs of conductors each. These index strips shall be marked with the industry standard, five colors on the pair index teeth, separating the tip and ring of each pair, to establish pair location.

    a. Number of Terminals per Field: One for each conductor in assigned cables.

C. Accessory Products

1. Provide any accessory products related to the 110 frame systems (including C-3, C-4, and C-5 clips) required to provide a complete and functional infrastructure system.
2. Provide complete with all required mounting hardware, fittings and cables needed to form a bonded (grounded) system.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Check actual site conditions prior to start of any work. Ensure all preceding trade work associated with the telecommunications system is accurate and complete before proceeding with installation or use of products specified in this section.

3.2 FDU's, UTP & UTP PATCH PANELS

A. Install all optical fiber and UTP termination panels according to manufacturer's instructions and per all ANSI/TIA-568 standards as shown in the T-series drawings.

B. The installation and performance parameters of all installed cable termination panels shall be verified by the contractor through ANSI/TIA-568 testing procedures.

C. Label all cable termination panels to identify each port and each specific panel in accordance with the ANSI/TIA-606 labeling scheme approved by Owners Representative.

D. Copper Category-6 UTP cables terminate on twenty-four (24) or forty-eight (48) port patch panels as indicated in the T-series drawings.

E. Fiber optic cables terminate on 19-inch Rack mountable FDU with maximum 144-positions with integrated splicing that accepts duplex LC-type connectors as indicated in the T-series drawings.

F. The installation and performance parameters of all installed cable termination panels shall be verified by the contractor through ANSI/TIA-568 testing procedures.

G. Spare port

3.3 COPPER PATCH PANEL CABLE DRESSING

A. Cables shall be dressed to the termination point as follows:

1. Cables for ports on the right half of the patch panel shall be routed in the vertical cable manager on the right as you look at the back of the patch panel.
2. Cables for ports on the left half of the patch panel shall be routed in the vertical cable manager on the left as you look at the back of the patch panel.

3.4 WALL-MOUNT 110 FRAME SYSTEM

A. Install all wall-mounted 110 frames according to the manufacturer's instructions and per all ANSI/TIA-568 standards as shown in the T-series drawings.

B. The installation and performance parameters of all installed category-5e backbone cable termination panels shall be verified through ANSI/TIA-568 testing procedures.

C. Sufficient slack shall be left on all cables terminating within the 110-frame systems to allow relocation of each binder group to adjacent vertical frames or to any space within the indicated frame.

D. Label all category-5e backbone cable termination panels in accordance with the ANSI/TIA-606 labeling scheme approved by Owners Representative.

3.5 RE-INSTALLATION

A. Refer to Section 27 00 00 Communications. - PART 3.7

3.6 CLOSEOUT ACTIVITIES

A. Refer to Section 27 00 00 Communications. - PART 3.8

END OF SECTION

SECTION 271123 - COMMUNICATION CABLE MANAGEMENT AND RUNWAY

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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 DESCRIPTION

A. The work covered by this Specification Section includes all labor necessary to perform and complete such construction, materials not provided by the Owners Representative, equipment incorporated or to be incorporated in such construction, and all services, facilities, tools and equipment necessary or used to perform and complete such construction.

1.3 SECTION INCLUDES

A. Vertical Cable Management

B. Horizontal Cable Management

C. Cable Runway System

1.4 REFERENCE STANDARDS AND CODES

A. Refer to Section 27 00 00 Communications for list of Reference Standards, Codes, and Documents. PART 1.3

1. Specific standards may be referenced throughout this section.

1.5 SCOPE

A. Provides specifications for cable management components utilized inside each telecommunications distribution space to support the management of horizontal workstation cabling, backbone cabling, and patch cords.

1.6 SUBMITTALS

A. Refer to Section 27 00 00 Communications. - PART 1.10

1.7 QUALITY ASSURANCE

A. Refer to Section 27 00 00 Communications. - PART 1.11

1.8 CONTRACT ADMINISTRATION

A. Refer to Section 27 00 00 Communications. – PART 1.12 – 1.13

PART 2 - PRODUCTS

2.1 ALTERNATES AND SUBSTITUTIONS

A. Refer to Section 27 00 00 Communications. PART 1.7 – 1.8

1. No Substitution without pre-approval

2.2 VERTICAL CABLE MANAGEMENT

A. Manufacturer List:

1. Chatsworth Products
2. B-line – Cooper Industries
3. Middle Atlantic Products

B. Description:

1. All vertical cable management on 19” relay racks shall be six inch (0’-6”), ten inch (10”) or twelve (12”) in width as noted in the T-series drawings.
2. All vertical cable management on 19” relay racks shall be eighty-four inches (84”) in height unless otherwise noted in the T-series drawings.
3. Vertical cable management shall be double sided and shall provide sufficient depth to allow for standard copper and fiber bend radii internally and when entering and/or leaving the cable management frame. Dual hinged, removable, full-length doors shall be provided on the front and back of the management.
4. All components of the cable management system shall be black in color.

C. Accessory Products:

1. Provide any accessory products related to the cable management components to provide a complete and functional infrastructure system.

2.3 HORIZONTAL CABLE MANAGEMENT

A. Manufacturer List:

1. Chatsworth Products
2. B-line – Cooper Industries
3. Middle Atlantic Products

B. Description:

1. All horizontal cable management on 19” relay racks shall be provided in rack unit dimensions as noted in the T-series drawings.
2. Horizontal cable managers shall have sufficient depth and surfaces to allow for Category-6A copper cables bend radii. Single sided horizontal cable managers to be minimum 3.5” D.
3. Horizontal cable management shall have dual hinged, removable covers.
4. Transition cable management shall be two rack unit (2U) deep upper jumper tray provided with a one and half inch (1.5”) bend radius component compliant with ANSI/TIA-568 bend radius requirements.
5. All components of the cable management system shall be black in color.

C. Accessory Products:

1. Provide any accessory products related to the cable management components to provide a complete and functional infrastructure system.

2.4 CABLE RUNWAY SYSTEM

A. Manufacturer List:

1. B-line – Redi-Rail
2. Chatsworth Products
3. Middle Atlantic Products

B. Description:

1. C-channel cable runway: UL listed, 1 ½"" x 0.375" aluminum side rails, with 17/64” diameter holes at 1.571” intervals and rungs on 9" centers; aluminum finish, complete with all required mounting hardware, fittings and cables needed to form a bonded (grounded) system.
2. Cable runway system shall include structural engineered and approved components to provide and install the necessary seismic zone support system including end caps, wall angle support brackets, bonding straps, butt splice kits, junction splice kits, and top rack-to-runway mounting kits.
3. All components of the cable runway system shall be black in color.

C. Accessory Products:

1. Provide any accessory products related to the cable runways system to provide a complete and functional infrastructure system. The cable runway accessories include, but are not limited to:

    a. Cable runway bend radius drop assemblies (sized per runway section);

    b. Cable runway movable cross member assemblies to support cable runway bend radius drop assemblies;

    c. Runway butt-splice, swivel splice and foot kits; Heavy duty stringer splice kits and brackets shall be used to attach end to end horizontal cable runway segments.

    d. Cable runway corner brackets (sized per runway and site conditions);

    e. Rack-to-runway mounting plates (sized per runway section);

    f. Cable runway elevation kits (sized per site conditions);

    g. Wall angle support brackets (sized per runway section);

    h. Threaded rod assemblies with rod protectors for overhead attachment;

    i. Slotted Support brackets for runway attachment to threaded rod assemblies;

    j. Runway end termination kits.

    k. Vertical wall-mounting brackets;

    l. Cable retaining posts (6” as required);

    m. Runway bonding kits, unless UL Listed splice kit provides bonding;

n. Protective end caps.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Check actual site conditions prior to start of any work. Ensure all preceding trade work associated with the telecommunications system is accurate and complete before proceeding with installation or use of products specified in this section.

3.2 VERTICAL AND HORIZONTAL CABLE MANAGEMENT

A. Process:

1. Install all vertical and horizontal cable management per the manufacturer's recommended installation instructions, as indicated in the T-series drawings.
2. Where cable bundles are necessary inside the telecommunications rooms, they shall be secured with Velcro cable wraps; plastic wire ties are not acceptable.
3. Cable ties and Velcro wraps shall not be pulled tight enough to kink the cable jacket.

3.3 CABLE RUNWAY SYSTEM

A. Process:

1. Install all vertical and horizontal cable runways per the manufacturer's recommended installation instructions, as indicated in the project drawings.
2. Coordinate the cable runway rungs with the vertical cable manager locations to provide for an unobstructed opening above the vertical cable managers. The specified C-channel cable runway rungs can be relocated to accommodate this requirement.
3. Install radius runway drop-out fittings at all instances of cable runway grids where cable bundles enter or exit the cable runway system. Multiple drop-out fittings may need to be placed next to each other to accommodate cable routing. Install drop-out wing sections at the ends of the waterfall drop-out fittings to ensure cable radius requirements are met where cables exit or enter the cable runway grid from the sides of the runway stringers.
4. Install radius runway drop-out fittings at all instances on both sides above front end of vertical cable managers of cable runway to accommodate patch cord routing in both directions.
5. Install cable-retaining posts on both sides of the cable runway grid. Retaining posts to be installed at all 90-degree corners, ends of each runway section and at 24" intervals along straight sections. Retaining posts to be installed on both sides of the runway ladder.
6. Open ended cable runway sections shall be closed with runway termination kits.
7. Support vertical cable runway sections to the plywood backboards with runway hold down clamp kits.
8. Vertical support shall be provided if a cable runway section spans a distance greater than four (4) feet.
9. Provide vertical cable support where vertical cable sections are greater than three (3) feet.
10. Provide vertical cable runway sections from slab level to slab level in each telecom room where cables enter the telecom room through the floor slab and exit the telecom room through the ceiling slab.
11. Provide vertical cable runway sections from slab level to the horizontal cable runway grid in each telecom room where cables enter the telecom room through the floor or ceiling slab and do not continue through to floor or ceiling slab.
12. Inside telecom spaces the primary cable transport system shall be the overhead cable runway system, as shown in the T-series drawings. Contractor-installed cable runway system shall include

all components to complete the installation whether indicated in the contract documents or implied by the design.

13. Install all components of the cable runway system under the codes, standards, guidelines, and manufacturer recommendations.
14. Diagonal braces and threaded rod stiffeners shall be installed as additional structural support assembly as required by the Seismic Requirements for Non-Structural Components for all structural bracing and support of telecommunications equipment.

3.4 RE-INSTALLATION

A. Refer to Section 27 00 00 Communications. - PART 3.7

3.5 CLOSEOUT ACTIVITIES

A. Refer to Section 27 00 00 Communications. - PART 3.8

END OF SECTION

SECTION 271313 - COMMUNICATION COPPER BACKBONE CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 DESCRIPTION

A. The work covered by this Specification Section includes all labor necessary to perform and complete such construction, materials not provided by the Owners Representative, equipment incorporated or to be incorporated in such construction, and all services, facilities, tools and equipment necessary or used to perform and complete such construction.

1.3 SECTION INCLUDES

A. Backbone Multi-Pair UTP Cable

1.4 REFERENCE STANDARDS AND CODES

A. Refer to Section 27 00 00 Communications for list of Reference Standards, Codes, and Documents. PART 1.3

1. Specific standards may be referenced throughout this section.

1.5 SCOPE

A. Provides specifications for copper backbone cabling to distribute network signals from MDF space to IDF locations and from the Entrance facility to MDF.

1.6 SUBMITTALS

A. Refer to Section 27 00 00 Communications. - PART 1.10

1.7 QUALITY ASSURANCE

A. Refer to Section 27 00 00 Communications. - PART 1.11

1.8 CONTRACT ADMINISTRATION

A. Refer to Section 27 00 00 Communications. – PART 1.12 – 1.13

PART 2 - PRODUCTS

2.1 ALTERNATES AND SUBSTITUTIONS

A. Refer to Section 27 00 00 Communications. PART 1.7 – 1.8

1. No Substitution without pre-approval

2.2 BACKBONE MULTI-PAIR UTP CABLE

A. Manufacturer List:

1. Superior Essex
2. Berk-Tek
3. Panduit
4. Commscope

B. Description:

1. All voice and data ISP and OSP copper backbone cable is to be rated per the environmental conditions in which installed and verified by the contractor prior to installation. Per code, plenum cable is to be installed at all times when a communications cable is exposed in a plenum air space. It is the responsibility of the contractor to bid, purchase, install, and verify the rating of the ISP and OSP cable for the specific environmental conditions.
2. Backbone cables that are exposed to moisture shall be either indoor/outdoor or outdoor rated and contain moisture-blocking materials to prevent moisture damage to cable performance. Select the appropriate cable construction, including external jacket properties, when installing cables in aerial, outdoor, underground and corrosive environments. This includes conduit installed in slab-on-grade.
3. Backbone multi-pair UTP cable shall be Category-5e copper UTP, twenty-four (24) AWG cable. The total pair count of each Category-5e cable shall be provided as noted in the project drawings. Multiple 25-Pair cables may be required.
4. The performance criteria for the UTP backbone cable shall be in accordance with the specific standards for the particular cable's rating. All backbone cables shall perform up to, or beyond the current specification parameters for the published Category-5e rating by the current edition of ANSI/TIA-568.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Check actual site conditions prior to start of any work. Ensure all preceding trade work associated with the telecommunications system is accurate and complete before proceeding with installation or use of products specified in this section.

3.2 COPPER BACKBONE CABILING

A. Install all copper backbone cable per the manufacturer's installation instructions and ANSI/TIA-568 standards, and in quantities indicated in the T-series drawings.

B. Install all cables with proper attention paid to bend radii, pulling method, attachment method, and pulling forces. The cable manufacturer's specifications for each particular cable type shall be followed exactly.

C. Backbone cable shall be visually inspected for sufficient bend radius during and after pulling. Damaged cables, or those installed under questionable methods and/or circumstances shall be replaced at no additional cost to Owners Representative.

D. All cable shall be pulled using an appropriate measuring device to ensure that the specified force is not exceeded as noted in BICSI best practices.

E. Install backbone cables with attention paid to aesthetic means and methods when routing cabling within IT spaces.

F. No backbone cable shall be left unsupported for more than three (3) feet vertically or horizontally at any time.

G. All backbone cables shall be clearly labeled on both ends and in an accessible location no more than one (1) foot from each cable end.

3.3 RE-INSTALLATION

A. Refer to Section 27 00 00 Communications. – PART 3.7

3.4 CLOSEOUT ACTIVITIES

A. Refer to Section 27 00 00 Communications. – PART 3.8

END OF SECTION

SECTION 271323 - COMMUNICATION OPTICAL FIBER BACKBONE CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 DESCRIPTION

A. The work covered by this Specification Section includes all labor necessary to perform and complete such construction, materials not provided by the Owners Representative, equipment incorporated or to be incorporated in such construction, and all services, facilities, tools and equipment necessary or used to perform and complete such construction.

1.3 SECTION INCLUDES

A. Backbone Single-mode Optical Fiber Cable

1.4 REFERENCE STANDARDS AND CODES

A. Refer to Section 27 00 00 Communications for list of Reference Standards, Codes, and Documents. PART 1.3

1. Specific standards may be referenced throughout this section.

1.5 SCOPE

A. Provides specifications for Optical Fiber backbone cabling to distribute network signals from MDF space to IDF locations and from the Entrance facility to MDF.

1.6 SUBMITTALS

A. Refer to Section 27 00 00 Communications. - PART 1.10

1.7 QUALITY ASSURANCE

A. Refer to Section 27 00 00 Communications. - PART 1.11

1.8 CONTRACT ADMINISTRATION

A. Refer to Section 27 00 00 Communications. – PART 1.12 – 1.13

PART 2 - PRODUCTS

2.1 ALTERNATES AND SUBSTITUTIONS

A. Refer to Section 27 00 00 Communications. PART 1.7 – 1.8

1. No Substitution without pre-approval

2.2 BACKBONE SINGLE-MODE OPTICAL FIBER CABLE

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

1. Berk-Tek; a Nexans company
2. SYSTIMAX Solutions; a CommScope Inc. brand.
3. Superior Essex and Leviton Network Solutions.

B. Product Options:

1. The manufacturers noted above shall be the only manufacturers acceptable to Owners Representative and A/E.

C. Description:

1. All single-mode optical fiber cable shall be capable of Ethernet signal transmission at 10 Gb/s up to 10,000 meters in the 1310nm operating window. Maximum attenuation for a single-mode indoor/outdoor cable shall be no greater than 0.5dB per kilometer using 1310nm and 1550nm wavelengths.
2. Each optical fiber strand shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical, and environmental requirements of this specification and all ANSI/TIA-568 performance parameters.
3. All optical fibers inside each individual cable shall be provided in counts indicated in the T-series drawings and usable to the fullest capacity specified by the manufacturer and meet required specifications at all times.
4. Indoor backbone single-mode optical fiber cables shall be:

    a. Individual jacketed, tight buffered fiber type.
    b. The individual fibers are grouped in jacketed subunits color coded per ANSI/TIA-598.
    c. Have integrated dielectric central and strength members.
    d. The fiber core is protected by a flexible, spirally wrapped interlocking armored metal made of aluminum or galvanized steel without interruption from end to end for protection and strength. The metallic armor shall also be wrapped in a yellow-colored flame retardant outer sheath to designate the type of optical fiber.

5. Outside Plant (OSP) backbone single-mode optical fiber cables shall be:

    a. Flame-retardant UV-resistant indoor/outdoor rated cables.
    b. The individual fibers are grouped in jacketed subunits color coded per TIA-598.
    c. Have dielectric integrated central strength member with surrounding water-swellable water-blocking strength members.

6. The optical fiber cables shall be rated per the installation environment as required by the local Authority Having Jurisdiction and/or National Fire Codes. Select an appropriate cable construction, including external jacket properties, when installing optical fiber cables in aerial, outdoor, underground and corrosive environments.
7. All SMF shall meet or exceed TIA compliant network cable-testing device certification by an independent laboratory, such as ETL, for verification of high speed, ANSI/TIA-568 compliant performance.

D. Accessory Products:

1. Provide any accessory products related to the optical fiber backbone cabling required to provide a complete and functional infrastructure system.

PART 3 - EXECUTION

3.1 GENERAL

A. Prevention of dust, metal filings and debris collection in the equipment during construction is critical to the longevity of the installed equipment. The Contractor shall maintain a dust free environment around all fiber optic equipment that is occupying the space during construction.

3.2 EXAMINATION

A. Check actual site conditions prior to start of any work. Ensure all preceding trade work associated with the telecommunications system is accurate and complete before proceeding with installation or use of products specified in this section.

3.3 BACKBONE OPTICAL FIBER (SMF) CABLE

A. Install all horizontal cable per the manufacturer's recommended installation instructions, under the guidelines of ANSI/TIA/EIA-568 and BICSI best practices, and in quantities indicated in the T-series drawings.

B. Install all cables with proper attention paid to bend radii, pulling method, attachment method, and pulling forces. The cable manufacturer's specifications for each particular cable type shall be followed exactly.

C. Backbone cable shall be visually inspected for sufficient bend radius during and after pulling. Damaged cables, or those installed under questionable methods and/or circumstances shall be replaced at no additional cost to Owners Representative.

D. All cable shall be pulled using an appropriate measuring device to ensure that the specified force is not exceeded as noted in BICSI best practices.

E. Install backbone cables with attention paid to aesthetic means and methods when routing cabling within IT spaces. No backbone cable shall be left unsupported for more than five (5) feet vertically or horizontally at any time.

F. Fiber optic cables shall be separated from other communications cabling. Fiber optic cables shall be neatly placed and lashed with Velcro ties to the horizontal and vertical cable management and runways at minimum 4-foot intervals, not to exceed every 4th rung, plus all locations where the cables change direction.

G. Provide radius drop out fittings at all locations where fiber optic cables transition from vertical to horizontal cable management systems.

H. All backbone cable shall be securely fastened to the termination shelf with a manufacturers strain relief bracket and termination panel (FDU) cable clamp in a way that does not damage the optical fiber strands or impede the performance of the media. This secure fastening method shall also serve to insure a secure termination environment.

I. A minimum of three feet (3'-0") of each optical fiber strand shall be left protected within the termination shelf (FDU) for any future re-termination of a particular optical fiber strand.

J. All backbone cables shall be clearly labeled on both ends and in an accessible location no more than one (1) foot from each cable end.

3.4 RE-INSTALLATION

A. Refer to Section 27 00 00 Communications. PART 3.7

3.5 CLOSEOUT ACTIVITIES

A. Refer to Section 27 00 00 Communications. PART 3.8

END OF SECTION

SECTION 271333 - COMMUNICATION COAXIAL BACKBONE CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 DESCRIPTION

A. The work covered by this Specification Section includes all labor necessary to perform and complete such construction, materials not provided by the Owners Representative, equipment incorporated or to be incorporated in such construction, and all services, facilities, tools and equipment necessary or used to perform and complete such construction.

1.3 SECTION INCLUDES

A. RG-11 Coaxial Cabling

B. QR 540 Coaxial Cable

1.4 REFERENCE STANDARDS AND CODES

A. Refer to Section 27 00 00 Communications for list of Reference Standards, Codes, and Documents. PART 1.3

1. Specific standards may be referenced throughout this section.

1.5 SCOPE

A. Provides specifications for coaxial backbone cabling to distribute RF-based signals between telecommunications distribution spaces.

1.6 SUBMITTALS

A. Refer to Section 27 00 00 Communications. - PART 1.10

1.7 QUALITY ASSURANCE

A. Refer to Section 27 00 00 Communications. - PART 1.11

1.8 CONTRACT ADMINISTRATION

A. Refer to Section 27 00 00 Communications. – PART 1.12 – 1.13

PART 2 - PRODUCTS

2.1 ALTERNATES AND SUBSTITUTIONS

A. Refer to Section 27 00 00 Communications. PART 1.7 – 1.8

1. No Substitution without pre-approval

2.2 RG-11 COAXIAL CABLE

A. Manufacturer List:

1. Belden
2. Commscope
3. Superior Essex

B. Description

1. RG-11 coaxial cable shall exhibit a nominal impedance of seventy-five (75) Ohms.
2. Typical attenuation for RG-11 coaxial cables shall be 3.5dB (± 0.5 db) per 100 feet (100') of cable at a seven hundred and fifty (750) megahertz wavelength. All coaxial cables shall be swept-tested to 2.2 GHz or greater.
3. The coaxial center conductor shall be solid gauge that is encased by a foam dielectric used to meet or exceed electrical and fire-safety and code compliance and performance.
4. RG-11 coaxial cable shall exhibit stable performance in a building environment, as well as in an exterior exposed environment, and shall have a minimum ninety five percent (95%) braided shield design.
5. RG-11 coaxial cables that are exposed to moisture shall contain moisture-blocking materials to prevent moisture damage to cable performance.
6. Select an appropriate cable construction, including external jacket properties, when installing cables in aerial, outdoor, underground and corrosive environments.

C. Accessory Products:

1. Provide any accessory products related to the coaxial backbone cabling required to provide a complete and functional infrastructure system.

2.3 QR 540 COAXIAL CABLING

A. Manufacturer List:

1. Commscope Products

B. Product Options:

1. QR 540 JCAR – Indoor Riser (CATVR)
2. QR 540 JCASS - Underground

C. Description

1. QR 540 coaxial cable shall exhibit a nominal impedance of seventy-five (75) Ohms.
2. Typical attenuation for QR 540 coaxial cables shall be 1.80dB (± 0.5 db) per 100 feet (100') of cable at a seven hundred and fifty-megahertz wavelength.
3. The coaxial center conductor shall be solid gauge that is encased by a dielectric used to meet or exceed electrical and fire-safety and code compliance and performance.
4. QR 540 coaxial cable shall exhibit stable performance in a building environment, as well as in an underground exposed environment. Coaxial cables that are exposed to moisture shall contain moisture-blocking materials to prevent moisture damage to cable performance.
5. Select an appropriate cable construction considering code requirements and environmental conditions when installing cables in aerial, outdoor, underground and corrosive environments.

D. Accessory Products:

1. Provide any accessory products related to the coaxial backbone cabling required to provide a complete and functional infrastructure system.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Check actual site conditions prior to start of any work. Ensure all preceding trade work associated with the telecommunications system is accurate and complete before proceeding with installation or use of products specified in this section.

3.2 BACKBONE COAXIAL CABILING

A. Install all backbone coaxial cable per BICSI Best Practices, the manufacturer's installation instructions and ANSI/TIA-568 standards, and in quantities indicated in the T-series drawings.

B. Install all cables with proper attention paid to bend radii, pulling method, attachment method, and pulling forces. The cable manufacturer's specifications for each particular cable type shall be followed exactly.

C. Backbone coaxial cable shall be visually inspected for insufficient bend radius during and after pulling. Damaged cables, or those installed under questionable methods and/or circumstances shall be replaced at no additional cost to the owner.

D. Install backbone coaxial cables with attention paid to aesthetic means and methods when routing cabling within IT spaces. No backbone cable shall be left unsupported for more than five (5) feet vertically or horizontally at any time.

E. All backbone coaxial cables shall be clearly labeled on both ends and in an accessible location no more than one (1) foot from each cable end.

3.3 RE-INSTALLATION

A. Refer to Section 27 00 00 Communications. - PART 3.7

3.4 CLOSEOUT ACTIVITIES

A. Refer to Section 27 00 00 Communications. - PART 3.8

END OF SECTION

SECTION 271334 - COMMUNICATION COAXIAL SPLICING AND TERMINATION

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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 DESCRIPTION

A. The work covered by this Specification Section includes all labor necessary to perform and complete such construction, materials not provided by the Owners Representative, equipment incorporated or to be incorporated in such construction, and all services, facilities, tools and equipment necessary or used to perform and complete such construction.

1.3 SECTION INCLUDES

A. RG-11 Connectors

B. RG-6 Connectors

C. QR 540 Connectors

1.4 REFERENCE STANDARDS AND CODES

A. Refer to Section 27 00 00 Communications for list of Reference Standards, Codes, and Documents. PART 1.3

1. Specific standards may be referenced throughout this section.

1.5 SCOPE

A. Provides specifications for the termination of coaxial station and backbone cabling to distribute RF-based network signals between telecommunications distribution spaces and to/from coaxial workstation outlets.

1.6 SUBMITTALS

A. Refer to Section 27 00 00 Communications. - PART 1.10

1.7 QUALITY ASSURANCE

A. Refer to Section 27 00 00 Communications. - PART 1.11

1.8 CONTRACT ADMINISTRATION

A. Refer to Section 27 00 00 Communications. – PART 1.12 – 1.13

PART 2 - PRODUCTS

2.1 ALTERNATES AND SUBSTITUTIONS

A. Refer to Section 27 00 00 Communications. PART 1.7 – 1.8

1. No Substitution without pre-approval

2.2 RG-11 F-TYPE CONNECTORS

A. Manufacturer List:

1. Belden

2. Thomas & Betts

B. Description:

1. RG-11 coaxial connectors shall be sealed to prevent moisture from migrating into the connector and have three hundred sixty (360) degree radial compression.

2. All coaxial connections shall have a minimum cable retention rating of forty (40) pounds.

3. All modular outlet coaxial connectors shall function to the specified performance parameters for video signal traffic that is connected via video patch cords in the IDF(s), Head End and/or MDF.

4. Ensure connector size and type is compatible with the specified RG-11 backbone cable.

5. Utilize corrosion resistant connectors when applicable.

C. Accessory Products:

1. Provide any accessory products related to the coaxial cabling termination connectors required to provide a complete and functional infrastructure system.

2.3 RG-6 F-TYPE CONNECTORS

A. Manufacturer List:

1. Belden

2. Thomas & Betts

B. Description

1. RG-6 coaxial connectors shall be sealed to prevent moisture from migrating into the connector and have three hundred sixty (360) degree radial compression.

2. All coaxial connections shall have a minimum cable retention rating of forty (40) pounds.

3. All coaxial connections shall be manufactured with RG-6 F-type interface that is compatible with components specifically manufactured for RG-6 F-type threaded ports.

4. All modular outlet coaxial connectors shall function to the specified performance parameters for video signal traffic that is connected via video patch cords in the IDF(s), Head End and/or MDF.

5. Ensure connector size and type is compatible with the specified RG-6 backbone cable.

6. Utilize corrosion resistant connectors when applicable.

C. Accessory Products:

1. Provide any accessory products related to the coaxial cabling termination connectors required to provide a complete and functional infrastructure system.

2.4 QR 540 CONNECTORS

A. Manufacturer List:

1. Corning Gilbert Products

2. Belden

3. Thomas & Betts

B. Product Options:

1. The indicated manufacturers shall be the basis of the design and each component selected shall address the particular infrastructure requirements.

C. Description

1. QR 540 coaxial connectors shall be 2-piece connector construction with a bandwidth range from 5 MHz to 1 GHz. Nominal impedance shall be 75 ohms.
2. The connector shall be constructed from ASTM 6000 series aluminum alloy with gold chromate conversion coating for corrosion resistance. Contact pins and support sleeves shall be brass with bright acid tin plating for RF conductivity.
3. All modular outlet coaxial connectors shall function to the specified performance parameters for video signal traffic that they support.
4. Ensure connector size and type is compatible with the specified QR 540 backbone coaxial cable.
5. Utilize corrosion resistant connectors when applicable.

D. Accessory Products:

1. Provide any accessory products related to the coaxial cabling termination connectors required to provide a complete and functional infrastructure system.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Check actual site conditions prior to start of any work. Ensure all preceding trade work associated with the telecommunications system is accurate and complete before proceeding with installation or use of products specified in this section.

3.2 RG-11, RG-6, QR 540 CONNECTORS

A. Install all connectors and required couplers per the manufacturer's installation instructions and ANSI/TIA-568 standards, and in quantities indicated in the T-series drawings.

B. The installation and performance parameters of all installed connectors shall be verified by the contractor through ANSI/TIA-568 testing procedures for each connector.

3.3 RE-INSTALLATION

A. Refer to Section 27 00 00 Communications. PART 3.7

3.4 CLOSEOUT ACTIVITIES

A. Refer to Section 27 00 00 Communications. PART 3.8

END OF SECTION

SECTION 271513 - COMMUNICATION COPPER HORIZONTAL CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 DESCRIPTION

A. The work covered by this Specification Section includes all labor necessary to perform and complete such construction, materials not provided by the Owners Representative, equipment incorporated or to be incorporated in such construction, and all services, facilities, tools and equipment necessary or used to perform and complete such construction.

1.3 SECTION INCLUDES

A. Category 6 Four-Pair UTP Cabling

B. Category 6A Four-Pair UTP Cabling

1.4 REFERENCE STANDARDS AND CODES

A. Refer to Section 27 00 00 Communications for list of Reference Standards, Codes, and Documents. PART 1.3

1. Specific standards may be referenced throughout this section.

1.5 HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called "permanent link," a term that is used in the testing protocols.

1. TIA/EIA-568-B.1 requires that a minimum of two telecommunications outlet/connectors be installed for each work area.
2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
3. Bridged taps and splices shall not be installed in the horizontal cabling.
4. Splitters shall not be installed as part of the optical fiber cabling.

B. A work area is the area identified on the drawings.

C. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to equipment. The maximum allowable length does not include an allowance for the length of 16 feet in the horizontal cross-connect.

1.6 SCOPE

A. Provides specifications for four-pair UTP copper horizontal workstation cabling to distribute network signals from telecommunications distribution spaces to workstation outlet locations.

1.7 SUBMITTALS

A. Refer to Section 27 00 00 Communications. - PART 1.10

1.8 QUALITY ASSURANCE

A. Refer to Section 27 00 00 Communications. - PART 1.11

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 450 or less.

1.9 CONTRACT ADMINISTRATION

A. Refer to Section 27 00 00 Communications. – PART 1.12 – 1.13

PART 2 - PRODUCTS

2.1 ALTERNATES AND SUBSTITUTIONS

A. Refer to Section 27 00 00 Communications. PART 1.7 – 1.8

1. No Substitution without pre-approval

2.2 FOUR PAIR UTP CABLING (Category 6)

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

1. Berk-Tek; a Nexans company
2. SYSTIMAX Solutions; a CommScope Inc. brand.
3. Superior Essex and Leviton Network Solutions.

B. 100 Ohm Enhanced Category 6 Unshielded Twisted Pair (UTP) Cable

1. Physical Characteristics:

a. Shall be plenum rated and meet applicable requirements of ANSI/ICEA S- 80-576. All 4 pairs must be insulated with F.E.P. No constructions that use mixed insulation materials will be allowed.
b. The diameter of the insulated conductor shall be .026 in. nominal.
c. Shall consist of (4) 23 AWG twisted pairs.
d. Shall be suitable for the environment in which they are to be installed.
e. The color coding of pairs shall be:

1) Pair 1: W-BL; BL
2) Pair 2: W-O; O

3) Pair 3: W-G; G
4) Pair 4: W-BR; BR

f. The overall diameter of the cable shall be no larger than 0.250 inches.
g. The ultimate breaking strength measured in accordance with ASTM D 4565 shall be 400 N minimum.
h. Cable shall withstand a bend radius of 1 inch at -20 degrees Celsius without jacket or insulation cracking.
i. Cable shall be third party verified to meet ANSI/TIA/EIA-568-B.2-1.

C. All horizontal data station cable and voice cable shall terminate on modular patch panels or 110 cross-connecting blocks in their respective Telecommunications Room or Equipment Room as specified on the project Drawings.

D. All cables in a cable run shall be from the same manufacturer and shall be the same type.

E. A mix of UTP cables from different manufactures shall not be used.

F. Accessory Products:

1. Provide any accessory products related to the UTP copper 4-pair cabling required to provide a complete and functional infrastructure system.

2.3 FOUR PAIR UTP CABLING (Category 6A)

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

1. Berk-Tek; a Nexans company
2. SYSTIMAX Solutions; a CommScope Inc. brand.
3. Superior Essex and Leviton Network Solutions.

B. Description

1. Shall be plenum rated and meet applicable requirements of ANSI/ICEA S- 80-576. All 4 pairs must be insulated with F.E.P. No constructions that use mixed insulation materials will be allowed.
2. All Category-6A performance four (4) pair UTP cable shall consist of eight (8) twenty-three (23) gauge, or twenty-two (22) gauge, thermoplastic insulated solid twisted conductors that utilize the industry standard color code designations and provided with overall aluminum foil shield and longitudinal drain wire.
3. The performance criteria for four (4) pair UTP cable shall be meet or exceed specific ANSI/TIA-568 standards for Category-6A cable rating and shall show stable performance with documented electrical characterization out to 500 MHz
4. Cables shall be rated per the installation environment as required by the local AHJ and building codes.
5. Select an appropriate cable construction, including external jacket properties, when installing cables in aerial, outdoor, underground and corrosive environments.

C. Accessory Products:

1. Provide any accessory products related to the UTP copper 4-pair cabling required to provide a complete and functional infrastructure system.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Check actual site conditions prior to start of any work. Ensure all preceding trade work associated with the telecommunications system is accurate and complete before proceeding with installation or use of products specified in this section.

1. Electrical requirements (conduit installation and capacity)
2. The telecommunications rooms are the size shown on the project drawings.
3. Adequate clearances of doors, riser spaces and ceilings for all component of the telecommunications system.
4. Examine and compare the telecommunications drawings and specifications with the drawings and specifications of other trades. Report any discrepancies between them to the A/E and obtain written instructions for changes or revisions.

3.2 FOUR PAIR UTP CABLING INSTALLATION

A. Comply with TIA/EIA-568-B.1.

B. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."

C. General Requirements for Cabling:

1. Install 110-style IDC termination hardware unless otherwise indicated.
2. MUTOA shall not be used as a cross-connect point.
3. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:

    a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
    b. Locate consolidation points for UTP at least 49 feet from communications equipment room.

4. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
8. 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.
9. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
10. In the communications equipment room, install a 10-foot- long service loop on each end of cable.
11. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
12. Install all horizontal station cabling per the manufacturer’s recommended installation instructions, under the guidelines of ANSI/TIA-568 and BICSI best practices, and in quantities indicated in the T-series drawings.
13. Install all cables with proper attention paid to bend radii, pulling method, attachment method, and pulling forces. All cable shall be pulled using an appropriate measuring device to ensure that the

specified force is not exceeded as noted in BICSI best practices. Also refer to the cable manufacturer's specifications for exact cable requirements per the particular cable type.

14. Cable Bundles

    a. Bundling of cables is to be avoided; where bundling is necessary bundles shall be limited to no more than 24 cables.
    b. Allow cables to lay naturally in cable tray and runways whenever possible.
    c. Cables shall be neatly dressed from the point of emergence from vertical cable managers to the point of termination.

15. All cables shall be visually inspected for sufficient bend radius during and after pulling. Damaged cables, or those installed under questionable methods and/or circumstances shall be replaced at no additional cost to Owner.
16. Contractor shall ensure that all industry standards and best practices are met, with special regard to maximum pair un-twist. No twisted pair cables shall have more than three-eight inch (3/8") of pair un-twist. The cable jacket shall be maintained as close as possible to the connecting hardware.
17. Install the horizontal cabling with attention paid to aesthetic means and methods when routing cabling within IT spaces. All horizontal cabling should terminate in their respective floor serving technology space; specifically cables from floor outlets need to terminate in their corresponding floor telecom room.
18. All cabling distributed horizontally through metal stud framing shall have plastic protective bushings inserted to protect cables prior to installation.
19. All cables shall be clearly labeled on both ends and in an accessible location no more than six inches (0'-6") from the cable ends.

D. UTP Cable Installation:

1. Comply with TIA/EIA-568-B.2.
2. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Group connecting hardware for cables into separate logical fields.

G. Owner reserves the right to specify a new location for any outlet or equipment without increasing contractor unit cost – providing that the new location is specified prior to roughing-in of technology cable and is not farther than ten (10) feet away from the original location specified.

3.3 RE-INSTALLATION

A. Refer to Section 27 00 00 Communications. - PART 3.7

3.4 CLOSEOUT ACTIVITIES

A. Refer to Section 27 00 00 Communications. - PART 3.8

END OF SECTION

SECTION 271533 - COMMUNICATION COAXIAL HORIZONTAL CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

B. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 DESCRIPTION

A. The work covered by this Specification Section includes all labor necessary to perform and complete such construction, materials not provided by the Owners Representative, equipment incorporated or to be incorporated in such construction, and all services, facilities, tools and equipment necessary or used to perform and complete such construction.

1.3 SECTION INCLUDES

A. RG-6 Coaxial Cable

1.4 REFERENCE STANDARDS AND CODES

A. Refer to Section 27 00 00 Communications for list of Reference Standards, Codes, and Documents. PART 1.3

1. Specific standards may be referenced throughout this section.

1.5 SCOPE

A. Provides specifications for coaxial horizontal workstation cabling to distribute RF-based network signals between telecommunications distribution spaces and various workstation outlet locations.

1.6 SUBMITTALS

A. Refer to Section 27 00 00 Communications. - PART 1.10

1.7 QUALITY ASSURANCE

A. Refer to Section 27 00 00 Communications. - PART 1.11

1.8 CONTRACT ADMINISTRATION

A. Refer to Section 27 00 00 Communications. – PART 1.12 – 1.13

PART 2 - PRODUCTS

2.1 ALTERNATES AND SUBSTITUTIONS

A. Refer to Section 27 00 00 Communications. PART 1.7 – 1.8

1. No Substitution without pre-approval

2.2 RG-6 COAXIAL CABLE

A. Manufacturer List:

1. Belden Coaxial Cable
2. Panduit Coaxial Cable
3. Commscope Coaxial Cable
4. Approved Equal

B. Description:

1. RG-6 coaxial cable shall exhibit a nominal impedance of seventy-five (75) Ohms.
2. Typical attenuation for RG-6 coaxial cables shall be 5.5dB (± 0.5 db) per 100 feet (100') of cable at a seven hundred and fifty (750) megahertz wavelength. All coaxial cables shall be swept-tested to 2.2 GHz.
3. The coaxial center conductor shall be solid gauge that is encased by a foam dielectric used to meet or exceed electrical and fire-safety and code compliance and performance.
4. RG-6 coaxial cable shall exhibit stable performance in a building environment, as well as in an exterior exposed environment, and shall have a quad shield design.
5. It is the responsibility of the contractor to bid, purchase, install, and verify the rating of the ISP and OSP cable for the specific construction conditions.
6. Select an appropriate cable construction, including external jacket properties, when installing cables in aerial, outdoor, underground and corrosive environments.

C. Accessory Products

1. Provide any accessory products related to the coaxial horizontal cabling required to provide a complete and functional infrastructure system.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Check actual site conditions prior to start of any work. Ensure all preceding trade work associated with the telecommunications system is accurate and complete before proceeding with installation or use of products specified in this section.

1. Electrical requirements (conduit installation and capacity)
2. The telecommunications rooms are the size shown on the project drawings.
3. Adequate clearances of doors, riser spaces and ceilings for all component of the telecommunications system.
4. Examine and compare the telecommunications drawings and specifications with the drawings and specifications of other trades. Report any discrepancies between them to the A/E and obtain written instructions for changes or revisions.

3.2 RG-6 HORIZONTAL CABLE

A. Install all RG-6 coaxial per the manufacturer's installation instructions and ANSI/TIA-568 standards, and in quantities indicated in the T-series drawings.

B. Install all cables with proper attention paid to bend radii, pulling method, attachment method, and pulling forces. The cable manufacturer's specifications for each particular cable type shall be followed exactly.

C. RG-6 coaxial cable shall be visually inspected for sufficient bend radius during and after pulling. Damaged cables, or those installed under questionable methods and/or circumstances shall be replaced at no additional cost to the owner.

D. All cable shall be pulled using an appropriate measuring device to ensure that the specified force is not exceeded as noted in BICSI best practices.

E. Install RG-6 coaxial cables with attention paid to aesthetic means and methods when routing cabling within IT spaces. No cable shall be left unsupported for more than five (5) feet vertically or horizontally at any time.

F. All RG-6 coaxial cables shall be clearly labeled on both ends and in an accessible location no more than one (1) foot from each cable end.

3.3 RE-INSTALLATION

A. Refer to Section 27 00 00 Communications. - PART 3.7

3.4 CLOSEOUT ACTIVITIES

A. Refer to Section 27 00 00 Communications. - PART 3.8

END OF SECTION

SECTION 271543 - COMMUNICATION FACEPLATES AND CONNECTORS

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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 DESCRIPTION

A. The work covered by this Specification Section includes all labor necessary to perform and complete such construction, materials not provided by the Owners Representative, equipment incorporated or to be incorporated in such construction, and all services, facilities, tools and equipment necessary or used to perform and complete such construction.

1.3 SECTION INCLUDES

A. Copper UTP Connectors

B. Indoor Multimode Optical Fiber Connectors (Field Termination Type)

C. Outdoor Multimode Optical Fiber Connectors (Field Termination Type)

D. Single Mode Optical Fiber Pigtail Connector Assemblies

E. Outlet Housing Components (faceplates etc.)

F. Optical Fiber Couplers at workstation outlet locations

1.4 REFERENCE STANDARDS AND CODES

A. Refer to Section 27 00 00 Communications for list of Reference Standards, Codes, and Documents. PART 1.3

1. Specific standards may be referenced throughout this section.

1.5 SCOPE

A. Provides specifications for horizontal workstation cable termination components and outlet housing components. Includes wall-mount, floor-mount, and ceiling-mount components to support the various workstation outlets throughout the cabling plant.

1.6 SUBMITTALS

A. Refer to Section 27 00 00 Communications. - PART 1.10

1.7 QUALITY ASSURANCE

A. Refer to Section 27 00 00 Communications. - PART 1.11

1.8 CONTRACT ADMINISTRATION

A. Refer to Section 27 00 00 Communications. – PART 1.12 – 1.13

PART 2 - PRODUCTS

2.1 ALTERNATES AND SUBSTITUTIONS

A. Refer to Section 27 00 00 Communications. PART 1.7 – 1.8

1. No Substitution without pre-approval

2.2 COPPER UTP CONNECTORS

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

1. Berk-Tek/Ortronics a Nexans company.
2. SYSTIMAX Solutions; a CommScope Inc. brand.
3. Superior Essex and Leviton Network Solutions.

B. Description:

1. All UTP connectors shall be rated to perform at or above current ANSI/TIA-568 performance parameters of the UTP cabling it is terminating within the communications system.
2. All UTP connectors shall have an eight (8) Position, eight (8)-Contact (8P8C) module that accepts 8P8C plugs with integral IDC-type terminals.
3. When utilized as part of a channel or permanent link, all high-performance modular connectors shall match the horizontal cable performance transmission requirements before and after installation as specified in ANSI/TIA-568 Commercial Building Telecommunications Cabling Standard (horizontal cable section) in all noted performance parameters.

C. Accessory Products:

1. Provide any accessory products related to the UTP connectors required to provide a complete and functional infrastructure system.

2.3 INDOOR MULTIMODE OPTICAL FIBER CONNECTORS

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

1. Berk-Tek/Ortronics a Nexans company.
2. SYSTIMAX Solutions; a CommScope Inc. brand.
3. Superior Essex and Leviton Network Solutions.

B. Description:

1. All indoor multimode optical fiber connectors shall be LC-type connectors, rated and approved by the manufacturer to perform at the level designated by the optical fiber strands being terminated.
2. The connector shall be field installable type.
3. Connector shall have a fiber stub in the ceramic connector ferrule that is bonded in the ferrule micro-hole, the connector shall not require end face polishing in the field, and the end tip shall be Ultra Physical Contact (UPC) type.

4. The connector crimp-on mechanism shall protect the bare fiber from the ingress of air or waterborne contaminants.
5. When tested in accordance with FOTP-171, the connector shall be consistently capable of insertion losses $\leq$ 0.1 dB (typical) and shall be $\leq$ 0.5 dB (maximum) when installed in accordance with the manufacturers recommended procedure.

C. Accessory Products:

1. Provide any accessory products and tool kits related to the termination of the optical fiber connectors to provide a complete and functional infrastructure system.

2.4 OUTDOOR MULTIMODE OPTICAL FIBER CONNECTORS

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

1. Berk-Tek/Ortronics a Nexans company.
2. SYSTIMAX Solutions; a CommScope Inc. brand.
3. Superior Essex and Leviton Network Solutions.

B. Description:

1. All outdoor multimode optical fiber connectors shall be ST-type connectors, rated and approved by the manufacturer to perform at the level designated by the optical fiber strands being terminated.
2. The connector shall be field installable.
3. Connector shall have a fiber stub in the ceramic connector ferrule that is bonded in the ferrule micro-hole, the connector shall not require end face polishing in the field, and the end tip shall be Ultra Physical Contact (UPC) type.
4. The connector crimp-on mechanism shall protect the bare fiber from the ingress of air or waterborne contaminants.
5. When tested in accordance with FOTP-171, the connector shall be consistently capable of insertion losses $\leq$ 0.1 dB (typical) and shall be $\leq$ 0.5 dB (maximum) when installed in accordance with the manufacturers recommended procedure.

C. Accessory Products:

1. Provide any accessory products and tool kits related to the termination of the optical fiber connectors to provide a complete and functional infrastructure system.

2.5 SINGLE MODE OPTICAL FIBER PIGTAIL CONNECTOR ASSEMBLIES

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

1. Berk-Tek/Ortronics a Nexans company.
2. SYSTIMAX Solutions; a CommScope Inc. brand.
3. Superior Essex and Leviton Network Solutions.

B. Description:

1. Single-mode Optical fiber pigtail connector assemblies housed in manufacturers connector panels.
2. LC style connectors.

3. Maximum insertion loss across mated pair shall be less than 0.3 dB, tested per FOTP-171 Method A. Typical Insertion loss should be maximum of 0.15 dB.
4. Minimum return loss shall be less than 60.5 dB, tested per FOTP-171. Typical return loss should be 60 dB.
5. Pigtails shall have minimum 2 meters of attached cordage.
6. Pigtails shall be assembled and tested by the connector manufacturer.

C. Accessory Products:

1. Provide any accessory products and tool kits related to the termination of the optical fiber connectors to provide a complete and functional infrastructure system.

2.6 SINGLE MODE OPTICAL FIBER FUSION SPLICE-ON CONNECTOR ASSEMBLIES

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

1. Berk-Tek/Ortronics a Nexans company.
2. SYSTIMAX Solutions; a CommScope Inc. brand.
3. Superior Essex and Leviton Network Solutions.

B. Description:

1. Single-mode optical fiber fusion splice-on connector assemblies.
2. LC style connectors.
3. Maximum insertion loss across mated pair shall be less than 0.3 dB, tested per FOTP-171 Method A. Typical Insertion loss should be maximum of 0.15 dB.
4. Minimum return loss shall be less than 60.5 dB, tested per FOTP-171. Typical return loss should be 60 dB.

C. Accessory Products:

1. Provide any accessory products and tool kits related to the termination of the optical fiber connectors to provide a complete and functional infrastructure system.

2.7 OUTLET HOUSING COMPONENTS

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

1. Berk-Tek/Ortronics a Nexans company.
2. SYSTIMAX Solutions; a CommScope Inc. brand.
3. Superior Essex and Leviton Network Solutions.

B. Description:

1. All outlet housings at the various technology outlet locations shall provide the designated number modular insert ports as indicated in the T-series drawings.
2. All flush-mounted faceplates shall be provided per the port configuration as shown on the telecom drawings.
3. Faceplates for wall-mounted data outlets shall be two (2) port high-impact plastic faceplates with snap-in jacks that can accommodate any combination of UTP, optical fiber and coaxial work area cords.

a. Flush mounting jacks, position the cord at a downward 45-degree angle.

4. Faceplates for wall-mounted phones shall be one (1) port single gang stainless steel faceplates that have wall-mount lugs allowing vertical phone mounting.
5. Faceplates for flush floor mounted outlets shall be coordinated with the floor box or poke thru device that will be selected and installed outside the scope of this section.
6. System furniture faceplates shall be capable of fitting in the furniture system selected by Owners Representative. Furniture faceplates shall be provided per the port configurations shown on the telecom drawings. Furniture faceplate extenders shall be used (if required) to maintain proper bend radii within the furniture raceway/pathway.
7. Surface mounted boxes shall be capable of the quantity of outlet jack requirements at each outlet locations indicted in the T-series drawings.
8. All outlet-housings shall provide a clear ANSI/TIA-606 labeling location for both the individual outlet port and the entire outlet housing location, unless otherwise indicated in the project drawings.

    a. Legend: Factory labeled by silk-screening or engraving for stainless steel faceplates.
    b. Legend: Machine printed, in the field, using adhesive-tape label.
    c. Legend: Snap-in, clear-label covers and machine-printed paper inserts.

C. Accessory Products:

1. Provide any accessory products related to the workstation outlet housing components required to provide a complete and functional infrastructure system.

2.8 OPTICAL FIBER COUPLERS AT WORKSTATION OUTLET LOCATIONS

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

1. Berk-Tek/Ortronics a Nexans company.
2. SYSTIMAX Solutions; a CommScope Inc. brand.
3. Superior Essex and Leviton Network Solutions.

B. Description:

1. The optical fiber couplers shall be LC-style small form factor and manufactured by the same manufacturer of the workstation outlet housing.
2. Ensure coupler size and type is compatible with the specified optical fiber cable and outlet housing at each outlet location.
3. Provide angled type couplers.
4. Optical fiber couplers shall not limit the functionality or performance of the optical fiber cables or connectors when installed at each outlet location.

C. Accessory Products:

1. Provide any accessory products related to the workstation outlet optical fiber termination connectors and coupler components required to provide a complete and functional infrastructure system.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Check actual site conditions prior to start of any work. Ensure all preceding trade work associated with the telecommunications system is accurate and complete before proceeding with installation or use of products specified in this section.

3.2 COPPER UTP CONNECTORS

A. Process:

1. Install all connectors per ANSI/TIA-568 standards, BICSI Best Practices, and manufacturer instructions.
2. The installation and performance parameters of all installed couplers and connectors shall be verified by the trade contractor through ANSI/TIA-568 testing procedures.

3.3 OUTLET HOUSINGS

A. Process:

1. Color of all outlet housing components shall be coordinated with Owners Representative before purchase and installation.
2. All technology outlets located on walls shall be flush mounted, level and plumb.
3. All technology outlets shall be mounted at right angles and parallel to the floor, unless installation requirements or design dictate otherwise.
4. Install blank inserts in outlet housing spaces that are not being filled with cable termination modules. Blank inserts shall match the workstation housing color, unless otherwise indicated in the T-series drawings.
5. All outlets located in systems furniture may be served from a wall adjacent to the furniture cluster or a floor box. If the cable is exposed prior to entering furniture raceway, install spiral wrap tubing to protect the cable per the manufacturer's recommendations.
6. All outlet housings as well as each individual utilized port shall be labeled in accordance with Owners Representative approved labeling scheme.

3.4 OPTICAL FIBER CONNECTORS AND COUPLERS

A. Process:

1. Install all couplers per ANSI/TIA-568 standards, BICSI Best Practices, and manufacturer instructions.
2. The installation and performance parameters of all installed couplers and connectors shall be verified by the trade contractor through ANSI/TIA-526 testing procedures.

3.5 RE-INSTALLATION

A. Refer to Section 27 00 00 Communications. - PART 3.7

3.6 CLOSEOUT ACTIVITIES

A. Refer to Section 27 00 00 Communications. - PART 3.8

END OF SECTION

SECTION 271619 - COMMUNICATION PATCH & EQUIPMENT CORDS

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. Specifications throughout all Divisions of the Project Manual are directly applicable to this Section, and this Section is directly applicable to them.

1.2 DESCRIPTION

A. Provide copper and fiber optic patch cords.

B. Install cords between the network equipment LAN hardware, horizontal station cabling, and fiber optic backbone cabling, including dressing and bundling.

C. Provide identification labeling on all patch cords.

1.3 SECTION INCLUDES

A. Copper UTP Patch Cords

B. Fiber Optic Jumpers (Patch Cords)

1.4 REFERENCE STANDARDS AND CODES

A. Refer to Section 27 00 00 Communications for list of Reference Standards, Codes, and Documents. PART 1.3

1. Specific standards may be referenced throughout this section.

1.5 DEFINITIONS

A. Use the following definitions for the meaning of terms used in this specification section:

1. Patch Cords: Factory made 8P8C cord assembly used to cross-connect passive cabling infrastructure (e.g., patch panel to patch panel). Also used as a generic reference.
2. Equipment Cords: Factory made 8P8C cord assembly used to attach directly to active equipment (e.g., network switch, computer, security camera, AV equipment)

1.6 SUBMITTALS

A. Comply with the requirements of Section 27 00 00 Communications. - PART 1.10

B. Cord quantities

1. Submit a table of cables to be provided for the project including the following information:

a. Copper cables:

1) Total Quantity of horizontal copper cables being provided for each IDF/MDF.

2) Quantity of copper cables being provided, shown by length.
3) Submit color of cables to be provided.

b. Fiber optic interconnection cables:

1) Quantity of fiber optic cables being provided for each IDF/MDF.

C. Provide a complete list of the following information to the Owner a minimum of 5 weeks prior to the commencement of patching for preparation of the patching matrix:

1. Cable ID of the connection point of each contractor-provided device.
2. System to which the component belongs (i.e., AV, security, electrical, BMS, etc).

1.7 QUALITY ASSURANCE

A. Refer to Section 27 00 00 Communications. - PART 1.11

1.8 CONTRACT ADMINISTRATION

A. Refer to Section 27 00 00 Communications. – PART 1.12 – 1.13

PART 2 - PRODUCTS

2.1 ALTERNATES AND SUBSTITUTIONS

A. Refer to Section 27 00 00 Communications. PART 1.7 – 1.8

1. No Substitution without pre-approval

2.2 COPPER UTP INTERCONNECTION CORDS

A. Manufacturers:

1. Shall comply with system warranty requirements for permanently installed horizontal cabling system.

B. Description:

1. Category 6 and Category 6A UTP Copper cords for equipment connection: Modular 8P8C male plug connector's equipped with (8) eight gold anodized pins shall be factory terminated at each end of the cord. Modular plugs shall be snag free in design or utilize a molded plastic boot to cover the modular plug tab.
2. All copper UTP patch cords shall have stranded conductors that match the ANSI/TIA-568 performance characteristics.
3. All copper cord lengths for patching inside the telecom rooms are to be provided appropriate to patching from network equipment ports to the copper patch panels ports within the MDF.
4. Coordinate patch cord color with owner prior to ordering.
5. Any patch cord purchased without written authorization by Owners Representative are purchased at the contractor's risk.

C. Accessory Products:

1. Provide any accessory products related to the fiber optic cabling required to provide a complete and functional infrastructure system.

2.3 FIBER OPTIC INTERCONNECTION CABLES

A. Manufacturers:

1. Shall comply with system warranty requirements for permanently installed cabling system.

B. Description:

1. All fiber optic jumpers shall conform to the requirements of the ANSI/TIA-568 standard performance parameters for the multimode or single-mode fiber optic specified and installed, and shall have the same manufacturer, cable type, and connector type as noted for the backbone/horizontal fiber.
2. LC to LC cables are the standard configuration for fiber optic cables.

    a. Prior to ordering, coordinate with the network installation contractor to determine if a quantity of other connector configurations is required. Provide up to 2% of the fiber optic interconnection cables in configurations other than LC-LC if required by network installation contractor.

3. MDF / IDF fiber optic jumper lengths shall be provided appropriate to patching from network equipment ports to the Fiber Distribution Unit (FDU) ports within the MDF and IDF(s).
4. Workstation fiber optic jumper lengths shall be provided appropriate to patching from the workstation outlet to the equipment or other IP end device Network Interface Card (NIC).
5. Multimode (MM) jumpers are to be industry standard Aqua in color and provided in a duplex configuration.
6. All single-mode (SM) jumpers are to be industry standard yellow in color and provided in a duplex configuration.
7. Any fiber optic jumper purchased without written authorization by Owners Representative are purchased at the contractor's risk.

2.4 CABLE MANAGEMENT

A. Manufacturer List:

1. Panduit
2. Markertek
3. Velcro
4. Or approved equal

B. Description

1. Hook and Loop (Velcro) cable management
2. Low-profile, flexible
3. Adjustable, and reusable
4. Width as required to properly manage cables
5. Roll-based, cut to fit
6. Color: black

C. Accessory Products

1. Provide any accessory products related to the fiber optic cabling required to provide a complete and functional infrastructure system.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Check actual site conditions prior to start of any work. Ensure all preceding trade work associated with the telecommunications system is accurate and complete before proceeding with installation or use of products specified in this section.

3.2 COPPER AND FIBER OPTIC CORD INSTALLATION

A. Installation work of this section includes only interconnection patch cables installed in telecommunications spaces (MDF, IDF, Service Entrance Rooms, MPOE, etc.).

B. Installation work in this section does not include:

1. Installation of cords to connect Owner-provided devices to telecommunication outlet at the work areas are contractor furnished - Owner installed (CFOI).
2. Equipment cords used to connect contractor-provided components (e.g., security cameras, AV equipment, security panels, etc.) to the telecommunications outlet at the work area are part of the project. They are to be furnished and installed by the contractor responsible for providing the equipment and are separate from the line cords quantified in this specification.
3. Cords for connecting contractor-provided equipment to the network may not be provided from the quantities shown in this specification section: contractor-equipment end point cords are not included and are to be provided in addition to the cord quantities identified in this section by the contractor responsible for providing the work area device.

C. Install Category 6 and Category 6A copper cables between network switch(es) and the horizontal station cabling patch panel as indicated in the Owner provided patching matrix.

D. Installation of fiber optic jumpers as identified on the Owner provided patching matrix.

3.3 COPPER AND FIBER OPTIC PATCH CORD INSTALLATION AND ROUTING

A. Install as directed in the Owner provided patching matrix.

B. Bundle patch cord cables in sequential order in bundles not to exceed (24) cables.

C. Bundle fiber optic and copper patch cords separately.

D. Use Velcro strips to dress copper patch cord bundles from the point where they enter the cable manager to the connection point.

E. Maintain clear access to all power and modules installed in the network equipment.

F. At all times provide clear access to all power receptacles located in the telecommunications racks.

G. Dress the cables neatly and support the cables to avoid pinching, crimping or other deformations of the interconnection cables.

H. Provide fittings to maintain required bend radius for copper and fiber optic cables.

3.4 PATCH CORD IDENTIFICATION AND LABELING

A. Label each patch cord at both ends with a 2-row unique identifier consisting of the following: (see Telecom Detail Drawings for requirements)

1. Top Row: Identifies the patch panel or workstation outlet end of the cord.
2. Bottom Row: Identifies the equipment end of the cord.

3.5 QUANTITIES OF ITEMS

A. Provide the following quantity of copper equipment cords, percentage based on horizontal cabling quantity:

1. MDF: Provide equipment cords in the following quantities:

a. 7’ patch cables: Quantity = 25
b. 10’ patch cables: Quantity = 40
c. 20’ patch cables: Quantity = 10

B. Provide the following quantity of workstation equipment cords:

1. Provide quantity equal to 50% of the quantity of horizontal work station cable placed. Provide in the following proportions:

a. 7’ patch cables: 60%
b. 10’ patch cables: 40%

C. Provide the following quantity of fiber optic jumpers:

1. MDFs: (10) SM fiber jumpers:

a. 3-meter jumpers: Quantity = 2
b. 5-meter jumpers: Quantity = 6
c. 7-meter jumpers: Quantity = 2

3.6 ADDED PATCHES

A. Provide for (1) return trip within 30 days of occupancy to add and/or dress patch cords due to Owner directed changes since occupancy.

B. Contractor shall be responsible for up to an additional 5% above the original quantity of patches during return trip.

C. Place, dress and label the cables as identified in this specification section.

3.7 RECORD DOCUMENTS

A. Modify the Owner provided patching matrix to reflect the actual, as-built conditions.

B. Submit in the format that the original patching matrix was provided to the contractor.

3.8 RE-INSTALLATION

A. Refer to Section 27 00 00 Communications. - PART 3.7

3.9 CLOSEOUT ACTIVITIES

A. Refer to Section 27 00 00 Communications. - PART 3.8

END OF SECTION

SECTION 280500 - COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Electronic safety and security equipment coordination and installation.

2. Sleeves for raceways and cables.

3. Sleeve seals.

4. Grout.

5. Common electronic safety and security installation requirements.

1.3 DEFINITIONS

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

B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

A. Product Data: For sleeve seals.

1.5 COORDINATION

A. Coordinate arrangement, mounting, and support of electronic safety and security equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.

2. To provide for ease of disconnecting the equipment with minimum interference to other installations.

3. To allow right of way for piping and conduit installed at required slope.

4. All connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.

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

C. Coordinate location of access panels and doors for electronic safety and security items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping. “.”

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

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

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

C. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches and no side more than 16 inches, thickness shall be 0.052 inch.

b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches and 1 or more sides equal to, or more than, 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE SEALS

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

1. Manufacturers: Subject to compliance with requirements, [provide products by one of the following] [available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following]:

2. Basis-of-Design Product: Subject to compliance with requirements, provide [product indicated on Drawings] <Insert manufacturer's name; product name or designation> or comparable product by one of the following:

a. Advance Products & Systems, Inc.

b. Calpico, Inc.

c. Metraflex Co.

d. Pipeline Seal and Insulator, Inc.

e. <Insert manufacturer's name.>

3. Sealing Elements: [EPDM] [NBR] <Insert other> interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.

4. Pressure Plates: [Plastic] [Carbon steel] [Stainless steel]. Include two for each sealing element.

5. Connecting Bolts and Nuts: [Carbon steel with corrosion-resistant coating] [Stainless steel] of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRONIC SAFETY AND SECURITY INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electronic safety and security equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRONIC SAFETY AND SECURITY PENETRATIONS

A. Electronic safety and security penetrations occur when raceways, pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches above finished floor level.

G. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants.".

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

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

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

M. Underground, Exterior-Wall Penetrations: Install pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for 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.

3.4 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electronic safety and security installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION

SECTION 280513 - CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. UTP cabling.
2. Single mode optical fiber cabling.
3. RS-232 cabling.
4. RS-485 cabling.
5. Low-voltage control cabling.
6. Control-circuit conductors.
7. Fire alarm wire and cable.
8. Identification products.

1.3 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel section.

C. EMI: Electromagnetic interference.

D. IDC: Insulation displacement connector.

E. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).

F. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.

G. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).

H. RCDD: Registered Communications Distribution Designer.

I. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

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

1. For coaxial cable, include the following installation data for each type used:

a. Nominal OD.

b. Minimum bending radius.

c. Maximum pulling tension.

B. Shop Drawings: Cable layout, showing route to scale, with relationship between the route and adjacent structural, electrical, and mechanical elements. Include the following:

1. Vertical and horizontal offsets and transitions.

2. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

C. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.

D. Source quality-control reports.

E. Field quality-control reports.

F. Maintenance Data: For wire and cable to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Testing Agency Qualifications: An NRTL.

1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: **25** or less.

2. Smoke-Developed Index: **50** or less.

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

1.6 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test optical fiber cable to determine the continuity of the strand end to end. Refer to 27 08 00 Communications Commissioning.

2. Test optical fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.

3. Test each pair of UTP cable per 27 08 00 Communications Commissioning.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install UTP, optical fiber, and coaxial cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. Support of Open Cabling: NRTL labeled for support of **Category 6** cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.

1. Support brackets with cable tie slots for fastening cable ties to brackets.

2. Lacing bars, spools, J-hooks, and D-rings.

3. Straps and other devices.

B. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems.

1. Outlet boxes shall be no smaller than 2 inches wide, 3 inches high, and 2-1/2 inches deep.

2.2 BACKBOARDS

A. Backboards: Plywood, **fire-retardant treated,** 3/4 by 48 by 96 inches. Comply with requirements for plywood backing panels in Division 06 Section "Rough Carpentry".

2.3 UTP CABLE

A. Manufacturers: Reference 27 15 13 Communication Horizontal Cabling

2.4 UTP CABLE HARDWARE

A. Manufacturers: Reference 27 11 19 Communication Termination Blocks and Patch Panels

2.5 OPTICAL FIBER CABLE

A. Manufacturers: Reference 27 15 23 Communication Optical Fiber Horizontal Cabling

2.6 OPTICAL FIBER CABLE HARDWARE

A. Manufacturers: Reference 27 11 19 Communication Termination Blocks and Patch Panels

2.7 COAXIAL CABLE

A. Manufacturers: Reference 27 15 33 Communication Coaxial Horizontal Cabling

2.8 COAXIAL CABLE HARDWARE

A. Manufacturers: Reference 27 13 34 Communication Coaxial Splicing and Termination

2.9 RS-232 CABLE

A. Standard Cable: NFPA 70, Type CM.

1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.

2. Polypropylene insulation.

3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.

4. PVC jacket.

5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.

6. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.

2. Plastic insulation.

3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.

4. Plastic jacket.

5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.

6. Flame Resistance: Comply with NFPA 262.

2.10 RS-485 CABLE

A. Standard Cable: NFPA 70, Type CM **or CMG**.

1. Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.

2. PVC insulation.

3. Unshielded.

4. PVC jacket.

5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated Cable: NFPA 70, Type CMP.

1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.

2. Fluorinated ethylene propylene insulation.

3. Unshielded.

4. Fluorinated ethylene propylene jacket.

5. Flame Resistance: NFPA 262, Flame Test.

2.11 LOW-VOLTAGE CONTROL CABLE

A. Paired Lock Cable: NFPA 70, Type CMG.

1. 1 pair, twisted, No. 16 AWG, stranded (19x29) tinned copper conductors.

2. PVC insulation.

3. Unshielded.

4. PVC jacket.

5. Flame Resistance: Comply with UL 1581.

B. Plenum-Rated, Paired Lock Cable: NFPA 70, Type CMP.

1. 1 pair, twisted, No. 16 AWG, stranded (19x29) tinned copper conductors.

2. PVC insulation.

3. Unshielded.

4. PVC jacket.

5. Flame Resistance: Comply with NFPA 262.

C. Paired Lock Cable: NFPA 70, Type CMG.

1. 1 pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors.

2. PVC insulation.

3. Unshielded.

4. PVC jacket.

5. Flame Resistance: Comply with UL 1581.

D. Plenum-Rated, Paired Lock Cable: NFPA 70, Type CMP.

1. 1 pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors.

2. Fluorinated ethylene propylene insulation.

3. Unshielded.

4. Plastic jacket.

5. Flame Resistance: NFPA 262, Flame Test.

2.12 CONTROL-CIRCUIT CONDUCTORS

A. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, in raceway complying with UL 83.

B. Class 2 Control Circuits: Stranded copper, power-limited cable, concealed in building finishes complying with UL 83.

C. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or TF, complying with UL 83.

2.13 IDENTIFICATION PRODUCTS

A. Comply with 270553 Communication Identification.

2.14 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.

C. Factory test UTP cables according to TIA/EIA-568-B.2.

D. Factory test Single mode optical fiber cables.

E. Cable will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 INSTALLATION OF PATHWAYS

A. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

B. Comply with requirements in Division 27 Section 27 05 33 "Communication Conduit and Boxes" for installation of conduits and wireways.

C. Install manufactured conduit sweeps and long-radius elbows whenever possible.

D. Pathway Installation in Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.

2. Install cable trays to route cables if conduits cannot be located in these positions.

3. Secure conduits to backboard when entering room from overhead.

4. Extend conduits a minimum **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.

3.2 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA/EIA-568-B.1.

2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."

3. Install 110-style IDC termination hardware unless otherwise indicated.

4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.

5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.

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 ITSIM, "Cabling Termination Practices" Chapter. 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. Heat lamps shall not be used for heating.

9. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:

1. Comply with TIA/EIA-568-B.2.

2. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.

D. Optical Fiber Cable Installation:

1. Comply with TIA/EIA-568-B.3.

2. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.

2. Suspend copper cable not in a wireway or pathway a minimum of 8 inches above ceilings by cable supports not more than **60 inches** apart.

3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.

2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.

b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.

c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.

b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.

c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

a. Electrical Equipment Rating Less Than 2 kVA: No requirement.

b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.

c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.

5. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.

6. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.3 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.

3.4 CONNECTIONS

A. Comply with requirements in Division 28 Section "Intrusion Detection" for connecting, terminating, and identifying wires and cables.

B. Comply with requirements in Division 28 Section "Access Control" for connecting, terminating, and identifying wires and cables.

C. Comply with requirements in Division 28 Section "Video Surveillance" for connecting, terminating, and identifying wires and cables.

3.5 FIRESTOPPING

A. Comply with requirements in Division 07 Section "Penetration Firestopping."

B. Comply with TIA/EIA-569-A, "Firestopping" Annex A.

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.6 GROUNDING

A. For communications wiring, comply with ANSI-J-STD-607 and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. For low-voltage wiring and cabling, comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."

3.7 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606. Comply with requirements for identification specified in Division 27 Section "Communication Identification"

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections: Comply with requirements in Division 27

1. Optical Fiber Cable Tests: Comply with requirements in Division 27

2. Coaxial Cable Tests: Comply with requirements in Division 27

C. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.

D. End-to-end cabling will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION

SECTION 28 13 00 - VIDEO INTERCOM AND ACCESS CONTROL SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SECTION INCLUDES

A. Hands-free color video intercom system.

1.3 RELATED SECTIONS

A. Section 087100 - Door Hardware

B. Section 280500 - Common Work Results for Electronic Safety and Security

C. Section 280513 - Conductors and Cables for Electronic Safety and Security

D. Section 28 23 00 - Video Surveillance and Mosquito Type Sonic Security Devices

1.4 REFERENCES

A. ISO 9001:2008 – Quality Management Systems – Requirements.

1.5

1.6 4. When busy tone sounds while pressing TALK button, another station is in use.

1.7

1.8 1.5 SYSTEM DESCRIPTION – ENHANCED VIDEO INTERCOM SYSTEM

1.9

1.10

A. Answering Door Call in Hands-Free Mode:

1. Press CALL button.
2. Chime tone sounds, caller is seen on video monitor, and outside sound is heard.
3. Audio and video turn off after approximately 45 seconds if not answered.
4. Press TALK button momentarily, and after beep, communicate hands-free. Red transmit LED lights when you talk and goes off as you listen to caller or hear outside sounds.
5. Press TALK button again, and after beep, communication ends.

B. Answering Door Call in Press-to-Talk (PTT) Mode:

1. Press CALL button.
2. Chime tone sounds, caller is seen on video monitor, and outside sound is heard.
3. Audio and video turn off after approximately 45 seconds if not answered.

4. During communication, press and hold TALK button for minimum of 1 second to change to press-to-talk mode. Beep sounds, and after approximately 1 second another beep sounds, PTT mode is entered. If TALK button is pressed less than 0.5 seconds, communication ends.
5. To continue speaking using press-to-talk mode, press TALK button for minimum of 1 second each time to talk, and release to listen to caller.
6. Press TALK button again momentarily, and after beep, communication ends.

C. Activating Door Release:

1. During communication, instant voice call, or entrance monitoring, press MENU/MEMO button to display menu screen.
2. Press CALL button.
3. pen door while release mechanism is activated. During activation of door release, release symbol is displayed.

D. Message for Entrance:

1. During communication, instant voice call, or entrance monitoring, press MENU/MEMO button to display menu screen.
2. Press PLAY button.
3. Press either CALL button or PLAY button. Selected message changes to yellow, “SENDING MESSAGE” is displayed, and selected message is played from door station.

E. Entrance Monitoring:

1. Press MONITOR button in standby mode.
2. Video monitor displays image from door station 1 and incoming audio is heard. If you do not press TALK button, caller will not hear sounds from inside station.
3. Press MONITOR button again to switch to door station 2. Each time MONITOR button is pressed, unit switches in sequence “Standby” to “Door station 1 monitor” to “Door station 2 monitor” to “Standby”.
4. Press MONITOR button again to end.

F. Room-to-Room Communication:

1. Press CALL button to talk with other person.
2. Red CALL button flashes and “All Call” function is activated to link all master and sub master stations.
3. Reply of other person is not heard.
4. If other person presses TALK button, hands-free communication is possible.
5. Press and release TALK button to end.

G. Transfer Entrance Call:

1. During communication with door station, press CALL button to call transferring station.
2. Red CALL button flashes and communication with door station is put on hold.
3. “All Call” function is activated to link all master and sub master stations.
4. If TALK button is pressed at transferred station, unit enters room-to-room communication. Sender informs receiver that communication will be transferred, and TALK button is pressed and released at either transferring station or transferred station to end room-to-room communication. Screen continues to display image of door station.
5. If TALK button is pressed at transferred station, communication with door station is established.
6. Press TALK button to end communication.

H. Automatic Recording:

1. If a call is received from video door station, unit starts recording automatically.
2. Red record LED flashes during recording.
3. Recording starts approximately 2 seconds after CALL button of video door station is pressed.
4. Maximum length of approximately 8 seconds (8 shots) can be recorded with 1 picture and 1 shot for each second.
5. Maximum of 50 pictures can be recorded (combined total of automatic recording and manual recording pictures).
6. If 50 pictures are exceeded, pictures are overwritten starting from picture with oldest recording date.

I. Manual Recording:

1. Display video image with operation such as entrance monitoring.
2. Press REC button. Red record LED flashes and recording starts.
3. Maximum length of approximately 8 seconds (8 shots) can be recorded with 1 picture and 1 shot for each second.
4. Maximum of 50 pictures can be recorded (combined total of automatic recording and manual recording pictures).
5. If 50 pictures are exceeded, pictures are overwritten starting from picture with oldest recording date.

J. Play Recorded Picture:

1. Press PLAY button in standby mode to display play screen.
2. Press PLAY button on play screen. Recorded picture is played. When play of 1 picture ends, next image is displayed.
3. To advance play frame-by-frame, press PLAY button during playback to pause. Play moves forward frame-by-frame each time REC button is pressed. When frames of 1 picture end, next picture is displayed.
4. Press TALK button to end.

K. Save Recorded Picture:

1. Display picture that you want to save in play screen. Press MENU/MEMO button to display save/erase selection.
2. Press CALL button. If picture is saved, key symbol is displayed. If picture has already been saved, save is cancelled. Each time CALL button is pressed, operation switches between save and cancel.

L. Erase Recorded Picture:

1. Display picture that you want to erase in play screen. Press MENU/MEMO button to display save/erase selection screen.
2. Press REC button.
3. Press CALL button to erase.
4. Press PLAY button to stop erasure and return to play screen.

M. Recording Voice Memos:

1. Press MENU/MEMO button in standby mode.
2. Select Voice memo with CALL button. Each time CALL button is pressed, cursor switches between A, B, and C.
3. Press REC button to record Voice memo.
4. Press CALL button to end recording.
5. Press CALL button to check recording results. Press PLAY button to stop play and return to Voice memo selection screen.
6. Press TALK button to return to standby mode.

N. Playing Voice Memos:

1. Press MENU/MEMO button in standby mode.
2. Select Voice memo that you want to play via CALL button. Each time CALL button is pressed, cursor switches between A, B, and C.
3. Press PLAY button to play memo.
4. Press CALL button to end.
5. Press TALK button to return to standby mode.

O. Erasing Voice Memos:

1. Press MENU/MEMO button in standby mode.
2. Select memo that you want to erase via CALL button. Each time CALL button is pressed, cursor switches between A, B, and C.
3. Press MENU/MEMO button.
4. Press CALL button to ERASE. Press PLAY button to stop erasure and return to Voice memo selection screen.
5. Press TALK button to return to standby mode.

P. External Sensor:

1. When external sensor is activated or call button is pressed, notification sound goes off and red transmit LED flashes.
2. Warning screen is displayed on video monitor.
3. Press TALK button to stop notification sound.

1.11 SUBMITTALS

A. Comply with Section 01330 (01 33 00) – Submittal Procedures.

B. Product Data: Submit manufacturer's product data, including installation instructions.

C. Shop Drawings: Submit the following:

1. Wiring Diagrams: Indicate wiring for each item of equipment and interconnections between items of equipment.
2. Include manufacturer's names, model numbers, ratings, power requirements, equipment layout, device arrangement, complete wiring point-to-point diagrams, and conduit layouts.

D. Installation and Operation Manuals:

1. Submit manufacturer's installation and operation manual, including operation instructions and component wiring diagrams.
2. Provide detailed information required for Owner to properly operate equipment.

E. Warranty: Submit manufacturer's standard warranty.

1.12 QUALITY ASSURANCE

A. Manufacturer's Qualifications: ISO 9001:2008 certified company.

B. Contractor Qualifications:

1. The Contractor shall have installed the system bid for this project in at least two projects of similar size and nature. Submit a description of three similar projects along with references including names and telephone numbers.

2. The Contractor shall be a factory authorized dealer and/or integrator of the products and components provided for all elements of the systems.
3. The Contractor shall maintain a fully staffed local office including a service center within the Pennsylvania area. The service center shall be staffed by factory trained and certified technicians and adequately equipped to provide emergency service within four hours after being called, 24 hours per day, whether or not the Owner purchases a maintenance contract with the Contractor.
4. The Contractor shall ensure compliance with and have an understanding of all local code and contract conditions pertaining to this project.
5. The Contractor shall maintain a local inventory of all spare parts and any other items necessary to system operation.
6. The Contractor shall comply with union trade requirements.

1.13 SEQUENCING AND SCHEDULING

A. The Contractor shall submit a detailed schedule with the proposal identifying planned dates for the following milestones:

1. Submit prefabrication submittals.
2. Shop fabrication and staging.
3. Install head end equipment and software.
4. Install field components.
5. System completion.
6. Final testing.
7. Owner training.
8. As-Built documentation submittals.

1.14 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying product name and manufacturer.

B. Storage: Store materials in clean, dry area indoors in accordance with manufacturer's instructions.

C. Handling: Protect materials during handling and installation to prevent damage.

1.15 WARRANTY

A. If, within one year after the date of final acceptance of the Work and equipment as determined by the Engineer or designated representative or within such longer period of time as may be prescribed by law or by the terms of any applicable special warranty required by the Contract Documents or provided by a manufacturer, any of the work or equipment is found to be defective or not in accordance with the Contract Documents, the Contractor shall correct it promptly at Contractor's sole cost and expense, including all parts and labor after receipt of a written notice from the Owner to do so unless the Engineer has previously given the Contractor a written acceptance of such condition. This obligation shall survive termination of the contract. The Owner shall give such notice promptly after discovery of the condition.

B. Nothing contained in the contract documents shall be construed to establish a shorter period of limitation with respect to any other obligation which the Contractor might have under the contract documents or any manufacturers' warranty. The establishment of the time period of one year after the date of final acceptance or such longer period of time as may be prescribed by law or by the terms of any warranty required by the contract documents relates only to the specific obligation of the Contractor to correct the work or equipment, and has no relationship to the time within which his obligation, to comply with the Contractor documents may be sought to be enforced, nor to the time within which proceedings may be commenced to establish the Contractor's liability with respect to his obligations other than specifically to correct the work or equipment.

C. Include a manufacturers software maintenance agreement within the one-year warranty period and include all software updates, revisions and telephone service assistance. The software maintenance agreement shall include training for any changes in operation due to the software revisions.

D. Perform repair or replacement service during the warranty period in accordance with the following schedule:

1. Schedule A - 7 days, 24 hour, 4 hour response time.
2. Schedule B - 8:00 - 5:00 business days, excluding holidays, 4 hour response time.

E. Schedule A shall apply to major system components including but not limited to the intercom master station, and intercom door station.

F. Schedule B shall apply for all other components and devices not included in Schedule A.

G. Provide as part of this bid an afterhours labor rate for any warranty service required during hours not covered under schedule B.

H. If the Contractor cannot restore system operation during the warranty period within four (4) business days of a system failure, the Owner reserves the right to require the Contractor to provide on-site manufacturer's service technicians at no additional cost.

I. The Owner reserves the right to expand or add to the system during the warranty period using firm(s) other than the Contractor for such expansion without affecting the Contractor's responsibilities, provided that the expansion is done by a firm which is an authorized dealer or agent for the equipment or system being expanded.

1.16 SYSTEM ADJUSTMENTS

A. During the one-year period following the date of substantial completion, provide up to 16 hours of on-site support to make physical setting and programming adjustments to tune system performance.

B. Adjustments shall be scheduled at the request of the Owner.

1.17 SYSTEM INTERFACES

A. Fire Alarm

B. Digital Video Surveillance

C. Automatic door operator

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Aiphone Corporation, 6670 185th Ave NE, Redmond Washington 98052. Toll Free (800) 692-0200. Phone (425) 455-0510. Fax (425) 455-0071. Website www.aiphone.com. E-mail info@aiphone.com.

2.2 VIDEO INTERCOM AND ACCESS CONTROL SYSTEM

A. Enhanced Hands-Free Color Video Intercom System: Aiphone “JF Series”.

1. Power Source:

a. 18 V DC.

b. Model PS-1820UL.

2. Calling:

   a. Chime, image, and audio.
   b. Approximately 45 seconds.

3. Communication:

   a. Automatic (hands-free): To activate, momentarily press TALK button.
   b. Manual (press-to-talk/release-to-listen): To activate, press TALK button for 1 second or until talk LED turns on.

4. Camera: CCD.
5. Video Monitor:

   a. 3.5-inch direct-view TFT color LCD.
   b. Scanning Lines: 525.
   c. Minimum Illumination: 5 Lux at 1 foot.

6. Night Viewing: Up to 1 foot from camera, with white LED projected, background beyond 1 foot cannot be seen.
7. Door Release:

   a. Contact Rating: N/O 24 V AC/DC, 500 mA.
   b. Door Release Relay: Model RY-18L for Form C high-current contact.

8. Wiring:

   a. Door to Master Station: 2 conductor.
   b. Enhanced Master Monitor Station to Sub Monitor Station: 4 conductor.
   c. Mid capacitance, solid, non-shielded.

9. Distance:

   a. Door to Enhanced Master Station:

      1) 22 AWG: 165 feet.
      2) 18 AWG: 330 feet.

   b. Enhanced Master Station to Farthest Sub Monitor Station:

      1) 22 AWG: 165 feet.
      2) 18 AWG: 330 feet.

10. Picture Memory:

    a. Record up to 50 image sequences (1 frame per second, 8 frames per image).
    b. Save up to 10 sequences (80 frames).

11. Voice Memo: Record maximum 3 voice memos (maximum approximately 15 seconds per memo).
12. Message for Entrance: Record maximum 2 messages (maximum approximately 10 seconds per message).

B. Door Stations:

1. Fixed Video Door Station: Model JF-DVF.

    a. Faceplate: Stainless steel.
    b. Flush mount.
    c. Microphone.
    d. Speaker.
    e. Camera: Color CCD with white illuminator LEDs.
    f. Call button.
    g. Vandal resistant.
    h. Weather resistant.
    i. Operating Temperature: 14 degrees F to 140 degrees F (minus 10 degrees C to 60 degrees C).

C. Enhanced Master Stations:

1. Master Station: Model JF-2MED.

    a. Supports:

        1) 2 color video door stations.
        2) 3 inside color monitor stations.

    b. Power: 18 V DC.
    c. Current Consumption: 520 mA maximum.
    d. Calling: Chime and image, approximately 45 seconds.
    e. Communication:

        1) Hands-Free Mode: Approximately 60 seconds.
        2) PTT Mode: Press-to-talk, release to listen, approximately 60 seconds.

    f. Door Release Contact: 24 V AC/DC, 500 mA (N/O dry closure contact L, L).
    g. Picture memory.
    h. Microphone.
    i. Speaker.
    j. Video Monitor:

        1) 3.5-inch direct-view TFT color LCD.
        2) Scanning Lines: 525.

    k. CALL button with red door call-in LED.
    l. PLAY button with red play LED.
    m. REC button with red record LED.
    n. MENU/MEMO button with red memo LED.
    o. POWER switch.
    p. MONITOR button.
    q. Red transmit LED.
    r. TALK button.
    s. Screen brightness control.
    t. Receive volume control.
    u. Chime tone, alert sound volume.
    v. Call-in Setting Switch:

        1) Setting 1: Call-in from door station 1 only.
        2) Setting 2: Call-in from door station 2 only.
        3) Setting 1 and 2: Call-in from both door stations 1 and 2.

w. Operating Temperature: 32 degrees F to 104 degrees F (0 degrees C to 40 degrees C).
x. 2) PTT Mode: Press-to-talk, release to listen, approximately 60 seconds.
y. e. Microphone.
z. f. Speaker.
aa. g. Red/green entrance LED.
bb. h. Red transmit LED.
cc. i. TALK button.
dd. j. DOOR RELEASE button.
ee. k. CALL button.
ff. l. Receive volume control.

2.3 ACCESSORIES

Selective Door Release Adaptor: Model RY-3DL.

A.

B. External Signaling Relay: Model RY-ES

C. CCTV Camera Interface Module: Model JBW-M.

D. Fire Alarm Relay for releasing strike in the event of a fire.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive hands-free color video intercom system.

B. Notify Architect of conditions that would adversely affect installation or subsequent use.

C. Do not begin installation until unacceptable conditions are corrected.

3.2 INSTALLATION

A. Install hands-free color video intercom system in accordance with manufacturer's instructions at locations indicated on the Drawings.

B. Mount equipment plumb, level, square, and secure.

3.3 ADJUSTING

A. Adjust hands-free color video intercom system for proper operation in accordance with manufacturer's instructions.

3.4 DEMONSTRATION AND TRAINING

A. Demonstration:

1. Demonstrate that hands-free color video intercom system functions properly.
2. Perform demonstration at final system inspection by qualified representative of manufacturer.

B. Instruction and Training:

1. Provide instruction and training of Owner's personnel as required for operation of hands-free color video intercom system.

2. Provide hands-on demonstration of operation of system components and complete system, including user-level program changes and functions.
3. Provide instruction and training by qualified representative of manufacturer.

3.5 PROTECTION

A. Protect installed hands-free color video intercom system from damage during construction.

END OF SECTION

SECTION 282300 – VIDEO SURVEILLANCE AND MOSQUITO TYPE SONIC SECURITY DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes a video surveillance system consisting of cameras, network video recorder, data transmission wiring, and a control station with its associated equipment.

B. Video surveillance system shall be integrated with existing PPR network equipment.

C. Video surveillance system shall integrate with intercom access control system via interface module. Provide applicable license for integrating video feed from intercom system for storage.

1.3 DEFINITIONS

A. AGC: Automatic gain control.

B. BNC: Bayonet Neill-Concelman - type of connector.

C. B/W: Black and white.

D. CCD: Charge-coupled device.

E. FTP: File transfer protocol.

F. IP: Internet protocol.

G. LAN: Local area network.

H. MPEG: Moving picture experts group.

I. NTSC: National Television System Committee.

J. PC: Personal computer.

K. PTZ: Pan-tilt-zoom.

L. RAID: Redundant array of independent disks.

M. TCP: Transmission control protocol - connects hosts on the Internet.

N. UPS: Uninterruptible power supply.

O. WAN: Wide area network.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Video surveillance system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions and data on features, performance, electrical characteristics, ratings, and finishes.

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

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types and sizes.
3. Dimensioned plan and elevations of equipment racks, control panels, and consoles. Show access and workspace requirements.
4. UPS: Sizing calculations.
5. Wiring Diagrams: For power, signal, and control wiring (if provided).
6. Storage Device Calculations.
7. Network Bandwidth Requirements and Fiber Optic Channel Link-Loss Budgets .
8. Existing Equipment Frame Elevations, where new equipment is being added.

C. Equipment List: Include every piece of equipment by model number, manufacturer, serial number, location, and date of original installation. Add pretesting record of each piece of equipment, listing name of person testing, date of test, set points of adjustments, name and description of the view of preset positions, description of alarms, and description of unit output responses to an alarm.

1.6 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For video surveillance, cameras, camera-supporting equipment, accessories, and components, from manufacturer.

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

B. Field quality-control reports.

C. Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For cameras, power supplies, infrared illuminators, monitors, videotape recorders, digital video recorders, video switches, and control-station components to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

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

B. Comply with NECA 1.

C. Comply with NFPA 70.

D. Electronic data exchange between video surveillance system with an access-control system shall comply with SIA TVAC, if access-control system is provided.

1.9 PROJECT CONDITIONS

A. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Control Station: Rated for continuous operation in ambient temperatures of 50 to 95 deg F (10 to 35 deg C) and a relative humidity of 20 to 80 percent, noncondensing.
2. Interior, Controlled Environment: System components, except central-station control unit, installed in temperature-controlled interior environments shall be rated for continuous operation in ambient temperatures of 36 to 122 deg F (2 to 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 1 enclosures.
3. Interior, Uncontrolled Environment: System components installed in non- temperature-controlled interior environments shall be rated for continuous operation in ambient temperatures of 0 to 122 deg F (minus 18 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 3R enclosures.
4. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient temperatures of minus 30 to plus 122 deg F (minus 34 to plus 50 deg C) dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to 85 mph (137 km/h) and snow cover up to 24 inches (610 mm) thick. Use NEMA 250, Type 4X enclosures.
5. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
6. Corrosive Environment: System components subject to corrosive fumes, vapors, and wind-driven salt spray in coastal zones. Use NEMA 250, Type 4X enclosures.
7. Security Environment: Camera housing for use in high-risk areas where surveillance equipment may be subject to physical violence.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of cameras, equipment related to camera operation, and control-station equipment that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Final Acceptance by the City.

B. Warranty Requirements: Contractor shall warrant DPP (or PPR) that the equipment will be free and clear of any lien or encumbrance on the final acceptance date. Contractor shall further warrant for a period of three (3) year from the date of Substantial Completion that the Security System will, under normal use and service, be free from defects and faulty workmanship except as set forth below:

1. Contractor's obligation under this warranty is to repair or replace defective equipment, parts, and associated labor thereto at its expense. Contractor shall warrant that replacement or repaired equipment furnished hereunder and labor shall be in accordance with current industrystandards.
2. PPR is granted a nontransferable fully paid license (Genetec) to use all software furnished by the Contractor as part of furnishing the security system equipment provisions under terms established by the software manufacturer. The Authority will be provided with a copy of all applicable licenses. Contractor shall warrant that it has the right to grant such licenses.
3. A copy of Contractor's standard warranty agreement must be provided and must match or exceed manufacturer's warranty, minimum of 3 years.
4. Upgrade of software during warranty period.
5. Provide Service for three (3) years after substantial completion, includes all labor and material cost associated with the repair, with the exception of third-party negligence or acts ofvandalism.
6. Contractor's personnel shall respond to all system failures within four (4) hours of the occurring event. All failure shall be corrected within eight (8) hours of the arrival on site of Contractor's personnel.

PART 2 - PRODUCTS

2.1 GENERAL SYSTEM REQUIREMENTS

A. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor's entry connection to components.

B. Tamper Protection: Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station, control-unit alarm display shall identify tamper alarms and indicate locations.

C. Compatibility: Video Management Software must be compatible with IP video equipment. The contractor, if submitting components from different manufactures must submit with either shop drawings, or product data, statements of compatibility from each manufacturer guaranteeing IP video components are compatible with the IP video management software submitted.

2.2 IP VIDEO SYSTEMS

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

1. Genetec
2. Vivotek
3. Axis Communications
4. DVTEL

B. Description:

1. System shall provide high-quality delivery and processing of IP-based video, audio, and control data using standard Ethernet-based networks.
2. System shall have seamless integration of all video surveillance and control functions.
3. Graphical user interface software shall manage all IP-based video matrix switching and camera control functions, two-way audio communication, alarm monitoring and control, and recording and archive/retrieval management. IP system shall also be capable of integrating into larger system environments.
4. System design shall include all necessary compression software for high-performance, dual-stream, MPEG-2/MPEG-4 video and H.264 video. Unit shall provide connections for all video cameras, bidirectional audio, discreet sensor inputs, and control system outputs.

5. All camera signals shall be compressed, encoded, and delivered onto the network for processing and control by the IP video-management software.
6. Camera system units shall be ruggedly built and designed for extreme adverse and urban environments, complying with NEMA Type environmental standards. Where required provide vandal proof exterior camera housings.
7. Encoder/decoder combinations shall place video, audio, and data network stream that can be managed from multiple workstations on the user's LAN or WAN at the same time.
8. All system interconnect cables, workstation PCs, and network intermediate devices shall be provided for full performance of specified system.

2.3 STANDARD IP CAMERAS

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

1. Genetec (AutoVu SharpV)
2. Vivotek
3. Axis Communications
4. DVTEL

B. Network Indoor Dome Camera, HD/2Megapixel: Assembled and tested as a complete manufactured unit.

1. Image Sensor - 1/3" Progressive scan CMOS
2. Lens - 2.7-9mm Motorized Varifocal
3. Day/Night Sensor – Electronic or True
4. Minimum Illumination/Light Sensitivity (lux) - 0.5 color, 0.1 black and white.
5. Maximum Resolution (pixels) - 1920x1080 (2MP)
6. Video Compression - H.264/MPEG4/M-JPEG
7. Frames per Second - 30
8. Alarm Inputs/Outputs - 2
9. Network Protocol - TCP/IP, HTTP, DHCP, DNS, DDNS, RTP/RTSP, PPPoE, SMTP, NTP
10. Power - PoE or DC Input
11. Vandal Resistant - Yes
12. Digital Pan/Tilt/Zoom
13. 20M IR LED
14. Mounting:

    a. Indoor Ceiling Mount (Vandal Proof)
    b. Wall Mount (Vandal Proof)

C. Network Indoor Dome Camera, HD/3Megapixel: Assembled and tested as a complete manufactured unit.

1. Image Sensor - 1/3" Progressive scan CMOS
2. Lens - 2.7-9mm Motorized Verifocal
3. Day/Night Sensor – Electronic or True
4. Minimum Illumination/Light Sensitivity (lux) - 0.8 color, 0.1 black and white
5. Maximum Resolution (pixels) - 2048x1536 (3MP)
6. Video Compression - H.264/MPEG4/M-JPEG
7. Frames per Second – 30
8. Alarm Inputs/Outputs - 2
9. Network Protocol - TCP/IP, HTTP, DHCP, DNS, DDNS, RTP/RTSP, PPPoE, SMTP, NTP
10. Power - PoE or DC Input
11. Vandal Resistant - Yes
12. Digital Pan/Tilt/Zoom

13. 20M IR LED
14. Mounting:

    a. Indoor Ceiling Mount (Vandal Proof)
    b. Wall Mount (Vandal Proof)

D. Network Outdoor Dome Camera, HD/ (2) Megapixel: Assembled and tested as a complete manufactured unit.

1. Image Sensor - 1/3" Progressive scan CMOS
2. Lens – 2.7-9mm Motorized Verifocal
3. Minimum Illumination/Light Sensitivity (lux) - 0.08 color, 0.1 black and white.
4. Maximum Resolution (pixels) - 1920x1080
5. Video Compression - H.264/MPEG4/M-JPEG
6. Frames per Second - 30
7. Intelligent Alarm
8. Network Protocol - TCP/IP, HTTP, DHCP, DNS, DDNS, RTP, RTSP, PPPoE, SMTP, NTP, SNMP, HTTPS, FTP, 802.1x, Qos
9. Power - PoE
10. Outdoor Use - Outdoor Ready
11. Vandal Resistant - Yes
12. Digital Pan/Tilt/Zoom
13. 20M IR LED
14. Heater - Integrated with housing.
15. Mounting:

    a. Outdoor Wall Mount (Vandal Proof)
    b. Outdoor Wall Mount on Pole Mount Adapter, Min. Three Clamps (Vandal Proof)

E. Network Outdoor Dome Camera, HD/ (3) Megapixel: Assembled and tested as a complete manufactured unit.

1. Image Sensor - 1/3" Progressive scan CMOS
2. Lens – 2.7-9mm Motorized Verifocal
3. Minimum Illumination/Light Sensitivity (lux) 0.5 color, 0 black and white
4. Maximum Resolution (pixels) - 2048x1536 (3MP)
5. Video Compression - H.264/MPEG4/M-JPEG
6. Frames per Second - 30
7. Intelligent Alarm
8. Network Protocol - TCP/IP, HTTP, DHCP, DNS, DDNS, RTP, RTSP, PPPoE, SMTP, NTP, SNMP, HTTPS, FTP, 802.1x, Qos
9. Power - PoE
10. Outdoor Use - Outdoor Ready
11. Vandal Resistant - Yes
12. Digital Pan/Tilt/Zoom
13. 20M IR LED
14. Heater - Integrated with housing
15. Mounting:

    a. Outdoor Wall Mount(Vandal Proof)
    b. Outdoor Wall Mount on Pole Mount Adapter, Min. Three Clamps(Vandal Proof)

F. Mini Dome Camera, HD/ 2 Megapixel: Assembled and tested as a complete manufactured unit.

1. Image Sensor - 1/3" Progressive scan CMOS

2. Lens - 4mm
3. Day/Night Sensor - Automatic
4. Minimum Illumination/Light Sensitivity (lux) - 0.5 color, 0.1 black and white with dynamic capture, 1.1 color, 0.2 black and white with light finder
5. Maximum Resolution (pixels) - 1920x1080 (2MP)
6. Video Compression - H.264/MPEG4/M-JPEG
7. Frames per Second - 15
8. Intelligent Alarm
9. Network Protocol - TCP/IP, HTTP, DHCP, DNS, DDNS, RTP/RTSP, PPPoE, SMTP, NTP
10. Power - PoE
11. Outdoor Use - Outdoor Ready
12. Vandal Resistant – Yes
13. Mounting:

    a. Indoor Ceiling Mount (Vandal Proof)
    b. Wall Mount (Vandal Proof)

G. Network Outdoor Multi-Sensor 360° Camera HD/ 20 Megapixel: Assembled and tested as a complete manufactured unit.

1. Image Sensor - 1/2.7" Progressive scan CMOS
2. Lens - 3.7-7.7mm Motorized Varifocal
3. Day/Night Sensor - Auto
4. Minimum Illumination/Light Sensitivity: 0.035LUX at (F1.9, on color), 0.005LUX at (F1.9, on black and white)
5. Maximum Resolution (pixels) - 2688x1920 (5MP) x 4
6. Video Compression – H.265/H.264/M-JPEG
7. Frames per Second min – 12 per sensor
8. Alarm Inputs/Outputs – 7/2
9. Network Protocol - TCP/IP, HTTP, DHCP, DNS, DDNS, RTP/RTSP, PPPoE, SMTP, NTP
10. Power - PoE or DC Input
11. Vandal Resistant - Yes
12. ePTZ Function: 48x digital zoom (4x on IE plug-in, 12x built-in)
13. Tilt range: 0° ~ 105° each lens
14. IR Illuminator: Built-in, 30M with Smart IR
15. Mounting:

    a. Outdoor Corner Mount (Vandal Proof)
    b. Pole Mount (Vandal Proof)

H. Network Indoor Dome Camera (360deg. or fish eye lens), HD/2Megapixel: Assembled and tested as a complete manufactured unit.

1. Image Sensor – 1/1.8" Progressive scan CMOS
2. Lens – 1.27mm, F2.8 angle of view 180 deg. (wall mount) 360 deg. (ceiling mount).
3. Day/Night Sensor - Auto
4. Minimum Illumination/Light Sensitivity: 0.05 LUX at (F1.2, AGC on color), 03 LUX at (F2.8, AGC on color), 0.0 LUX black and white
5. Maximum Resolution - 3072x2048
6. Video Compression - H.264/MPEG4/M-JPEG
7. Frames per Second - 50
8. Network Protocol - TCP/IP, HTTP, DHCP, DNS, DDNS, RTP/RTSP, PPPoE, SMTP, NTP
9. Power - PoE or DC Input
10. Vandal Resistant - Yes

11. Mounting:

    a. Indoor Ceiling Mount (Vandal Proof)
    b. Wall Mount (Vandal Proof)

2.4 VIDEO DECODERS

A. Video Decoder capable of displaying up to 48 cameras across HDMI, DVI or Analog monitor outputs.

1. Network - IPv4 or IPv6
2. Power - PoE, DC
3. Monitor Support - Up to 2 HDMI, DVI or Analog
4. Network Configurable
5. Camera Viewing capability only, no control.

2.5 POWER SUPPLIES

A. Low-voltage power supplies matched for voltage and current requirements of cameras and accessories, and of type as recommended by manufacturer of camera and lens.

1. Enclosure: NEMA 250, Type 3.
2. Input - 115VAC
3. Output - 16 fuse protected outputs:

    a. 12VDC or 24VDC
    b. 4A total continuous supply
    c. 3.5A rated outputs

4. Temperature Operating Range - 0 to 49 C
5. Input/Output LED Indicators
6. On/Off Switch
7. Locking Enclosure

2.6 CAMERA-SUPPORTING EQUIPMENT

A. Manufacturers: Subject to compliance with requirements of:

1. Genetec

B. Minimum Load Rating: Rated for load in excess of the total weight supported times a minimum safety factor of two.

C. Mounting Brackets for Fixed Cameras: Type matched to items supported and mounting conditions. Include manual pan-and-tilt adjustment.

D. Protective Housings for Fixed Cameras: Steel enclosures with internal camera mounting and connecting provisions that are matched to camera/lens combination and mounting and installing arrangement of camera to be housed.

1. Tamper switch on access cover sounds an alarm signal when unit is opened or partially disassembled. Central-control unit shall identify tamper alarms and indicate location in alarm display.
2. Camera Viewing Window: Polycarbonate window, aligned with camera lens.
3. Duplex Receptacle: Internally mounted.
4. Alignment Provisions: Camera mounting shall provide for field aiming of camera and permit removal and reinstallation of camera lens without disturbing camera alignment.

5. Built-in, thermostat-activated heater units. Units shall be automatically controlled so the environmental limits of the camera equipment are not exceeded.
6. Sun shield shall not interfere with normal airflow around the housing.
7. Mounting bracket and hardware for wall or ceiling mounting of the housing. Bracket shall be of same material as the housing; mounting hardware shall be stainless steel.
8. Finish: Housing and mounting bracket shall be factory finished using manufacturer's standard finishing process suitable for the environment.

2.7 MONITORS

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

1. NEC Display (security monitor not TV)
2. Samsung (security monitor not TV)
3. Sharp (security monitor not TV)
4. LG (security monitor not TV)
5. TATUNG (security monitor not TV)

B. Monitors shall be sized per the drawings. If size is not specified, the size shall be 26” to 32" minimum.

C. Monitors shall be mounted within a see through vandal proof enclosure. Vandal proof enclosure shall be lockable and wall mountable.

2.8 NETWORK VIDEO RECORDERS/VIDEO SERVERS

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

1. Genetec

B. Internal 12 TB min hard disk.

1. Contractor shall provide storage calculations based on quantity of cameras and recording parameters, 40TB shall be the minimum size NVR acceptable, contractor shall increase size based on number of cameras maintaining 20% spare capacity for recording and expansion.
2. Video and audio recording over TCP/IP network.
3. Video recording of MPEG-2 and MPEG-4 streams.
4. Video recording up to 48 Mbps for internal storage and up to 100 Mbps for external storage.
5. Duplex Operation: Simultaneous recording and playback.
6. Continuous and alarm-based recording.
7. Full-Featured Search Capabilities: Search based on camera, time, or date.
8. Automatic data replenishment to ensure recording even if network is down.
9. Digital certification by watermarking.
10. Internal RAID storage of up to 40 TB.
11. Full integration with LAN, Intranet, or Internet through standard Web browser or video management software, see next section.
12. Integrated Web server FTP server functionality.
13. Network video recording/storage devices shall be sized to store video at 2MP for 30 days with 20% capacity remaining, 30 fps, record on motion. Multiple storage devices shall be required as necessary. At a minimum, one storage device per facility will be required.

C. Minimum Device Requirements:

1. OS Windows 10 Enterprise LTSB.

2. Intel Core i5-8500 3.00GHz
3. RAM 16 GB DDR4
4. Onboard 1GB Network adapter

D. Each NVR shall be supplied with a keyboard and mouse for IP camera control at the viewing station. The Keyboard shall be connected directly to the NVR. The keyboard shall allow user logon, display selection, monitor configuration and camera control.

E. Contractor shall configure all new cameras for each building or each specified location for viewing, recording and playback on the NVR. Each NVR setup will be unique, and configuration will be determined by the Department of Public Property. Contractor shall submit NVR and recording setup and configuration of cameras for review and approval.

F. NVR shall be mounted with a vandal proof enclosure. Vandal Proof enclosure shall be lockable and mountable.

2.9 RACK MOUNTED EQUIPMENT

A. Each recreational center shall have one new equipment cabinet installed at a location to be directed by the owner.

B. Equipment cabinet shall include:

1. Uninterruptible Power Supply (UPS): Hardware furnished and installed by Security Contractor. Software furnished, installed, and programmed by Security Contractor.

a. The UPS shall have the following minimum requirements:

1) AC 120V – 2000VA, 1800W capacity
2) 2U, Rack-mountable
3) RS232, USB
4) Output connectors 8
5) Standard 19”

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

1) APC
2) Emerson
3) Tripp-Lite
4) Eaton

2. 24 Port Patch Panel: Provide (1) 24-Port Category 6 Patch Panel.

a. Refer to Section “27 11 19 Communication Termination Blocks and Patch Panels” for requirements.
b. Quantity: 1

3. Core Switch: Hardware provided by Contractor. Software furnished, installed, and programmed by Contractor.

a. The Core Switch shall have the following minimum requirements.

1) 24 ports 10G Fiber
2) 800 W PS SPB – L3

3) 24 X 10 Gigabit SFP
4) 6 X 40 Gigabit QSFP
5) 10G Fiber SFP+SR
6) 5-year support warranty

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

1) Aruba
2) Cisco
3) BCD Video
4) Samsung

4. Edge Switch: Hardware provided by Contractor. Software furnished, installed and programmed by Contractor. Refer to contractor documents for quantity and locations.

a. The Edge Switch shall have the following minimum requirements.

1) 24 ports POE
2) 1000 W PS SPB – L3
3) 24X 10/100/1000 (POE+) 2SFP, 2SFP
4) 10G Fiber SFP+SR
5) Managed
6) Rack-mountable
7) 5-year support warranty

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

1) Aruba
2) Cisco
3) BCD Video
4) Samsung

5. Horizontal Cable Management

a. Refer to Section “27 11 23 Communication Cable Management and Runway” for requirements.
b. Quantity: 1

6. Contractor shall furnish and install one new 20A, 120V single phase circuit from electrical panel to a new duplex receptacle within new equipment cabinet for UPS power.

2.10 POWER OVER ETHERNET (POE) POWER INJECTORS

A. Minimum Device Requirements:

1. Ports - 16 (min.) actual device quantities on drawings, use 24 port if necessary.
2. Power Input - 115VAC.
3. Max Power - 30W per port, Total Power 300W.
4. 19" Rack Mountable

2.11 MOSQUITO TYPE SONIC SECURITY DEVICES

A. Mosquito Sonic Devices Model Number–MK 4 with Multi-Age as manufactured by Moving Sound Technologies, or PPR approved equal.

B. Devices shall be secured with Standard Security Cage as manufactured by Moving Sound Technologies, or PPR approved equal.

C. Devices shall be connected to existing electrical panel and circuited through a new time clock. Electromechanical timer model number Tork 7200 or PPR approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways and other elements for compliance with space allocations, installation tolerance, hazards to camera installation, and other conditions affecting installation.

B. Examine roughing-in for LAN, WAN, and IP network before device installation.

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

3.2 WIRING

A. Comply with requirements in Division 26 – Raceways and Boxes for Electrical Systems. If Division 26 is not provided, install wiring per below.

B. Wiring Method: Install cables in raceways unless otherwise indicated.

1. Except raceways are not required in accessible indoor ceiling spaces and attics.
2. Except raceways are not required in hollow gypsum board partitions.
3. Conceal raceways and wiring except in unfinished spaces.

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

D. Splices, Taps, and Terminations: For power and control wiring, use numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

E. For LAN connection and fiber-optic and copper communication wiring, comply with Section 271513-1.2 "Description."

F. Grounding: Provide independent-signal circuit grounding recommended in writing by manufacturer.

3.3 VIDEO SURVEILLANCE SYSTEM INSTALLATION

A. Install cameras and infrared illuminators level and plumb.

B. Install cameras with an 84-inch minimum clear space below cameras and their mountings to the finished floor or grade. Change type of mounting to achieve required clearance. For exterior camera mount cameras on building exteriors or steel poles to match exterior lighting system poles.

C. Set pan unit and pan-and-tilt unit stops to suit final camera position and to obtain the field of view required for camera. Connect all controls and alarms and adjust.

D. Install power supplies and other auxiliary components at control stations unless otherwise indicated.

E. Install tamper switches on components indicated to receive tamper switches, arranged to detect unauthorized entry into system-component enclosures and mounted in self-protected, inconspicuous positions.

F. Avoid ground loops by making ground connections only at the control station.

1. For 12- and 24-V dc cameras, connect the coaxial cable shields only at the monitor end.

G. Identify system components, wiring, cabling, and terminals.

3.4 FIELD QUALITY CONTROL

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

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
2. Pre-testing: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:

    a. Prepare equipment list described in "Informational Submittals" Article.
    b. Verify operation of auto-iris lenses.
    c. Set back-focus of fixed focal length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.
    d. Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object 50 to 75 feet (17 to 23 m) away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
    e. Set and name all preset positions; consult Owner's personnel.
    f. Set sensitivity of motion detection.
    g. Connect and verify responses to alarms.
    h. Verify operation of control-station equipment.

3. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
4. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.
5. Video surveillance system will be considered defective if it does not pass tests and inspections.

6. Prepare test and inspection reports and submit to PPR for review.

3.5 LABELING OF CAMERA DEVICES AND CONTROL SYSTEMS

A. Contractor to provide a recommended Labeling System to Project Coordinator prior to camera installation.

3.6 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits for this purpose at 6 months and 12 months. Tasks shall include, but are not limited to, the following:

1. Check cable connections.
2. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back- focus as needed.
3. Adjust all preset positions; consult Owner's personnel.
4. Recommend changes to cameras, lenses, and associated equipment to improve Owner's use of video surveillance system.
5. Provide a written report of adjustments and recommendations.
6. Cleaning per Section 3.7

3.7 CLEANING

A. Clean installed items using methods and materials recommended in writing by manufacturer.

B. Clean video-surveillance-system components, including camera-housing windows, lenses, and monitor screens.

3.8 DEMONSTRATION/TRAINING

A. Provide a minimum of 8 hours of training to Owner's maintenance personnel to adjust, operate, and maintain video-surveillance equipment.

END OF SECTION

SECTION 282607 - EMERGENCY CALL SYSTEM

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes providing a complete and operating emergency call system.

1. Emergency Call Annunciator Panel.
2. Emergency Call Stations.
3. System power supply with back-up

1.2 SUBMITTALS

A. Shop Drawings and Manufacturer's Literature.

1. Submittals are required for all material in brochure form complete with wiring diagrams. Include:

    a. Cable or wire as recommended by equipment manufacturer.
    b. Technical data on each product, including finish.
    c. Details of construction and connections.
    d. Description of system operation.
    e. Manufacturer's installation instructions.

B. Operation and Maintenance Instructions.

1.3 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer who is a factory-authorized service representative to perform the work of this Section.

B. Electrical Component Standard: Provide work complying with applicable requirements of City of Chicago Building Code (CCBC).

1.4 DELIVERY, STORAGE AND HANDLING

A. Deliver products in factory containers. Store in clean, dry space in original containers. Protect products from fumes and construction traffic. Handle carefully to avoid damage.

1.5 MAINTENANCE SERVICE

A. Furnish service and maintenance of emergency call system for one year from date of substantial completion.

1.6 WARRANTY

A. Provide manufacturers standard warranty or 1 year warranty, whichever is longer .

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Cornell

2.2 ANNUNICATOR PANEL

A. The annunciator panel shall include one alternate action switch with internal LED indicator for each zone. An audible alarm will be mounted on the annunciator panel which will emit a minimum sound level of 90 db at 30 cm. A yellow LED light on the annunciator will illuminate and the alarm will emit a repeating sound if any of the supervised lines are faulted.

B. The panel shall be constructed of 0.125" thick anodized aluminum with permanently silk-screened zone designations on the panel as well as a designation strip.

C. Manufacturer: Cornell A41 series or approved equal with the number of zones required.

2.3 CALL STATION

A. The call station shall consist of one momentary series switch with LED and one audible alarm device with a sound level minimum of 90db at 30 cm. The station will be wall mounted on a stainless steel plate.

2.4 POWER SUPPLY

A. Battery back-up/power supply, 24 VDC at 3 amps.

PART 3 - EXECUTION

3.1 WIRING

A. Wiring shall consist of 22 gauge (minimum) wire. Four conductors are required between each Call Station and the Annunciator Panel.

B. Power wire shall be 18 gauge (minimum). Two conductors are required between Model C-5243 battery power supply and the annunciator panel.

3.2 INSTALLATION

A. Install equipment where shown on drawings. Stations to be mounted plumb.

B. All wiring to be installed in conduit.

C. Make all connections to screw type terminals. Splices or soldered connections are prohibited.

3.3 CONTRACTOR STARTUP AND REPORTING

A. As a minimum, the system shall be tested to show that:

1. The complete system is free from grounds, opens and shorts.
2. Each device functions as specified.

3. Abnormal condition of any circuit required to be electrically supervised shall result in the specified trouble signals.

END OF SECTION

SECTION 284621.11 - ADDRESSABLE FIRE-ALARM SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1. Scope – Addition / Fire Alarm System Upgrade: Replace existing fire alarm system headend equipment and provide new fire alarm devices as indicated on the Drawings. Provide fire alarm device layout as required by the local code authority having jurisdiction, Fire Prevention Bureau and Americans with Disabilities Act. Electrical contractor shall provide a comprehensive inspection and test report of the existing fire alarm system in accordance with NFPA 72 standards prior to performing any work. Submit test report (findings and deficiency repair recommendations) to Architect of record, engineer of record and owner for review and recommended action.

B. Duct smoke detectors shall be furnished, installed and wired by Division 26. Division 23 Contractor to interface with the fan systems to which they are connected, and shall be monitored through the Digital Control System where applicable. Refer to Division 23 Section "Building Automation System (BAS) - Basic Materials, Interface Devices and Sensors." Duct smoke detectors shall be connected to the fire alarm control panel by Division 26 as defined by the local fire marshal, Smoke Detectors shall initiate a supervisory alarm.

1. Electrical contractor shall provide duct smoke detector on the return header duct with associated remote keyed test station / fan shut-down for HVAC equipment rated 2,000 CFM and greater.
2. Electrical contractor shall provide duct smoke detector on the supply and return header duct with associated remote keyed test station / fan shut-down for HVAC equipment rated 15,000 CFM and greater.
3. System carbon monoxide detectors/alarm shall be provided in all rooms or spaces where any fossil fuel combustion equipment is located as follows:

a. Boiler rooms
b. Mechanical rooms
c. Furnaces
d. Water heaters
e. Kitchen and food service cooking equipment
f. Natural gas fired generators

4. System carbon monoxide detectors/alarm shall NOT activate alarm at fire alarm control panel.

C. Where fire pump system is provided:

1. Provide a dedicated 20 amp, 120 volt, single-phase branch circuit with 2 #12 & 1 #12 ground in a ¾" conduit to fire pump controller for local supervisory power. This circuit shall be fed from an emergency panel where possible. The conduit shall be factory painted RED and clearly identified to read "Fire Pump Local Supervisory 120VAC circuit. This is to power a local pump run/power failure alarm that is built into the controller, separate from flow bells & the building alarm system.
2. Contractor shall reference the fire protection (FP) set of drawings including the fire protection system shop drawings for exact quantities and locations of all water flow switches and tamper switches. Provide all associated fire alarm signal wiring in ¾" conduit including addressable interface module and indicator lamp for each water flow switch and tamper switch.

D. Where combination fire/smoke dampers are provided:

1. Provide a dedicated 20 amp, 120 volt, single-phase branch circuit with 2 #12 & 1 #12 ground in a ¾" conduit to a maximum total of (6) six combination fire/smoke damper actuators. This circuit shall be fed from an emergency

panel where possible. The conduit shall be factory painted RED and clearly identified to read “Fire/Smoke Damper Supervisory 120VAC circuit. Provide a lock-on device on branch circuit breaker.
2. Provide a supervisory circuit (conduit and wiring) between each combination fire/smoke damper to the fire alarm system panel. Provide two (2) micro switch devices which provide the ability to remotely indicate the damper blade position. Each micro switch shall provide a positive status indictor. Provide electrical interface with a remote control on/off fan station with the micro-switch package. The system smoke detector or relay from alarm panel shall be wired in series. If smoke is detected, the contact opens and the damper springs close. If there is a building fire alarm, then the smoke detector auxiliary contacts close and signal an alarm at the fire alarm control panel. Note; where actuator auxiliary switch is used for alarm signaling or smoke control system, a re-test of the alarm will be required per local code.

E. Fire Alarm Control Panel shall monitor the following functions:

1. Kitchen Fire-extinguishing system operation.
2. Monitor Duct Detectors in supervisory mode only.

1.2 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. Device guards.
7. Magnetic door holders.
8. Remote annunciator.
9. Graphic annunciator.
10. Addressable interface device.
11. Digital alarm communicator transmitter.
12. Radio alarm transmitter.
13. Network communications.
14. System printer.

B. Related Requirements:

1. Section 270513 "Conductors and Cables for Communications Systems" for cables and conductors for fire-alarm systems.

1.3 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel.

C. HLI: High Level Interface.

D. NICET: National Institute for Certification in Engineering Technologies.

E. PC: Personal computer.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.

2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.

2. Include plans, elevations, sections, details, and attachments to other work.

3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.

4. Detail assembly and support requirements.

5. Include voltage drop calculations for notification-appliance circuits.

6. Include battery-size calculations.

7. Include input/output matrix.

8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.

9. Include performance parameters and installation details for each detector.

10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.

11. Provide program report showing that air-sampling detector pipe layout balances pneumatically within the airflow range of the air-sampling detector.

12. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.

b. Show field wiring required for HVAC unit shutdown on alarm.

c. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' control system.

d. Locate detectors according to manufacturer's written recommendations.

e. Show air-sampling detector pipe routing.

13. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.

14. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

C. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.

2. Shop Drawings shall be prepared by persons with the following qualifications:

a. Trained and certified by manufacturer in fire-alarm system design.

b. NICET-certified, fire-alarm technician; Level IV minimum.

c. Licensed or certified by authorities having jurisdiction.

D. Delegated-Design Submittal: For notification appliances and smoke and heat detectors, in addition to submittals listed above, indicate compliance with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation. Please note that the design drawings may not necessarily show or indicate all fire alarm devices. Contractor shall provide all code required fire alarm devices in accordance with NFPA 72 including all local fire codes.

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.

4. Submission to the local fire marshal and/or Bureau of Fire Prevention and Bureau of Electrical Inspection:

a. Submit detailed drawings in accordance with the AHJ procedures and requirements for the fire alarm plan review.

b. Provide identical submittal to the Architect for concurrent review.

c. Upon receipt of the comments from AHJ, submit a copy of all the annotated drawings or correction sheets to the Architect.

d. Incorporate all comments into the detailed drawings and resubmit to the AHJ until approval is obtained.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Seismic Qualification Data: Certificates, for fire-alarm control unit, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.6 Sample Warranty: For special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

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

a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.

c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.

d. Riser diagram.

e. Device addresses.

f. Air-sampling system sample port locations and modeling program report showing layout meets performance criteria.

g. Record copy of site-specific software.

h. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.

2) Frequency of testing of installed components.

3) Frequency of inspection of installed components.

4) Requirements and recommendations related to results of maintenance.

5) Manufacturer's user training manuals.

i. Manufacturer's required maintenance related to system warranty requirements.

j. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.

2. Program Software Backup: On magnetic media or compact disk, complete with data files.

3. Device address list.

4. Printout of software application and graphic screens.

1.8 MAINTENANCE MATERIAL SUBMITTALS

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

1. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than three units.

2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than three units.

3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than three unit of each type.

4. Detector Bases: Quantity equal to two percent of amount of each type installed, but no fewer than three unit of each type.

5. Keys and Tools: One extra set for access to locked or tamperproofed components.

6. Audible and Visual Notification Appliances: Three of each type installed.

7. Fuses: Two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III 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.

E. NFPA Certification: Obtain certification according to NFPA 72 in the form of a placard by an FM Global-approved alarm company.

F. NFPA Certification: Obtain certification according to NFPA 72.

1.10 PROJECT CONDITIONS

A. Perform a full test of the existing system prior to starting work. Document any equipment or components not functioning as designed.

B. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:

1. Notify Architect and Owner no fewer than seven days in advance of proposed interruption of fire-alarm service.

2. Do not proceed with interruption of fire-alarm service without Architect's and Owner's written permission.

C. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.11 SEQUENCING AND SCHEDULING

A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service, and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.

B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.12 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.

2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Source Limitations for Fire-Alarm System and Components: Components shall be compatible with, and operate as an extension of, existing system. Provide system manufacturer's certification that all components provided have been tested as, and will operate as, a system.

B. Noncoded, UL-certified addressable system, with multiplexed signal transmission and **horn**/strobe evacuation.

C. Automatic sensitivity control of certain smoke detectors.

D. All components provided shall be listed for use with the selected system.

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

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices **and systems**:

1. Manual stations.

2. Heat detectors.

3. Smoke detectors.

4. Duct smoke detectors.

5. Carbon monoxide detectors.

6. Combustible gas detectors.

7. Automatic sprinkler system water flow.

8. Preaction system.

9. Fire-extinguishing system operation.

10. Fire standpipe system.

11. Dry system pressure flow switch.

12. Fire pump running.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances, including voice evacuation notices.

2. Identify alarm and specific initiating device at fire-alarm control unit, connected network control panels, off-premises network control panels, and remote annunciators.

3. Transmit an alarm signal to the remote alarm receiving station.

4. Unlock electric door locks in designated egress paths.

5. Release fire and smoke doors held open by magnetic door holders.

6. Activate voice/alarm communication system.

7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.

8. Close smoke dampers in air ducts of designated air-conditioning duct systems.

9. Activate preaction system.

10. Recall elevators to primary or alternate recall floors.

11. Activate elevator power shunt trip.

12. Activate emergency lighting control.

13. Activate emergency shutoffs for gas and fuel supplies.

14. Record events in the system memory.

15. Record events by the system printer.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.

2. High- or low-air-pressure switch of a dry-pipe or preaction sprinkler system.

3. Alert and Action signals of air-sampling detector system.

4. Elevator shunt-trip supervision.

5. Fire pump running.

6. Fire-pump loss of power.

7. Fire-pump power phase reversal.

8. Independent fire-detection and -suppression systems.

9. User disabling of zones or individual devices.

10. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.

2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.

3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.

4. Loss of primary power at fire-alarm control unit.

5. Ground or a single break in internal circuits of fire-alarm control unit.

6. Abnormal ac voltage at fire-alarm control unit.

7. Break in standby battery circuitry.

8. Failure of battery charging.

9. Abnormal position of any switch at fire-alarm control unit or annunciator.

10. Hose cabinet door open.

E. System Supervisory Signal Actions:

1. Initiate notification appliances.

2. Identify specific device initiating the event at fire-alarm control unit, connected network control panels, off-premises network control panels, and remote annunciators.

3. Record the event on system printer.

4. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.

5. Transmit system status to building management system.

6. Display system status on graphic annunciator.

2.3 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2.4 FIRE-ALARM CONTROL UNIT

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

1. Notifier

2. Edwards Systems Technology, EST, A UTC Fire & Security Company.

3. Siemens Building Technologies, Inc.,

4. Gamewell

B. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.

a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.

b. Include a real-time clock for time annotation of events on the event recorder and printer.

c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.

d. The FACP shall be listed for connection to a UL listed Central-Station signaling system service.

e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.

2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.

3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.

C. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, 80 characters, minimum.

2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.

D. 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, two line(s) of 80 characters, minimum.

2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.

E. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, Class B.

2. Pathway Survivability: Level 1.

3. Install no more than 100 addressable devices on each signaling-line circuit.

4. Serial Interfaces:

a. One dedicated RS 485 port for central-station operation using point ID DACT.

b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).

c. One USB port for PC configuration.

d. One RS 232 port for VESDA HLI connection.

e. One RS 232 port for voice evacuation interface.

F. Stairwell and Elevator Shaft Pressurization, where required: Provide an output signal using an addressable relay to start the stairwell and elevator shaft pressurization system. Signal shall remain on until alarm conditions are cleared and fire-alarm system is reset. Signal shall not stop in response to alarm acknowledge or signal silence commands.

1. Pressurization starts when any alarm is received at fire-alarm control unit.

2. Alarm signals from smoke detectors at pressurization air supplies have a higher priority than other alarm signals that start the system.

G. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.

2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.

3. Record events by the system printer.

4. Sound general alarm if the alarm is verified.

5. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

H. Notification-Appliance Circuit:

1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.

2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.

3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

I. 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.

J. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall be connected to fire-alarm system.

K. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.

L. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

M. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

N. 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 and digital alarm radio 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.

O. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Sealed lead calcium.

P. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.5 PREACTION SYSTEM

A. Initiate Presignal Alarm: This function shall cause an audible and visual alarm and indication to be provided at the FACP. Activation of an initiation device connected as part of a preaction system shall be annunciated at the FACP only, without activation of the general evacuation alarm.

2.6 MANUAL FIRE-ALARM BOXES

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

1. Notifier

2. Edwards Systems Technology, EST, A UTC Fire & Security Company.

3. Siemens Building Technologies, Inc.,

4. Gamewell

B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. 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. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.

3. Station Reset: Key- or wrench-operated switch.

4. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.

5. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

C. Additional manual fire alarm boxes: Contractor shall include a total of five (5) manual fire alarm boxes including twenty (20) linear feet of conduit and FPLR type wiring for each manual fire alarm box in bid proposal beyond what is indicated on the plan drawings due added fire alarm boxes from the authority having jurisdiction and/or electrical inspector. Include all associated materials and labor for the installation of such additional fire alarm boxes in bid proposal. Turn over all un-used devices to owner for attic stock.

2.7 SYSTEM SMOKE DETECTORS

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

1. Notifier

2. Edwards Systems Technology, EST, A UTC Fire & Security Company.

3. Siemens Building Technologies, Inc.,

4. Gamewell

B. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.

2. Detectors shall be four-wire type.

3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

4. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.

5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.

6. Integral Visual-Indicating Light: LED type, indicating detector has operated 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 (8 or 11 deg C) 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 (57 or 68 deg C).

c. Multiple levels of detection sensitivity for each sensor.

d. Sensitivity levels based on time of day.

C. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.

2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

a. Primary status.

b. Device type.

c. Present average value.

d. Present sensitivity selected.

e. Sensor range (normal, dirty, etc.).

3. Additional photoelectric smoke detectors: Contractor shall include a total of five (5) photoelectric smoke detectors including twenty (20) linear feet of conduit and FPLR type wiring for each photoelectric smoke detectors in bid proposal beyond what is indicated on the plan drawings due added photoelectric smoke detectors from the authority having jurisdiction and/or electrical inspector. Include all associated materials and labor for the installation of such additional photoelectric smoke detectors in bid proposal. Turn over all un-used devices to owner for attic stock.

D. 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.

7. Division 26 to provide addressable control relay for FCP monitoring.

8. Division 26 to provide remote alarm indicator/test switch, which indicates activation of detector.

9. Duct Smoke Detector Remote Keyed Test Station/Switch. Test station mounted at 48" above finished floor.

10. Flush wall mounted except surface wall mounted or group wall mounted or grouped FATC flush door mounted in mechanical equipment rooms.

11. Alarm/power LED.

12. Stainless steel faceplate.

13. White lettering on red nameplate identifying associated duct smoke detector.

2.8 CARBON MONOXIDE DETECTORS

A. General: Carbon monoxide detector listed for connection to fire-alarm system.

1. Mounting: Adapter plate for outlet box mounting.

2. Testable by introducing test carbon monoxide into the sensing cell.

3. Detector shall provide alarm contacts and trouble contacts.

4. Detector shall send trouble alarm when nearing end-of-life, power supply problems, or internal faults.

5. Comply with UL 2075.

6. Locate, mount, and wire according to manufacturer's written instructions.

7. Provide means for addressable connection to fire-alarm system.

8. Test button simulates an alarm condition.

B. Additional Carbon Monoxide detectors: Contractor shall include a total of five (5) Carbon Monoxide detectors including twenty (20) linear feet of conduit and FPLR type wiring for device in bid proposal beyond what is indicated on the plan drawings due added devices from the authority having jurisdiction and/or electrical inspector. Include all associated materials and labor for the installation of such additional devices in bid proposal. Turn over all un-used devices to owner for attic stock.

C. Sensors: The detector shall be comprised of four sensing elements including a smoke sensor, a carbon monoxide sensor, an infrared sensor, and a heat sensor.

1. Smoke sensor shall be photoelectric type as described in "System Smoke Detectors" Article.

2. Carbon monoxide sensor shall be as described in "Carbon Monoxide Detectors" Article.

3. Heat sensor shall be as described in "Heat Detectors" Article.

4. Each sensor shall be separately listed according to requirements for its detector type.

2.9 HEAT DETECTORS

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

1. Notifier

2. Edwards Systems Technology, EST, A UTC Fire & Security Company.

3. Siemens Building Technologies, Inc.,

4. Gamewell

B. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

C. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.

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.

D. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F (88 deg C).

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.

2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.10 NOTIFICATION APPLIANCES

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

1. Notifier

2. Edwards Systems Technology, EST, A UTC Fire & Security Company.

3. Siemens Building Technologies, Inc.,

4. Gamewell

B. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.

C. 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.

D. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.

E. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.

F. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn, using the coded signal prescribed in UL 464 test protocol.

G. 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- (25-mm-) high letters on the lens.

1. Rated Light Output:

a. 15/30/75/110 cd, selectable in the field.

2. Mounting: Wall mounted unless otherwise indicated.

3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.

4. Flashing shall be in a temporal pattern, synchronized with other units.

5. Strobe Leads: Factory connected to screw terminals.

6. Mounting Faceplate: Factory finished, **red**.

H. Additional combination horn/strobe Notification devices: Contractor shall include a total of five (5) combination horn/strobe Notification devices including twenty (20) linear feet of conduit and FPLR type wiring for each device in bid proposal beyond what is indicated on the plan drawings due added devices from the authority having jurisdiction and/or electrical inspector. Include all associated materials and labor for the installation of such additional devices in bid proposal. Turn over all un-used devices to owner for attic stock.

I. Voice/Tone Notification Appliances:

1. Comply with UL 1480.

2. Speakers for Voice Notification: Locate speakers for voice notification to provide the intelligibility requirements of the "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.

3. High-Range Units: Rated 2 to 15 W.

4. Low-Range Units: Rated 1 to 2 W.

5. Mounting: Flush or surface mounted and bidirectional.

6. Matching Transformers: Tap range matched to acoustical environment of speaker location.

J. Exit Marking Audible Notification Appliance:

1. Exit marking audible notification appliances shall meet the audibility requirements in NFPA 72.

2. Provide exit marking audible notification appliances at the entrance to all building exits.

3. Provide exit marking audible notification appliances at the entrance to areas of refuge with audible signals distinct from those used for building exit marking.

2.11 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnets: Require no more than 3 W to develop 25-lbf (111-N) holding force.

2. Wall-Mounted Units: Flush mounted unless otherwise indicated.

3. Rating: 24-V ac or dc.

B. Material and Finish: Match door hardware.

C. Additional Magnetic Door Holder devices: Contractor shall include a total of six (6) Magnetic Door Holder devices including twenty (20) linear feet of conduit and FPLR type wiring for each device in bid proposal beyond what is indicated on the plan drawings due added devices from the authority having jurisdiction and/or electrical inspector. Include all associated materials and labor for the installation of such additional devices in bid proposal. Turn over all un-used devices to owner for attic stock.

2.12 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.

2.13 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 and/or 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 notification devices.

2. Operate solenoids for use in sprinkler service.

2.14 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. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.

2. Address of the supervisory signal.

3. Address of the trouble-initiating device.

4. Loss of ac supply.

5. Loss of power.

6. Low battery.

7. Abnormal test signal.

8. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.15 RADIO ALARM TRANSMITTER

A. Transmitter shall comply with NFPA 1221 and 47 CFR 90.

B. Description: Manufacturer's standard commercial product; factory assembled, wired, and tested; ready for installation and operation.

1. Packaging: A single, modular, NEMA 250, Type 1 metal enclosure with a tamper-resistant flush tumbler lock.

2. Signal Transmission Mode and Frequency: VHF or UHF 2-W power output, coordinated with operating characteristics of the established remote alarm receiving station designated by Owner.

3. Normal Power Input: 120-V ac.

4. Secondary Power: Integral-sealed, rechargeable, 12-V battery and charger. Comply with NFPA 72 requirements for battery capacity; submit calculations.

5. Antenna: Omnidirectional, coaxial half-wave, dipole type with driving point impedance matched to transmitter and antenna cable output impedance. Wind-load strength of antenna and mounting hardware and supports shall withstand **100 mph (160 km/h)** with a gust factor of 1.3 without failure.

6. Antenna Cable: Coaxial cable with impedance matched to the transmitter output impedance.

7. Antenna-Cable Connectors: Weatherproof.

8. Alarm Interface Devices: Circuit boards, modules, and other auxiliary devices, integral to the transmitter, matching fire-alarm and other system outputs to message-generating inputs of the transmitter that produce required message transmissions.

C. Functional Performance: Unit shall receive alarm, supervisory, or trouble signal from fire-alarm control unit or from its own internal sensors or controls and shall automatically transmit signal along with a unique code that identifies the transmitting station to the remote alarm receiving station. Transmitted messages shall correspond to standard designations for fire-reporting system to which the signal is being transmitted and shall include separately designated messages in response to the following events or conditions:

1. Transmitter Low-Battery Condition: Sent when battery voltage is below 85 percent of rated value.

2. System Test Message: Initiated manually by a test switch within the transmitter cabinet, or automatically at an optionally preselected time, once every 24 hours, with transmission time controlled by a programmed timing device integral to transmitter controls.

3. Transmitter Trouble Message: Actuated by failure, in excess of one-minute duration, of the transmitter normal power source, derangement of the wiring of the transmitter, or any alarm input interface circuit or device connected to it.

4. Local Fire-Alarm-System Trouble Message: Initiated by events or conditions that cause a trouble signal to be indicated on the building system.

5. Local Fire-Alarm-System Alarm Message: Actuated when the building system goes into an alarm state. Identifies device that initiated the alarm.

6. Local Fire-Alarm-System, Supervisory-Alarm Message: Actuated when the building alarm system indicates a supervisory alarm.

2.16 NETWORK COMMUNICATIONS

A. Provide network communications for fire-alarm system according to fire-alarm manufacturer's written requirements.

B. Provide network communications pathway per manufacturer's written requirements and requirements in NFPA 72 and NFPA 70.

C. Provide integration gateway using BACnet for connection to building automation system.

2.17 SYSTEM PRINTER

A. Printer shall be listed and labeled as an integral part of fire-alarm system.

2.18 DEVICE GUARDS

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.

1. Factory fabricated and furnished by device manufacturer.

2. Finish: Paint of color to match the protected device.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

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

3.2 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.

2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.

1. Connect new equipment to existing control panel in existing part of the building.

2. Connect new equipment to existing monitoring equipment at the supervising station.

3. Expand, modify, and supplement existing control equipment as necessary to extend existing control functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.

C. Equipment Mounting: Install fire-alarm control unit on concrete base. Comply with requirements for concrete base specified in Section 033000 "Cast-in-Place Concrete."

1. Install seismic bracing. Comply with requirements in Section 270548.16 "Seismic Controls for Communications Systems."

2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (460-mm) centers around the full perimeter of concrete base.

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

4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

5. Install anchor bolts to elevations required for proper attachment to supported equipment.

D. Equipment Mounting: Install fire-alarm control unit on finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."

E. Install wall-mounted equipment, with tops of cabinets not more than 78 inches (1980 mm) above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 270548.16 "Seismic Controls for Communications Systems."

F. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches (1520 mm) of the exit doorway.

2. Mount manual fire-alarm box on a background of a contrasting color.

3. The operable part of manual fire-alarm box shall be between 42 inches (1060 mm) and 48 inches (1220 mm) above floor level. All devices shall be mounted at the same height unless otherwise indicated.

G. Smoke- or Heat-Detector Spacing:

1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.

2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for heat-detector spacing.

3. Smooth ceiling spacing shall not exceed **30 feet (9 m)**.

4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Annex A **or Annex B** in NFPA 72.

5. HVAC: Locate detectors not closer than **36 inches (910 mm)** from air-supply diffuser or return-air opening.

6. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture and not directly above pendant mounted or indirect lighting.

H. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

I. 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 (9100 mm) long shall be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

J. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

K. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.

L. 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.

M. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

N. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling. Install all devices at the same height unless otherwise indicated.

O. Device Location-Indicating Lights: Locate in public space near the device they monitor.

P. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that resists **100-mph (160-km/h)** wind load with a gust factor of 1.3 without damage.

3.3 PATHWAYS

A. Pathways above recessed ceilings and in nonaccessible locations may be routed exposed.

1. Exposed pathways located less than 96 inches (2440 mm) above the floor shall be installed in EMT.

B. Pathways shall be installed in EMT.

C. Exposed EMT shall be painted red enamel.

3.4 CONNECTIONS

A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Section 087100 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches (910 mm) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Alarm-initiating connection to smoke-control system (smoke management) at firefighters' smoke-control system panel.

2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.

3. Smoke dampers in air ducts of designated HVAC duct systems.

4. Magnetically held-open doors.

5. Electronically locked doors and access gates.

6. Alarm-initiating connection to elevator recall system and components.

7. Alarm-initiating connection to activate emergency lighting control.

8. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.

9. Supervisory connections at valve supervisory switches.

10. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.

11. Supervisory connections at elevator shunt-trip breaker.

12. Data communication circuits for connection to building management system.

13. Data communication circuits for connection to mass notification system.

14. Supervisory connections at fire-extinguisher locations.

15. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.

16. Supervisory connections at fire-pump engine control panel.

3.5 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 270553 "Identification for Communications Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.6 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.7 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

D. Perform the following tests and inspections 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 the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.

b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.

4. Test audible appliances for the private operating mode according to manufacturer's written instructions.

5. Test visible appliances for the public operating mode according to manufacturer's written instructions.

6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

F. Fire-alarm system will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

H. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

I. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.8 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication,

cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.9 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fire-alarm system.

END OF SECTION

SECTION 310000 – GENERAL EARTHWORK REQUIREMENTS

1.1 General earthwork requirements shall conform to the following minimum standards:

A. Provide positive drainage away from all structures.

B. Unless otherwise noted, minimum slope shall be ¼ inch per foot or 2% and a maximum slope shall not exceed 3:1 (h:v) or 33% for non-paved surfaces. Paved surfaces shall have a minimum grade or 1% and have positive drainage off of the pavement.

C. Grades on designated handicapped accessible areas/routes shall comply with the provisions of the Americans with Disabilities Act.

D. Notify the PPR immediately if slope requirements cannot be met. At no time will slopes in excess of those above the maximum allowed, be accepted, unless prior approval is received in writing by PPR.

E. Grade earthen, non-paved, surfaces to a smooth finish. Slope lawn areas in swales to a gentle crown along the centerline.

F. Grade all seeded fine lawn areas flush with finish grade. Adjust finished grade to the proper depth where sod abuts paved areas.

G. Grade all tree/shrub/groundcover planting beds to 3 inches below top of abutting curbs, paving, or lawn areas to allow for mulching.

H. Adjust existing and new manhole, catch basins, and drains rim/grate elevations to new grade elevations (pavement or soil).

I. Finished surfaces shall be graded smooth and even with no abrupt or awkward changes in grade.

J. Provide properly compacted subgrades of native soil or approved fill. Native soils, fill, or subgrades deemed insufficient shall be removed and replaced with appropriate material. Subgrades shall be inspected by a qualified inspector to ensure compaction requirements are met. Submit test reports and field logs to PPR for review and for record.

K. Existing on-site soils should be evaluated for both suitability for use in construction as well as environmentally for contaminants by licensed and qualified professionals such geotechnical engineers and environmental scientists. Many sites throughout the City include various types of urban fill. In some cases there may be abandoned structures below grade. These soils and features should be evaluated before design and engineering newly planned features. Also, environmental due diligence and/or testing should be completed near the beginning of design and engineering to ascertain if on-site materials are clean or regulated. Testing of existing on-site soils and materials shall comply with the requirements of Pennsylvania Department of Environmental Protection requirements for fill management whether it is determined to be clean or regulated. Submit geotechnical testing and environmental due diligence reports to PPR for review and for record.

L. Any soil materials leaving the site or being brought to the site shall comply with the Pennsylvania Department of Environmental Protection requirements for fill management.

M. Environmental due diligence: investigative techniques, including, but not limited to, visual property inspections, electronic data base searches, review of property ownership, review of property use history, sanborn maps, environmental questionnaires, transaction screen, analytical testing, environmental assessments or audits. Submit all environmental due diligence reports to PPR for review and for record.

N. Analytical testing is not a required part of due diligence unless visual inspection and/or review of the past land use of the property indicates that the fill may have been subjected to a spill or release of a regulated substance. If the fill may have been affected by a spill or release of a regulated substance, it must be tested to determine if it qualifies as clean fill. Testing should be performed in accordance with appendix a of PADEP's policy "management of fill".

O. Fill material that does not qualify as clean fill is regulated fill. Regulated fill is waste and must be managed in accordance with the municipal or residual waste regulations in 25 pa code chapters 287 residual waste management or 271 municipal waste management, whichever is applicable.

P. Designers and contractors shall comply with the Pennsylvania Underground Utility Line Protection Law, Act 287 of 1974, as amended by Act 50 of 2017. This includes contacting the Pennsylvania One Call System or 811 as required by law.

Q. Designers and contractors, in additional to complying with the Pennsylvania Underground Utility Line Protection Law requirements shall research available utility records from the project owner for the site or facility. Upon evaluation of these records the designer or contractor can evaluate the need for extensive underground utility locating depending the project. The designer or contractor shall determine the need and level of underground utility located needed for the project in conformance with the American Society of Civil Engineers (ASCE) National Consensus Standard – ASCE C-I 38-02, Standard Guidelines for the Collection and Depiction of Existing Subsurface Utility Data. The designer or contractor shall determine the Quality Level of utility located required by the project, Levels D, C, B, or A. The costs associated with underground utility locating services shall be evaluated and balanced with the available utility information, conditions in the field, the type of project being proposed, the risks associated with utility conflict and/or damage, and the ability of a utility locator to obtain information. These evaluations shall be done in consultation with Philadelphia Parks and Recreation.

END OF SECTION 31000

SECTION 311000 - SITE CLEARING

1.1 SUMMARY

A. Section Includes:

1. Protecting existing vegetation to remain.
2. Removing existing vegetation.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Stripping and stockpiling rock.
6. Removing above- and below-grade site improvements.
7. Disconnecting, capping or sealing, and removing site utilities, abandoning site utilities in place.
8. Temporary erosion and sedimentation control.

B. Related Requirements:

1. Section 015000 "Temporary Facilities and Controls" for temporary erosion- and sedimentation-control measures.

C. Related Requirements:

1. Section 01500 "Temporary Facilities and Controls" for temporary erosion- and sedimentation-control measures.

1.2 DEFINITIONS

A. Subsoil: Soil beneath the level of sub grade; soil beneath the topsoil layers of a naturally occurring soil profile, typified by less than 1 percent organic matter and few soil organisms.

B. Surface Soil: Soil that is present at the top layer of the existing soil profile. In undisturbed areas, surface soil is typically called "topsoil," but in disturbed areas such as urban environments, the surface soil can be subsoil.

C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; the zone where plant roots grow.

D. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil; the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects larger than 2 inches in diameter; and free of weeds, roots, toxic materials, or other non-soil materials.

E. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction and indicated on Drawings.

F. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction and indicated on Drawings

G. Vegetation: Trees, shrubs, ground covers, grass, and other plants.

1.3 PREINSTALLATION MEETINGS

A. Conduct conference at Francis Meyers recreational Center, 5800 Chester Ave Philadelphia, PA 19143

1.4 MATERIAL OWNERSHIP

A. Except for materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.5 INFORMATIONAL SUBMITTALS

A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes reconstruction conditions that might be misconstrued as damage caused by site clearing.

1. Use sufficiently detailed photographs or video recordings.
2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plant designated to remain.

B. Topsoil stripping and stockpiling program.

C. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.6 QUALITY ASSURANCE

A. Topsoil Stripping and Stockpiling Program: Prepare a written program to systematically demonstrate the ability of personnel to properly follow procedures and handle materials and equipment during the Work. Include dimensioned diagrams for placement and protection of stockpiles.

1.7 FIELD CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Salvageable Improvements: Carefully remove items indicated to be salvaged and store on Owner's premises.

C. Utility Locator Service: Notify Pennsylvania One Call for area where Project is located before site clearing.

D. Do not commence site clearing operations until temporary erosion- and sedimentation-control measures are in place.

E. Tree- and Plant-Protection Zones: Protect according to requirements in Section 015639 "Temporary Tree and Plant Protection."

F. Soil Stripping, Handling, and Stockpiling: Perform only when the soil is dry or slightly moist.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 312000 "Earth Moving."

1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Verify that trees, shrubs, and other vegetation to remain or to be relocated have been flagged and that protection zones have been identified and enclosed according to requirements in Section 015639 "Temporary Tree and Plant Protection."

C. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction.

B. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

C. Remove erosion and sedimentation controls, and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION

A. Protect trees and plants remaining on-site according to requirements in Section 015639 "Temporary Tree and Plant Protection."

B. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations according to requirements in Section 015639 "Temporary Tree and Plant Protection."

3.4 EXISTING UTILITIES

A. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place.

1. Arrange with utility companies to shut off indicated utilities.

B. Locate, identify, and disconnect utilities indicated to be abandoned in place.

C. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others, unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Do not proceed with utility interruptions without Architect's written permission.

D. Removal of underground utilities is included in earthwork sections; in applicable fire suppression, plumbing, HVAC, electrical, communications, electronic safety and security, and utilities sections; and in Section 024116 "Structure Demolition" and Section 024119 "Selective Demolition."

3.5 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.

1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
2. Grind down stumps and remove roots larger than 2 inches in diameter, obstructions, and debris to a depth of 18 inches below exposed sub-grade.
3. Use only hand methods or air spade for grubbing within protection zones.
4. Chip removed tree branches and stockpile in areas approved by Architect.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches , and compact each layer to a density equal to adjacent original ground.

3.6 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to depth indicated on Drawings in a manner to prevent intermingling with underlying subsoil or other waste materials.

C. Stockpile topsoil away from edge of excavations without intermixing with subsoil or other materials. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.

1. Limit height of topsoil stockpiles to 72 inches .
2. Do not stockpile topsoil within protection zones.
3. Stockpile surplus topsoil to allow for respreading deeper topsoil.

3.7 STOCKPILING ROCK

A. Remove from construction area naturally formed rocks that measure more than 1 foot across in least dimension. Do not include excavated or crushed rock.

B. Stockpile rock where indicated on Drawings without intermixing with other materials. Cover to prevent windblown debris from accumulating among rocks.

1. Limit height of rock stockpiles to 36 inches .
2. Do not stockpile rock within protection zones.
3. Dispose of surplus rock. Surplus rock is that which exceeds quantity indicated to be stockpiled or reused.
   Stockpile surplus rock to allow later use by the Owner.

3.8 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.
2. Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that will remain exposed.

3.9 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

B. Separate recyclable materials produced during site clearing from other non recyclable materials. Store or stockpile without intermixing with other materials, and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 311000

SECTION 312000 - EARTH MOVING

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. Excavating and filling for rough grading the Site.
2. Preparing subgrades for walks, pavements and plants.
3. Excavating and backfilling for buildings and structures.
4. Drainage course for concrete slabs-on-grade.
5. Subbase course for concrete walks and pavements.
6. Subsurface drainage backfill for walls and trenches.
7. Excavating and backfilling trenches for utilities and pits for buried utility structures.

B. Related Requirements:

1. Section 013200 "Construction Progress Documentation"] [Section 013233 "Photographic Documentation" for recording pre-excavation and earth-moving progress.
2. Section 311000 "Site Clearing" for site stripping, grubbing, stripping topsoil, and removal of above- and below-grade improvements and utilities.
3. Section 315000 "Excavation Support and Protection" for shoring, bracing, and sheet piling of excavations.
4. Section 329200 "Turf and Grasses" for finish grading in turf and grass areas, including preparing and placing planting soil for turf areas.
5. Section 329300 "Plants" for finish grading in planting areas and tree and shrub pit excavation and planting.

1.3 UNIT PRICES

A. Work of this Section is affected by unit prices for earth moving specified in Section 012200 "Unit Prices."

B. Quantity allowances for earth moving are included in Section 012100 "Allowances."

C. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed the following. Unit prices for rock excavation include replacement with approved materials.

1. 24 inches outside of concrete forms other than at footings.
2. 12 inches outside of concrete forms at footings.
3. 6 inches outside of minimum required dimensions of concrete cast against grade.
4. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
5. 6 inches beneath bottom of concrete slabs-on-grade.
6. 6 inches beneath pipe in trenches, and the greater of 24 inches wider than pipe or 42 inches wide.

1.4 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

F. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
2. Bulk Excavation: Excavation more than [**10 feet**] in width and more than [**30 feet**] in length.
3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by Architect. Unauthorized excavation, as well as remedial work directed by Architect, shall be without additional compensation.

G. Fill: Soil materials used to raise existing grades.

H. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material 3/4 cu. yd. or more in volume that exceed a standard penetration resistance of 100 blows/2 inches when tested by a geotechnical testing agency, according to ASTM D1586.

I. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

J. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

K. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

L. Utilities: On-site underground pipes, conduits, ducts, and cables as well as underground services within buildings.

1.5 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Francis Meyers recreational Center 5800 Chester Ave. Philadelphia, PA 19143

1. Review methods and procedures related to earthmoving, including, but not limited to, the following:

    a. Personnel and equipment needed to make progress and avoid delays.
    b. Coordination of Work with utility locator service.
    c. Coordination of Work and equipment movement with the locations of tree- and plant-protection zones.
    d. Extent of trenching by hand or with air spade.
    e. Field quality control.

1.6 ACTION SUBMITTALS

A. Product Data: For each type of the following manufactured products required:

1. Geotextiles.
2. Controlled low-strength material, including design mixture.
3. Geofoam.
4. Warning tapes.

B. Samples for Verification: For the following products, in sizes indicated below:

1. Geotextile: 12 by 12 inches .
2. Warning Tape: 12 inches long; of each color.

1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:

1. Classification according to ASTM D2487.
2. Laboratory compaction curve according to ASTM D698

C. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earth-moving operations. Submit before earth moving begins.

1.8 QUALITY ASSURANCE

1.9 FIELD CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth-moving operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Improvements on Adjoining Property: Authority for performing earth moving indicated on property adjoining Owner's property will be obtained by Owner before award of Contract.

1. Do not proceed with work on adjoining property until directed by Architect.

C. Utility Locator Service: Notify Pennsylvania One Call for area where Project is located before beginning earth-moving operations.

D. Do not commence earth-moving operations until temporary site fencing and erosion- and sedimentation-control measures specified Section 311000 "Site Clearing are in place.

E. Do not commence earth-moving operations until plant-protection measures specified in Section 015639 "Temporary Tree and Plant Protection" are in place.

F. The following practices are prohibited within protection zones:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Foot traffic.
4. Erection of sheds or structures.
5. Impoundment of water.
6. Excavation or other digging unless otherwise indicated.
7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

G. Do not direct vehicle or equipment exhaust towards protection zones.

H. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D2487 or a combination of these groups; free of rock or gravel larger than [3 inches] in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D2487 or a combination of these groups.

1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Sub-base Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.

E. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 95 percent passing a 1-1/2-inch sieve and not more than 8 percent passing a No. 200 sieve.

F. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; with at least 90 percent passing a 1-1/2-inch sieve and not more than 12 percent passing a No. 200 sieve.

G. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D2940/D2940M; except with 100 percent passing a 1-inch sieve and not more than 8 percent passing a No. 200 sieve.

H. Drainage Course: Narrowly graded mixture of [**washed**]crushed stone, or crushed or uncrushed gravel; ASTM D448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch sieve and zero to 5 percent passing a No. 8 sieve.

I. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D448; coarse-aggregate grading Size 67; with 100 percent passing a 1-inch sieve and zero to 5 percent passing a No. 4 sieve.

J. Sand: ASTM C33/C33M; fine aggregate.

K. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

2.2 GEOTEXTILES

A. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Survivability: Class 2; AASHTO M 288.

2. Apparent Opening Size: No. 40 sieve, maximum; ASTM D4751.
3. Permittivity: 0.2 per second, minimum; ASTM D4491.
4. UV Stability: 50 percent after 500 hours' exposure; ASTM D4355.

2.3 CONTROLLED LOW-STRENGTH MATERIAL

A. Controlled Low-Strength Material: Self-compacting[**, low-density**], flowable concrete material produced from the following:

1. Portland Cement: ASTM C150/C150M, [**Type I**] [**Type II**] [**or**] [**Type III**].
2. Fly Ash: ASTM C618, Class C or F.
3. Normal-Weight Aggregate: ASTM C33/C33M, 3/4-inch nominal maximum aggregate size.
4. Water: ASTM C94/C94M.

B. Produce conventional-weight, controlled low-strength material with 80-psi compressive strength when tested according to ASTM C495/C495M.

2.4 GEOFOAM

A. Extruded-Polystyrene Board Insulation: ASTM C578, Type IV, 1.55-lb/cu. ft. density, 25-psi compressive strength

B. TM C578, Type I, 0.90-lb/cu. ft. density, 10-psi compressive strength

C. Rigid Cellular Polystyrene Geofoam: ASTM D6817, Type EPS 19, 1.15-lb/cu. ft. density, 5.8-psi compressive strength at 1 percent deformation; 16-psi compressive strength at 10 percent deformation

D. Connectors: [Geofoam manufacturer's multibarbed, galvanized-steel sheet connectors] [Deformed steel reinforcing bars, 3/4 inch in diameter].

2.5 ACCESSORIES

A. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored as follows:

1. Red: Electric.
2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth-moving operations.

B. Protect and maintain erosion and sedimentation controls during earth-moving operations.

C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

A. Provide dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.

B. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

C. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

D. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others.

3.3 EXPLOSIVES

A. Explosives: Do not use explosives.

3.4 EXCAVATION, GENERAL

A. Classified Excavation: Excavate to subgrade elevations. Material to be excavated will be classified as earth and rock. Do not excavate rock until it has been classified and cross sectioned by Architect. The Contract Sum will be adjusted for rock excavation according to unit prices included in the Contract Documents. Changes in the Contract Time may be authorized for rock excavation.

1. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; and soil, boulders, and other materials not classified as rock or unauthorized excavation.

a. Intermittent drilling; blasting, if permitted; ram hammering; or ripping of material not classified as rock excavation is earth excavation.

2. Rock excavation includes removal and disposal of rock. Remove rock to lines and subgrade elevations indicated to permit installation of permanent construction without exceeding the following dimensions:

a. 24 inches outside of concrete forms other than at footings.
b. 12 inches outside of concrete forms at footings.
c. 6 inches outside of minimum required dimensions of concrete cast against grade.
d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
e. 6 inches beneath bottom of concrete slabs-on-grade.
f. 6 inches beneath pipe in trenches and the greater of 24 inches wider than pipe or 42 inches wide.

3.5 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch . If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

B. Excavations at Edges of Tree- and Plant-Protection Zones:

1. Excavate by hand or with an air spade to indicated lines, cross sections, elevations, and subgrades. If excavating by hand, use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
2. Cut and protect roots according to requirements in Section 015639 "Temporary Tree and Plant Protection."

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.7 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit unless otherwise indicated.

1. Clearance: As indicated.

C. Trench Bottoms: Excavate trenches 4 inches deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.

1. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

D. Trenches in Tree- and Plant-Protection Zones:

1. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.
3. Cut and protect roots according to requirements in Section 015639 "Temporary Tree and Plant Protection."

3.8 EXCAVATION FOR ELEVATOR CYLINDER – N/A

3.9 SUBGRADE INSPECTION

A. Notify Architect when excavations have reached required subgrade.

B. If Architect determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

C. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices

D. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Architect, without additional compensation.

3.10 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of 2500 psi , may be used when approved by Architect.

1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by Architect.

3.11 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

B. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.12 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for Record Documents.
3. Testing and inspecting underground utilities.
4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring, bracing, and sheeting.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.13 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Trenches under Footings: Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Section 033000 "Cast-in-Place Concrete."

D. Trenches under Roadways: Provide 6-inch thick, concrete-base slab support for piping or conduit less than 30 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches Concrete is specified in Section 033000 "Cast-in-Place Concrete."

E. Backfill voids with satisfactory soil while removing shoring and bracing.

F. Initial Backfill:

1. Soil Backfill: Place and compact initial backfill of satisfactory soil, free of particles larger than 1 inch in any dimension, to a height of 12 inches over the pipe or conduit.

    a. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

2. Controlled Low-Strength Material: Place initial backfill of controlled low-strength material to a height of 12 inches over the pipe or conduit. Coordinate backfilling with utilities testing.

G. Final Backfill:

1. Soil Backfill: Place and compact final backfill of satisfactory soil to final subgrade elevation.

H. Warning Tape: Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.14 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows:

1. Under grass and planted areas, use satisfactory soil material.
2. Under walks and pavements, use satisfactory soil material.
3. Under steps and ramps, use engineered fill.
4. Under building slabs, use engineered fill..
5. Under footings and foundations, use engineered fill.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

3.15 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.16 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D698

1. Under structures, building slabs, steps, and pavements, scarify and recompact top 12 inches of existing subgrade and each layer of backfill or fill soil material at [95] percent.
2. Under walkways, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at [92] percent.
3. Under turf or unpaved areas, scarify and recompact top 6 inches below subgrade and compact each layer of backfill or fill soil material at [85] percent.
4. For utility trenches, compact each layer of initial and final backfill soil material at [85] percent.

3.17 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to elevations required to achieve indicated finish elevations, within the following subgrade tolerances:

1. Turf or Unpaved Areas: Plus or minus 1 inch
2. Walks: Plus or minus 1 inch
3. Pavements: Plus or minus 1/2 inch

C. Grading inside Building Lines: Finish subgrade to a tolerance of 1/2 inch when tested with a 10-foot straightedge.

3.18 SUBSURFACE DRAINAGE

A. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches of filter material, placed in compacted layers 6 inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches .

1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D698 with a minimum of two passes of a plate-type vibratory compactor.
2. Place and compact impervious fill over drainage backfill in 6-inch- thick compacted layers to final subgrade.

3.19 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

A. Place subbase course and base course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place subbase course and base course under pavements and walks as follows:
1. Shape subbase course[and base course] to required crown elevations and cross-slope grades.
2. Place subbase course[and base course] 6 inches or less in compacted thickness in a single layer.
3. Place subbase course[and base course] that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
4. Compact subbase course[and base course] at optimum moisture content to required grades, lines, cross sections, and thickness to not less than [95] percent of maximum dry unit weight according to[ASTM D698

3.20 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

A. Place drainage course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
1. Place drainage course 6 inches or less in compacted thickness in a single layer.
2. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D698.

3.21 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

B. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

C. Testing agency will test compaction of soils in place according to ASTM D1556, ASTM D2167, ASTM D2937, and ASTM D6938, as applicable. Tests will be performed at the following locations and frequencies:

1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 2000 sq. ft. or less of paved area or building slab but in no case fewer than three tests.
2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet (or less of wall length but no fewer than two tests.
3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length but no fewer than two tests.

D. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.22 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.

C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.23 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 312000

SECTION 312319 - DEWATERING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes construction dewatering.

B. Related Requirements:

1. Section 013233 "Photographic Documentation" for recording preexisting conditions and dewatering system progress.
2. Section 312000 "Earth Moving" for excavating, backfilling, site grading, and controlling surface-water runoff and ponding.

1.3 ALLOWANCES

A. Dewatering observation wells are part of dewatering allowance.

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Francis Meyers recreational Center, 5800 Chester Ave Philadelphia, PA 19143

1. Verify availability of Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
2. Review condition of site to be dewatered including coordination with temporary erosion-control measures and temporary controls and protections.
3. Review geotechnical report.
4. Review proposed site clearing and excavations.
5. Review existing utilities and subsurface conditions.
6. Review observation and monitoring of dewatering system.

1.5 ACTION SUBMITTALS

A. Shop Drawings: For dewatering system, prepared by or under the supervision of a qualified professional engineer.

1. Include plans, elevations, sections, and details.
2. Show arrangement, locations, and details of wells and well points; locations of risers, headers, filters, pumps, power units, and discharge lines; and means of discharge, control of sediment, and disposal of water.
3. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.
4. Include written plan for dewatering operations including sequence of well and well-point placement coordinated with excavation shoring and bracings and control procedures to be adopted if dewatering problems arise.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer, land surveyor and professional engineer.

B. Field quality-control reports.

C. Existing Conditions: Using photographs or video recordings, show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by dewatering operations. Submit before Work begins.

D. Record Drawings: Identify locations and depths of capped wells and well points and other abandoned-in-place dewatering equipment.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer that has specialized in design of dewatering systems and dewatering work.

1.8 FIELD CONDITIONS

A. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of a geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by a geotechnical engineer. Owner is not responsible for interpretations or conclusions drawn from this data.

1. Make additional test borings and conduct other exploratory operations necessary for dewatering according to the performance requirements.
2. The geotechnical report is referenced elsewhere in Project Manual.

B. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.

1. Design dewatering system, including comprehensive engineering analysis by a qualified professional engineer.
2. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, prevention of flooding in excavation, and prevention of damage to subgrades and permanent structures.
3. Prevent surface water from entering excavations by grading, dikes, or other means.
4. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.
5. Remove dewatering system when no longer required for construction.

B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with water- and debris-disposal regulations of authorities having jurisdiction.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.

1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site or surrounding area.
2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Provide temporary grading to facilitate dewatering and control of surface water.

D. Protect and maintain temporary erosion and sedimentation controls, which are specified in Section 311000 "Site Clearing," during dewatering operations.

3.2 INSTALLATION

A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.

1. Space well points or wells at intervals required to provide sufficient dewatering.
2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.

B. Place dewatering system into operation to lower water to specified levels before excavating below ground-water level.

C. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.

D. Provide standby equipment on-site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails.

3.3 OPERATION

A. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.

B. Operate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.

1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
2. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
3. Maintain piezometric water level a minimum of 24 inches below bottom of excavation.

C. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others.

D. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches below overlying construction.

3.4 FIELD QUALITY CONTROL

A. Observation Wells: Provide observation wells or piezometers, take measurements, and maintain at least the minimum number indicated; additional observation wells may be required by authorities having jurisdiction.

1. Observe and record daily elevation of ground water and piezometric water levels in observation wells.
2. Repair or replace, within 24 hours, observation wells that become inactive, damaged, or destroyed. In areas where observation wells are not functioning properly, suspend construction activities until reliable observations can be made. Add or remove water from observation-well risers to demonstrate that observation wells are functioning properly.
3. Fill observation wells, remove piezometers, and fill holes when dewatering is completed.

B. Survey-Work Benchmarks: Resurvey benchmarks regularly during dewatering and maintain an accurate log of surveyed elevations for comparison with original elevations. Promptly notify Architect if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

C. Provide continual observation to ensure that subsurface soils are not being removed by the dewatering operation.

D. Prepare reports of observations.

3.5 PROTECTION

A. Protect and maintain dewatering system during dewatering operations.

B. Promptly repair damages to adjacent facilities caused by dewatering.

END OF SECTION 312319

SECTION 315000 - EXCAVATION SUPPORT AND PROTECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes temporary excavation support and protection systems.

B. Related Requirements:

1. Section 013233 "Photographic Documentation" for recording preexisting conditions and excavation support and protection system progress.
2. Section 312000 "Earth Moving" for excavating and backfilling, for controlling surface-water runoff and ponding, and for dewatering excavations.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Francis Meyers recreational Center, 5800 Chester Ave Philadelphia, PA 19143

1. Review geotechnical report.
2. Review existing utilities and subsurface conditions.
3. Review coordination for interruption, shutoff, capping, and continuation of utility services.
4. Review proposed excavations.
5. Review proposed equipment.
6. Review monitoring of excavation support and protection system.
7. Review coordination with waterproofing.
8. Review abandonment or removal of excavation support and protection system.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, performance properties, and dimensions of individual components and profiles, and calculations for excavation support and protection system.

B. Delegated-Design Submittal: For excavation support and protection systems, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For the following:

1. Land surveyor.

B. Contractor Calculations: For excavation support and protection system. Include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

C. Existing Conditions: Using photographs and /or video recordings, show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by inadequate performance of excavation support and protection systems. Submit before Work begins.

1.6 CLOSEOUT SUBMITTALS

A. Record Drawings: Identify locations and depths of capped utilities, abandoned-in-place support and protection systems, and other subsurface structural, electrical, or mechanical conditions.

1.7 FIELD CONDITIONS

A. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks, and record existing elevations.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design excavation support and protection systems to resist all lateral loading and surcharge, including but not limited to, retained soil, groundwater pressure, adjacent building loads, adjacent traffic loads, construction traffic loads, material stockpile loads, and seismic loads, based on the following:

1. Compliance with OSHA Standards and interpretations, 29 CFR 1926, Subpart P.
2. Compliance with AASHTO Standard Specification for Highway Bridges or AASHTO LRFD Bridge Design Specification, Customary U.S. Units.
3. Compliance with requirements of authorities having jurisdiction.
4. Compliance with utility company requirements.
5. Compliance with railroad requirements.

2.2 MATERIALS

A. Provide materials that are either new or in serviceable condition.

B. Structural Steel: ASTM A36/A36M, ASTM A690/A690M, or ASTM A992/A992M.

C. Steel Sheet Piling: ASTM A328/A328M, ASTM A572/A572M, or ASTM A690/A690M; with continuous interlocks.

1. Corners: Site-fabricated mechanical interlock

D. Wood Lagging: Lumber, mixed hardwood, nominal rough thickness of 3 inches (75 mm)

E. Shotcrete: Comply with Section 033713 "Shotcrete" for shotcrete materials and mixes, reinforcement, and shotcrete application.

F. Reinforcing Bars: ASTM A615/A615M, Grade 60 (Grade 420), deformed.

G. Tiebacks: Steel bars, ASTM A722/A722M.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.

1. Shore, support, and protect utilities encountered.

3.2 INSTALLATION - GENERAL

A. Locate excavation support and protection systems clear of permanent construction, so that construction and finishing of other work is not impeded.

B. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

C. Install excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to excavation.

3.3 SOLDIER PILES AND LAGGING

A. Install steel soldier piles before starting excavation.

1. Extend soldier piles below excavation grade level to depths adequate to prevent lateral movement.
2. Space soldier piles at regular intervals not to exceed allowable flexural strength of wood lagging.
3. Accurately align exposed faces of flanges to vary not more than[2 inches (50 mm) from a horizontal line and not more than 1:120 out of vertical alignment

B. Install wood lagging within flanges of soldier piles as excavation proceeds.

1. Trim excavation as required to install lagging.
2. Fill voids behind lagging with soil, and compact.

C. Install wales horizontally at locations indicated on Drawings and secure to soldier piles.

3.4 SHEET PILING

A. Before starting excavation, install one-piece sheet piling lengths and tightly interlock vertical edges to form a continuous barrier.

B. Accurately place the piling using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer.

1. Limit vertical offset of adjacent sheet piling to 60 inches (1500 mm).
2. Accurately align exposed faces of sheet piling to vary not more than 2 inches (50 mm) from a horizontal line and not more than 1:120 out of vertical alignment

C. to uniform elevation at top of excavation.

3.5 TIEBACKS

A. Drill, install, grout, and tension tiebacks.

B. Test load-carrying capacity of each tieback, and replace and retest deficient tiebacks.

1. Have test loading observed by a qualified professional engineer responsible for design of excavation support and protection system.

C. Maintain tiebacks in place until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.6 BRACING

A. Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.

1. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by Architect.
2. Install internal bracing if required to prevent spreading or distortion of braced frames.
3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

3.7 MAINTENANCE

A. Monitor and maintain excavation support and protection system.

B. Prevent surface water from entering excavations by grading, dikes, or other means.

C. Continuously monitor vibrations, settlements, and movements to ensure stability of excavations and constructed slopes and to ensure that damage to permanent structures is prevented.

3.8 FIELD QUALITY CONTROL

A. Survey-Work Benchmarks: Resurvey benchmarks daily during installation of excavation support and protection systems, excavation progress, and for as long as excavation remains open.

1. Maintain an accurate log of surveyed elevations and positions for comparison with original elevations and positions.
2. Promptly notify Architect if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

B. Promptly correct detected bulges, breakage, or other evidence of movement to ensure that excavation support and protection system remains stable.

C. Promptly repair damages to adjacent facilities caused by installation or faulty performance of excavation support and protection systems.

3.9 REMOVAL AND REPAIRS

1. Remove excavation support and protection systems to a minimum depth of 48 inches 1200 mm below overlying construction, and abandon remainder.
2. Fill voids immediately with approved backfill compacted to density specified in Section 312000 "Earth Moving."
3. Repair or replace, as approved by Architect, adjacent work damaged or displaced by removing excavation support and protection systems.

END OF SECTION 315000

SECTION 321216 – ASPHALT PAVING

1.1 Asphalt paving sections shall be designed to withstand the use and traffic conditions they will be subjected to as well as the local soil conditions the pavements will be placed upon.

1.2 Asphalt paving shall conform to the following minimum standards:

A. Walkways and Trails:

1. Minimum Asphalt Thickness: 3.5 inches total thickness in two (2) layers/lifts:

a. Wearing Course: 1.5 inches thick PennDOT ID-2 Wearing meeting PennDOT Pub 408

b. Binder Course: 2 inches thick PennDOT ID-2 Binder meeting PennDOT Pub 408

2. Minimum Stone Base: 6” compacted gravel base (PennDOT 2A modified or approved equal).

3. Subgrade: Compacted and un-yielding to 95% minimum Standard Proctor ASTM D698

B. Drive Aisles and Parking Areas:

1. Minimum Asphalt Thickness: 4 inches total thickness in two (2) layers/lifts:

a. Wearing Course: 1.5 inches thick PennDOT ID-2 Wearing meeting PennDOT Pub 408

b. Binder Course: 2.5 inches thick PennDOT ID-2 Binder meeting PennDOT Pub 408

2. Minimum Stone Base: 6” compacted gravel base (PennDOT 2A modified or approved equal)

3. Subgrade: Compacted and un-yielding to 95% minimum ASTM D698 Standard Proctor

C. Asphalt Sports Courts:

1. Minimum Asphalt Thickness: 4 inches total thickness in two (2) layers/lifts:

a. Wearing Course: 1.5 inches thick PennDOT ID-2 ¼” gradation wearing meeting PennDOT Pub 408

b. Binder Course = 2.5 inches thick PennDOT ID-2 Binder meeting PennDOT Pub 408

2. Minimum Stone Base: 6” compacted gravel base (PennDOT 2A modified or approved equal)

3. Subgrade: Compacted and un-yielding to 95% minimum ASTM D698 Standard Proctor

D. Porous/Pervious Asphalt: Porous/pervious asphalt paving is not approved for use unless otherwise approved Philadelphia Parks and Recreation.

END OF SECTION 321216

SECTION 321313 – PLAIN CEMENT CONCRETE PAVING

1.1 Concrete paving shall conform to the following minimum standards:

A. Minimum Strength: 4,000 psi at 28 days.

B. Provide sealed/caulked expansion joints.

C. Provide control joints at a spacing as required to prevent cracking within panels.

D. Finish shall be non-slip broom type finish.

E. Joints shall be tooled prior to broom finishing to eliminate “window pane” appearance. Sawcut joints are not preferred. If designer/contractor wishes to utilize sawcut joints prior approval shall be obtained from Philadelphia Parks and Recreation.

F. Concrete paving shall conform to the flowing standards:

1. ACI 117 – Specification for Tolerance for Concrete Construction and Materials

2. ACI 318 – Building Code Requirements for Reinforced Concrete

3. PennDOT 408 – Construction Specifications

4. PennDOT RC-67M – Curb Ramp and Sidewalk Construction Details

G. Concrete shall contain either a water-reducing, plasticizing admixture or a high-range water-reducing admixture. All concrete shall contain an air-entraining admixture to provide 5%-7% air entrainment. Maximum chloride content shall be 0.15%. Maximum water/cement ratio shall be 0.45. Maximum design slump of 3 inches without super plasticizers. Aggregate size shall be 3/4 of an inch with a designation of 4S per ASTM C33.

H. Reinforcing: PPR prefers most pavements be unreinforced to facilitate future repairs and/or replacements. In some cases, reinforcing is required either by site conditions or by design requirements such as some sprayground elements require reinforcing. If reinforcing is provided if shall meet the following:

1. Welded wire fabric shall be galvanized and comply with ASTM A185.

2. Reinforcing steel bars shall be grade 60 per ASTM A615.

SECTION 321316 – DECORATIVE/COLORED CONCRETE PAVING

1.1 Decorative/colored concrete paving shall conform to the following minimum standards:

A. Comply with the requirements and specifications as set forth in Section 321313 Plain Cement Concrete Paving.

B. Decorative/colored concrete paving use should be limited and not utilized extensively as it can be challenging to replace if it needs to be repaired or replaced.

C. Stamped and surface colored concrete paving is not preferred. If designer/contractor wishes to utilize stamped and surface colored concrete paving prior approval shall be obtained from Philadelphia Parks and Recreation.

D. If decorative/colored concrete is to be used it should be integrally colored with coloring agent(s) combined as an add mixture into the concrete mix prior to pouring. Color shall be through the entire slab thickness and not added on top.

E. Approved coloring agent manufacturers:

1. Sika Scofield - 4155 Scofield Road, Douglasville, GA 30134, Phone: (800) 800-9900, Web: http://www.scofield.com

    a. CHROMIX Admixture for color conditioned concrete

2. Davis Colors - 3700 East Olympic Blvd., Los Angeles, CA 90023, Phone: (844) 341-4780, Web: www.daviscolors.com

    a. MIX-READY Pigments

3. Equal approved Philadelphia Parks and Recreation.

F. Approved Colors: Selected colors for decorative/colored concrete shall be from manufacturer's standard color lines. Custom or specialized colors are not preferred.

G. Colored concrete admixtures shall comply with ASTM C 979.

H. Installer Qualifications: Installer must have a minimum of 5 similar jobs completed and a minimum of 5 years prior experience installing decorative/colored concrete.

END OF SECTION 321316

SECTION 321400 - SITE STONE MASONRY

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 SECTION INCLUDES

A. Stone coping at sprayground wall. –ALTERNATE 4

B. Salvaged stone wall at sprayground wall. Stone material salvaged from existing stone wall. –ALT 4

C. Repair Existing Perimeter Site Stone Wall and Pier Capstone.

1.3 RELATED REQUIREMENTS

A. Section 32 13 14 – Site Concrete.

1.4 REFERENCE STANDARDS

A. American Society for Testing and Materials:
   1. ASTM A666 - Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.

1.5 PERFORMANCE REQUIREMENTS

A. American Society for Testing and Materials:
   1. Design anchor attachment to stone with a factor of safety of 5:1

1.6 SUBMITTALS

A. Product Data: For each type of product indicated including, but not limited to:
   1. Cementitious materials. Include brand, type, and name of manufacturer.
   2. Setting bed mortar mixes. Include description of type and proportions of ingredients.
   3. Joint sealants and backer rods.
   4. Anchors, clips, dowels, pins and other metal accessories.
   5. Shims and setting buttons; plastic or nylon.

B. Samples for Initial Selection
   1. For colored sealant, jointing materials and other items involving color selection. Include sample of manufacturers full range of standard colors.

C. Samples for Initial Selection

1. Stone wall coping:
    a. Submit one sample of coping and finish; 12-inch length x 15-inch width x 4-inch depth, for each finish type specified, illustrating general color range and texture, markings, and surface finish exhibiting extremes of the full range of visual characteristics expected in completed work.
2. Submit one sample for each type of attachment hardware to be used including anchors and shims.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified installer who employs experienced stonemasons and stone fitters.

B. Source Limitations for Stone: Obtain each variety of stone, regardless of finish, from one quarry with resources to provide materials of consistent quality in appearance and physical properties.

C. Source Limitations for Mortar Materials: Obtain mortar ingredients of a uniform quality, including color for exposed masonry, from single manufacturer for each cementitious component and from single source or producer for each aggregate.

D. Mockups: Build mockups to demonstrate aesthetic effects and set quality standards for materials and execution.
1. Locations of mockups to be submitted for approval by Landscape Architect. Preferred mockup location for veneered wall, stairs, and curbs to be adjoining to evaluate intersections and connections of stonework and associated concrete backup.
2. Build mockups for each type of stone masonry including, but not limited to,
    a. Stone wall including coping: Full wall height by three (3) coping widths per Drawings. Provide jointing mockups as required. Include full vertical joint and full horizontal joint including grout and sealant with backer rod in mockup. More than one and grout sealant color may be requested. Consult Landscape Architect prior to constructing mockup.
3. Protect accepted mockups from the elements with weather-resistant membrane.
4. Approval of mockups is for color, texture, and blending of stone; relationship of sealant or grout color to stone color; tooling of joints; and aesthetic qualities of workmanship.
    a. Jointing grout and sealant shall be fully cured prior to review for accurate color representation.
    b. Approval of mockups is also for other material and construction qualities Landscape Architect specifically approves in writing.
    c. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Landscape Architect specifically approves such deviations in writing.
5. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Store masonry units on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied. If units become wet, do not install until they are dry.

B. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

C. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

D. Deliver preblended, dry mortar mix in moisture-resistant containers designed for lifting and emptying into dispensing silo. Store preblended, dry mortar mix in delivery containers on elevated platforms, under cover, and in a dry location or in a metal dispensing silo with weatherproof cover.

E. Store masonry accessories, including metal items, to prevent corrosion and accumulation of dirt and oil.

1.9 PROJECT CONDITIONS

A. Protection of Stone Masonry: Cover partially completed stone masonry when construction is not in progress to protect from inclement weather.

B. Stain Prevention: Immediately remove mortar and soil to prevent them from staining the exposed surfaces of stone masonry.
   1. Protect base of walls from rain-splashed mud and mortar splatter by coverings spread on the ground and over the wall surface.
   2. Protect all exposed surfaces from mortar droppings, including adjacent constructions such as exposed aggregate concrete pavement or any other adjacent surface.

C. Cold-Weather Requirements: Do not use frozen materials or materials mixed or coated with ice or frost. Do not build on frozen substrates. Remove and replace stone masonry damaged by frost or freezing conditions. Comply with cold-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602.
   1. Cold-Weather Cleaning: Use liquid cleaning methods only when air temperature is 40 deg F and above and will remain so until masonry has dried, but not less than 7 days after completing cleaning. Protect all exposed surfaces from mortar droppings, including adjacent constructions such as exposed aggregate concrete pavement or any other adjacent surface.

D. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 60

1.10 COORDINATION

A. Advise installers of other work about specific requirements for placement of reinforcement, veneer anchors, and similar items to be built into stone masonry.

B. Verify field measurements prior to fabrication. Notify Landscape Architect of any discrepancies prior to fabrication.

1.11 WARRANTY

A. Unless stated otherwise in these Specifications, warranty shall state that all work is in accord with drawings and Specifications, as amended by any changes thereto authorized by the Landscape Architect, free from defects in materials and workmanship for a period of five (5) years from date of acceptance of the work by the Owner or failure of system to meet performance requirements. Contractor shall agree to repair or replace defective materials and workmanship during the guarantee period at no additional cost to the Owner.

1. Defective materials and workmanship are hereby defined to include evidence of abnormal deterioration, aging, structural failure of components resulting from exposure to normal load and forces, failure of operating parts to function normally, sealant failures, deterioration or discoloration of finishes in excess of normal aging, and failure to fulfill other specified performance.

PART 2 - PRODUCTS

2.1 STONE COPING

A. Defective Material: Referenced standards may allow a certain percentage of units to contain chips, cracks, or other defects exceeding limits stated in the standard. Do not use units where such defects will be exposed in the completed Work.

B. Grade A sound bluestone, free from laminations and open reeds. Size as shown on Drawings.

C. Products: Subject to compliance with requirements, provide the following:
   1. Finish/Color:
      a. Wall Coping: Thermal top, Thermal Front Edge, Sawn all other non-exposed surfaces. Color to be blue/gray range.
   2. Dimensions: per Drawings.

D. Cut stone from one block or contiguous, match blocks in which natural markings occur.

E. Match Architect's samples for color, finish, and other stone characteristics relating to aesthetic effects.

2.2 SALVAGED STONE

A. Defective Material: Referenced standards may allow a certain percentage of units to contain chips, cracks, or other defects exceeding limits stated in the standard. Do not use units where such defects will be exposed in the completed Work.

B. Salvaged stone – clean sufficiently for installation in new wall.

C. Products: Subject to compliance with requirements, provide the following:
   1. Finish/Color:
      a. Salvaged Stone: Stone is irregular and varies in dimensions. Contractor to hand tool stone to approximate dimensions required.
   2. Dimensions: per Drawings.

2.3 AGGREGATE MATERIALS

A. Graded Aggregate for foundation Subbase: Sound, crushed stone or gravel complying with requirements in Section 31 20 00 "Earthwork" for subbase material.

B. Aggregate Base Course for paving: Penn DOT No. 2A coarse aggregate; pit run, natural stone, free of shale, clay, friable material, sand, and debris; graded in accordance with ASTM C136.

2.4 MORTAR MATERIALS

A. Regional Materials: Provide aggregate for mortar and grout, cement, and lime that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles of Project site.

B. Portland Cement: ASTM C 150, Type I or II, except Type III may be used for cold-weather construction. Provide natural color or white cement as required to produce mortar color indicated.

C. Hydrated Lime: ASTM C 207, Type S.

D. Aggregate for Mortar: ASTM C 144.
   1. Colored-Mortar Aggregates: Natural sand or crushed stone of color necessary to produce required mortar color.

E. Mortar Pigments: Natural and synthetic iron oxides. Use pigments with a record of satisfactory performance in mortar. Pigments shall contain no carbon black.

F. Cold-Weather Admixture: Nonchloride, noncorrosive, accelerating admixture complying with ASTM C 494/C 494M, Type C, and recommended by manufacturer for use in masonry mortar of composition indicated.

2.5 MORTAR MIXES

A. General: Do not add mixtures including coloring pigments, air-entraining agents, accelerators, retarders, water repellent agents, anti-freeze compounds, or calcium chloride, unless otherwise indicated or previously approved by Landscape Architect.

B. Preblended, Dry Mortar Mix: Furnish dry mortar ingredients in form of a preblended mix. Measure quantities by weight to ensure accurate proportions, and thoroughly blend ingredients before delivering to Project site.

C. Mortar for Unit Masonry: Comply with ASTM C 270, Proportion Specification. Provide Type N unless another type is indicated.

D. Water: Potable, clean and free from deleterious acids, alkalies, and organic matter.

E. Mixing: Combine and thoroughly mix pre-blended dry materials to water in a mechanical batch mixer; comply with ASTM C270 proportion specification and manufacturer's instructions for mixing time and water content, unless otherwise indicated.

2.6 GROUT MATERIALS

A. Regional Materials: Provide aggregate and cement for grout that has been extracted, harvested, or recovered, as well as manufactured, within 500 miles of Project site.

B. Preblended, Dry Grout Mix: ANSI A108.10, furnish dry mortar ingredients in form of a preblended mix. Measure quantities by weight to ensure accurate proportions, and thoroughly blend ingredients before delivering to Project site.
   1. Produce required mortar color by using colored aggregates and natural color or white cement as necessary to produce required mortar color. Formulate blend as required to produce color to match sample jointing color and texture as selected during Action Submittals and Mockup.

2. Colored Mortar Pigments for Grout: Natural and synthetic iron and chromium oxides, compounded for use in mortar and grout mixes. Use only pigments that have proved, through testing and experience, to be satisfactory for use in portland cement grout.
3. Application: Use colored aggregate mortar for exposed grout joints with the following units:
   a. Face schist.
   b. Stone capstones.

C. Standard Cement Grout: ANSI A118.6, sanded.

D. Water: Potable.

2.7 ANCHORS AND FASTENERS

A. Anchor Material: Stainless steel, ASTM A 666, Type 304. Equal to Hohman & Bernard Inc.; Adjustable Anchor System for Rubble Stone.
1. Sizes and configurations: As required for vertical and horizontal support of stone and applicable loads.

B. Dowels and Pins Material: Stainless steel, ASTM A 276, Type 304

2.8 MISCELLANEOUS MASONRY ACCESSORIES

A. Backer Rod for Sealant Joints: Flexible, closed cell, non-gassing, polyethylene, rope-like joint backing material of appropriate diameter for specified joint size as indicated on the Drawings to resist pressure during sealant tooling. Backer rod shall not stain or adhere to sealant materials and shall be fully compatible with sealant compounds.

B. Sealant for Joints: In compliance with manufacturers instructions, provide Sonneborn Sonolastic NP 2, or approved comparable product. Landscape Architect shall select color from the full range of standard colors.

C. Weep/Vent Products: Use the following unless otherwise indicated:
1. Round Plastic Weep/Vent Tubing: Medium-density polyethylene, 3/8-inch OD by length required to extend from exterior face of stone to cavity behind.

D. Setting Shims: Plastic or vulcanized neoprene.

E. Setting Buttons: Resilient plastic buttons.

2.9 FABRICATION

A. Fabricate stone to comply with sizes, shapes, and tolerances recommended by applicable stone association or, if none, by stone source, for faces, edges, beds, and backs.
1. For granite, comply with recommendations in NBGQA's "Specifications for Architectural Granite."

B. Cut stone to produce pieces of thickness, size, and shape indicated, including details on Drawings. Dress joints (bed and vertical) straight and at right angle to face unless otherwise indicated.

C. Cut and drill slots, sinkages and holes in stone for anchors and supports.

D. Carefully inspect stone at salvage yard, supplier, quarry or fabrication plant for compliance with requirements for appearance, material, and fabrication. Replace defective units before shipment.
   1. Clean sawed backs of stone to remove rust stains and iron particles.

E. Thickness of Stone: Provide thickness indicated on Drawings.

F. Finish exposed faces and edges of stone to comply with requirements indicated for finish and to match approved samples and mockups as specified herein or as indicated otherwise on the Drawings.

G. Arrises: Remove the sharp edge from arrises to slightly blunt edge and to reduce chipping of the finished edge.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces indicated to receive stone masonry, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine substrate to verify that dovetail slots, inserts, reinforcement, veneer anchors, flashing, and other items installed in substrates and required for or extending into stone masonry are correctly installed.

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

D. Beginning installation means acceptance of existing conditions.

3.2 PREPARATION

A. Clean dirty or stained stone surfaces by removing soil, stains, and foreign materials before setting. Clean stone by thoroughly scrubbing with fiber brushes and then drenching with clear water. Use only mild cleaning compounds that contain no caustic or harsh materials or abrasives.

3.3 SETTING OF STONE MASONRY, GENERAL

A. Perform necessary field cutting and trimming as stone is set. Do not trim exposed ends or faces. Cuts shall be made a joints or hidden surfaces
   1. Use power saws to cut stone that is fabricated with saw-cut surfaces. Cut lines straight and true, with edges eased slightly to prevent snipping

B. Sort stone before it is placed to remove stone that does not comply with requirements relating to aesthetic effects, physical properties, or fabrication, or that is otherwise unsuitable for intended use.

C. Arrange stones as indicated on Drawings.

D. Set stone to comply with requirements indicated on Drawings. Install supports, fasteners, and other attachments indicated or necessary to secure stone masonry in place. Set stone accurately in locations indicated with edges and faces aligned according to established relationships and indicated tolerances.

E. Maintain uniform joint widths except for variations due to different stone sizes and where minor variations are required to maintain bond alignment if any. Set walls with joints not less than 1/4 inch at narrowest points or more than 1/2 inch at widest points.

F. Provide sealant joints of widths and at locations indicated.
   1. Keep sealant joints free of mortar and other rigid materials.

G. Place weep holes in joints where moisture may accumulate.
   1. Use specified product herein to form weep holes.
   2. Space weep holes as indicated on Drawings.

3.4 CONSTRUCTION TOLERANCES

A. Variation from Plumb: For vertical lines and surfaces, do not exceed 1/4 inch in 10 feet or more.

B. Variation from Level: For joints and lines of coping, horizontal grooves, and other conspicuous lines, do not exceed 1/4 inch in 20 feet or more.

C. Measure variation from level, plumb, and position shown in plan as variation of the average plane of the face of each stone from level, plumb, or dimensioned plane.

D. Variation in Mortar-Joint Thickness: Do not vary from joint size range indicated.

E. Variation in Plane between Adjacent Rough Stones: Do not exceed one-half of tolerance specified for thickness of stone.

3.5 INSTALLATION OF ANCHORED STONE MASONRY

A. Set stone in full bed of mortar unless otherwise indicated. Build anchors into mortar joints as stone is set.

B. Provide 1-inch minimum cavity between stone masonry and backup construction unless otherwise indicated. Keep cavity free of mortar droppings and debris.
   1. Place mortar spots in cavity at veneer anchors to maintain spacing.
   2. Slope beds toward cavity to minimize mortar protrusions into cavity.
   3. Do not attempt to trowel or remove mortar fins protruding into cavity.

C. Rake out joints for sealant to depth of not less than dimension indicated on Drawings before setting mortar has hardened. Rake joints to uniform depths with square bottoms and clean sides.

3.6 ERECTION TOLERANCES

A. Variation in Line: Do not exceed 1/8 inch in 96 inches.

B. Variation in Joint Width: Do not vary joint thickness more than 1/16 inch or 1/4 inch of nominal joint width, whichever is less.

C. Variation in Surface Plane: Do not exceed 1/8 inch in 10 feet maximum from level or slope Variation in Plane between Adjacent Units: Do not exceed 1/32-inch difference between planes of adjacent units.

3.7 WALL JOINTING

A. Prepare joint surfaces for sealant by removing mortar from joint before it sets and brush clean dust and mortar particles from joint prior to application of sealant.

B. Tape-off stone-joint to protect the adjacent surface from contact with the sealant and to create a crisp line. Tool joints, with a smooth jointing tool to produce a concave joint profile set just below the face of stone.

3.8 ADJUSTING AND CLEANING

A. Remove and replace stone masonry of the following description:
   1. Broken, chipped, stained, or otherwise damaged stone. Stone may be repaired if methods and results are approved by Landscape Architect.
   2. Defective joints.
   3. Stone masonry not matching approved samples and mockups.
   4. Stone masonry not complying with other requirements indicated.

B. Replace in a manner that results in stone masonry matching approved samples and mockups, complying with other requirements, and showing no evidence of replacement

C. In-Progress Cleaning: Clean stone masonry as work progresses. Remove mortar fins and smears and sealant before tooling joints.

D. Final Cleaning: After mortar is thoroughly set and cured, clean stone masonry as follows:
   1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.
   2. Test cleaning methods on mockup; leave one-half of panel uncleaned for comparison purposes. Obtain Landscape Architect's approval of sample cleaning before cleaning stone masonry
   3. Clean stone masonry by bucket and brush hand-cleaning method described in BIA Technical Note No. 20 Revised II, using job-mixed detergent solution.

3.4 PROTECTION OF FINISHED WORK

A. Do not permit construction traffic over unprotected paver surface.

3.5 CLEAN UP

A. Maintain the site in an orderly condition during the progress of work. Promptly remove debris and trash. Leave the site in a neat, orderly condition, broom clean.

END OF SECTION

SECTION 321600 – CURBS AND GUTTERS

PART 1 GENERAL

1.1 SUMMARY

A. Provide curbs and gutters.

1.2 SUBMITTALS

A. Product Data: Submit manufacturer's product data and installation instructions for each material and product used.

B. Test Reports: Submit for approval test reports.

1.3 QUALITY ASSURANCE

A. Comply with governing codes and regulations. Provide products of acceptable manufacturers, which have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

B. Construction Tolerance: 1/8' in 10' for grade and alignment; 1/4' in 10' for vertical or sloped face on longitudinal axis.

C. Mock-Ups: Provide mock-up as required to demonstrate quality of workmanship.

PART 2 PRODUCTS

2.1 MATERIALS

A. Precast Concrete Curbs and Gutters:
1. Manufacturers: Refer towww.arcat.com/divs/sec/sec/02770.html
2. Application: Roadway curbs and gutters.
3. Concrete: Portland Cement; normal weight aggregates; potable water.
4. Design Mix: 4000 psi, 28 day minimum compressive strength.
5. Finish: Smooth form finish.
6. Reinforcing Bars: Deformed steel bars.
7. Joint Dowel Bars: Plain steel bars.

B. Granite Curbs and Gutters:
1. Manufacturers: Refer towww.arcat.com/divs/sec/sec/02770.html
2. Vertical Granite Curb: Sawed top and smooth quarry split face.
3. Sloped Granite Curb: Smooth quarry split face.

PART 3 EXECUTION

3.1 INSTALLATION

A. Provide acceptable materials and install curbing in strict compliance with local DOT and City of Philadelphia Streets Department Standard Specifications.

B. Set curbs on compacted gravel subbase with joints between curb pieces from 1/8' to 3/4' wide. Point joints with mortar and tool concave; remove surplus mortar and clean curbs.

END OF SECTION 321600

SECTION 321816 - PLAYGROUND PROTECTIVE SURFACING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Bonded poured-in-place rubber seamless surface.

B. Related Sections:

1. Section 312000 "Earth Moving" for filling and grading and for drainage course drainage/separation geotextiles and subbase courses.

1.3 DEFINITIONS

A. Critical Height: Standard measure of shock attenuation. According to CPSC No. 325, this means "the fall height below which a life-threatening head injury would not be expected to occur."

B. SBR: Styrene-butadiene rubber.

1.4 PERFORMANCE REQUIREMENTS

A. Impact Attenuation: According to ASTM F 1292.

B. Accessibility of Surface Systems: According to ASTM F 1951.

C. US Consumer Product Safety Commission – Public Playground Safety Handbook No. 325.

D. ASTM F2479 – Standard Guide for Specification, Purchase, Installation and Maintenance of Pured-In-Place Playground Surfacing.

E. ASTM F2223 – Standard Guide for ASTM Standards on Playground Surfacing.

1.5 SUBMITTALS

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

B. Samples for verification: For each type of playground surface system indicated.
   1. Minimum 6-by-6-inch Sample of safety pad.
   2. Minimum 6-by-6-inch Sample of geotextile.

C. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

   1. Extent of surface systems and use zones for equipment.
   2. Critical heights for playground surfaces and fall heights for equipment.

D. Qualification Data and Certification: For qualified Installer.

E. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for each unitary synthetic playground surface system.
   1. Impact/drop test per the requirements of ASTM F1292 to show conformance with the G-Max and HIC criteria listed above. Per ASTM F1292 the impact/drop test shall be performed at the most adverse location on the playground. The impact/drop test shall be conducted by a Certtified Playground Safety Inspector (CPSI) who will prepare a certification report of the results. If the surface fails to meet the stated criteria the surface shall be corrected/removed and reinstalled.

F. Field quality-control reports.

G. Closeout Submittals - Warranty: Sample of special warranty.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: A company specializing in the manufacture of products specified in this Section with minimum of three (3) years experience

B. Installer Qualifications: Contractor shall have had experience with at least two (2) other projects of similar scope and complexity and shall perform work with personnel totally familiar with playground safety surface installation and construction techniques under the supervision of an experienced foreperson.

C. Source Limitations: Obtain playground surface system materials from single source from single manufacturer.

D. Provide secondary materials including geotextiles and repair materials of type and from source recommended by manufacturer of playground surface system materials.

E. Standards and Guidelines: Comply with CPSC No. 325, "Handbook for Public Playground Safety"; ASTM F 1292; and ASTM F 1487.

1.7 PROJECT CONDITIONS

A. Verify existing conditions in the field prior to start of work. Should Contractor, in the course of work, find any discrepancies between Drawings and physical conditions or any omissions or errors in Drawings, inform Owner immediately in writing for clarification. Work done after such discovery, unless authorized by Owner, shall be at Contractor's risk.

B. Environmental Requirements: Install surfacing system when minimum ambient temperature is 40 degrees F (1 degree C) and maximum ambient temperature is 90 degrees F (32 degrees C). Do not install in steady or heavy rain.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of playground surface system that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Reduction in impact attenuation.
b. Deterioration of surface and other materials beyond normal weathering.
c. Deterioration or failure of seams.

2. Warranty Period: Five years from date of Substantial Completion.

B. Proper drainage is critical to the longevity of the Poured-in-Place surfacing system. Inadequate drainage will cause premature breakdown of the poured system in affected areas; and void the warranty.

PART 2 - PRODUCTS

2.1 POURED-IN-PLACE PLAYGROUND SURFACING SYSTEM

A. Manufacturer: Surface America, Inc., PO Box 157, Williamsville, NY 14231, (716) 632-8413, or Safety Turf, Inc., 201 North 4th Avenue, P.O. Box 908, Royersford, PA 19468, (610) 792-0967, info@safetyturf.com, or Safety Turf, Inc., 201 North 4th Avenue, P.O. Box 908, Royersford, PA 19468, (610) 792-0967, info@safetyturf.com, or approved equal.

B. Product: Poured-in-place playground surfacing system as per Manufacturer - Surface America Proprietary Products/Systems, including the following:
1. PlayBound Poured-In-Place Primer:
a. Material: Urethane.
2. PlayBound Poured-in-Place Basemat:
a. Material: Blend of 100% recycled SBR (styrene butadiene rubber) and urethane.
b. Thickness: **To be coordinated and determined by fall height of play equipment.**
c. Formulation Components: Blend of strand and granular material.
3. PlayBound Poured-In-Place Top Surface:
a. Material: Blend of recycled EPDM (ethylene propylene diene monomer) rubber and aliphatic urethane binder.
b. Thickness: 1/2" (12.7 mm) minimum, thicken to 3/4” under swings, ends of slides, play equipment entrances/exits, and areas where there will be increased foot traffic such as around spinning play equipment.
c. Color A: 33% Teal, 33% Royal Blue, 33% Light Gray
d. Color B: 33% Bright Green, 33% Hunter Green, 33% Light Gray
e. Dry Static Coefficient of Friction (ASTM D2047): 1.0.
f. Wet Static Coefficient of Friction (ASTM D2047): 0.9.

g. Dry Skid Resistance (ASTM E303): 89.
h. Wet Skid Resistance (ASTM E303): 57.

4. Crushed Stone Base as per Manufacturer recommendations.
   a. The stone for the base must be compacted to a 95% Standard Proctor Compaction (as per A.S.T.M. Test). The stones shall be 2B (clean) stone that is spread and compacted to a flat surface leaving the thickness required safety surface below finish level.
5. Mixes
   a. Required mix proportions by weight:
      1) Basemat: 16+% urethane (as ratio: 14% urethane divided by 86% rubber). 14% urethane, 86% rubber (based on entire rubber & urethane mix).
      2) Top Surface: 22% urethane (ratio: 18% urethane divided by 82% rubber). 18% urethane, 82% rubber (based on entire rubber & urethane mix).

2.2 GEOSYNTHETICS

A. Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Survivability: Class 2; AASHTO M 288.
2. Apparent Opening Size: No. 40 sieve, maximum; ASTM D 4751.
3. Permittivity: 0.5 per second, minimum; ASTM D 4491.
4. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

PART 3 - EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

A. Comply with the instructions and recommendations of the playground surfacing manufacturer.

3.2 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for maximum moisture content, subgrade and substrate conditions, drainage, and other conditions affecting performance of the Work.

B. Verify that play equipment is in place.
   1. Begin installation of safety surface immediately upon completion of play equipment installation.

C. Verify that stone base is ready to receive poured-in-place safety surface.
   1. Verify gradients and elevations are correct.

D. Beginning of installation means acceptance of existing conditions.

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

3.3 PREPARATION

A. General: Prepare substrates to receive surfacing products according to playground surface system manufacturer's written instructions. Verify that substrates are sound and without high spots, ridges, holes, and depressions.

3.4 INSTALLATION, GENERAL

A. General: Comply with playground surface system manufacturer's written installation instructions. Install playground surface system over area and in thickness indicated.

B. Secure manufacturer's representative to observe all phases of safety surface installation and provide Owner with a written statement certifying compliance with manufacturer's drawings and specifications.

C. Install safety surface according to manufacturer's instructions and specifications in locations shown on Drawings.
   1. Meet or exceed current: CPSC guidelines, ADA guidelines and ASTM F-1292-93 requirements.

3.5 SUBGRADE
   1. Compact soil subgrade in accordance with Philadelphia Water Department requirements.

3.6 GEOSYNTHETIC INSTALLATION

A. General: Install geosynthetics according to playground surface system manufacturer's and geosynthetic manufacturer's written instructions.

   1. Geotextiles: Completely cover area indicated, overlapping sides and edges a minimum of 8 inches with manufacturer's standard treatment for overlapping loosely laid seams. Adhere edges on all sides to top of perimeter curb or footing.

3.7 POURED-IN-PLACE PLAYGROUND SURFACING SYSTEM INSTALLATION

A. Crushed Stone Base Installation:

   1. The minimum depth of the stone base is 6". Thickness is never to exceed 10”.
   2. The crushed stone base must be thoroughly compacted by using a tamper, roller or combination of both to a 95% compaction rate throughout the base.

B. Basemat Installation:

   1. Using screeds and hand trowels, install the basemat at a consistent density of 29 pounds, 1 ounce per cubic foot (466 kg/m3) to the specified thickness indicated on drawings.
   2. Allow basemat to cure for sufficient time so that indentations are not left in the basemat from applicator foot traffic or equipment.
   3. Do not allow foot traffic or use of the basemat surface until it is sufficiently cured.

C. Primer Application: Using a brush or short nap roller, apply primer to the basemat perimeter and any adjacent vertical barriers such as playground equipment support legs, curbs or slabs that will contact the surfacing system at the rate of 300 ft2/gal (7.5 m2/L).

D. Top Surface Installation:

1. Using a hand trowel, install top surface at a consistent density of 58 pounds, 9 ounces per cubic foot (938 kg/m3) to a nominal thickness of 1/2" (12.7 mm).

2. Layout color areas to dimensions as shown on plan. There shall be no hard lines between colors. Blending zone is a mix of the two colors specified.
3. Allow top surface to cure for a minimum of 48 hours.
4. At the end of the minimum curing period, verify that the top surface is sufficiently dry and firm to allow foot traffic and use without damage to the surface.
5. Do not allow foot traffic or use of the surface until it is sufficiently cured.

3.8 FIELD QUALITY CONTROL

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

B. Testing Services: Testing and inspecting of completed applications of playground surface system shall take place according to ASTM F 1292.

C. Remove and replace applications of playground surface system where test results indicate that it does not comply with requirements.

D. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with requirements.

3.9 CLEAN UP

A. Maintain the site in an orderly condition during the progress of work. Promptly remove debris and trash. Leave the site in a neat, orderly condition, broom clean.

END OF SECTION 321816

SECTION 323113 – CHAIN-LINK FENCING AND GATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Chain-link fences for exterior trash enclosures
2. Chain-link fences for exterior rooftop equipment enclosures and exterior perimeter replacement fencing
3. Chain-link fences for interior storage enclosures
4. Swing Gates
5. Privacy Slats

B. Related Sections:
1. Division 2 Section “Earthwork”.
2. Division 2 Section “Tree Protection and Trimming”.
3. Division 2 Section “Asphalt Paving”.
4. Division 2 Section “Site Concrete”.

1.2 REFERENCES

A. The following apply to work in this Section:
1. ASTM: Specifications of the American Society for Testing and Materials latest editions. Modifications specified herein shall govern where conflicts with ASTM standards occur.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design chain-link fences and gates, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements, meeting PPR standard requirements, and design criteria indicated.

B. Structural Performance: Chain-link fence and gate framework shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.

1. Minimum Post Size: Refer to Drawings.
2. Minimum Post Size and Maximum Spacing: Refer to Drawings.
    a. Fence Height: Refer to Drawings.
    b. Material Group: IA, ASTM F 1043, Schedule 40 steel pipe.

1.4 SUBMITTALS

A. Product Data: Submit product literature or tear sheets with name of product and manufacturer. Fence and gate posts, rails, fittings, and locks. Confirm that gate locking mechanism works with PPR preferred locking system.

1. Chain-link fences and gates.

2. Privacy Slat material for trash enclosure and color options.

B. Product Test Reports: For framing strength according to ASTM F 1043.

C. Field quality-control reports.

D. Warranty: Sample of warranty.

1.5 QUALITY ASSURANCE

A. Contractor shall have had experience with at least two (2) other projects of similar scope and complexity and shall perform work with personnel totally familiar with playground, chain link fence installation and construction techniques under the supervision of an experienced foreperson.

B. Manufacturer: Company specializing in the manufacture of chain link fences with minimum three (3) years experience.

1.6 REGULATORY REQUIREMENTS

A. Comply with all rules, regulations, laws and ordinances of local, state and federal authorities having jurisdiction. Provide labor, materials, equipment and services necessary to make work comply with such requirements without additional cost to Owner.

1. Coordinate work with utility companies. Notify Pennsylvania One Call System, Inc. 1-800-242-1776 not less than three working days prior to beginning work.

B. Investigate the conditions of public thoroughfares and roads as to availability, clearances, loads, limits, restrictions and other limitations affecting transportation to and ingress and egress at the site.

1. Do not close or obstruct streets, walks or other occupied or used facilities without permission from authorities having jurisdiction.

C. Conform to applicable code for disposal of debris.

D. Procure and pay for permits and licenses required for work.

1.7 DELIVERY STORAGE AND HANDLING

A. Deliver, store, handle and protect all materials from damage.

1.8 PROJECT CONDITIONS

A. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

B. Should any work performed under this Section expose previously unknown conditions, immediately report the discovery to Architect. However, during this time use any measures necessary to maintain adequate safety conditions.

1. Should Contractor, in the course of work, find any discrepancies between Drawings and physical conditions or any omissions or errors in Drawings, inform Architect immediately in writing for clarification. Work done after such discovery, unless authorized by Owner, shall be at Contractor's risk.

1.9 WARRANTY

A. Warranty: Manufacturer's standard form in which Installer agrees to repair or replace components of chain-link fences and gates that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CHAIN-LINK FENCE FABRIC

A. General: Provide fabric in one-piece heights measured between top and bottom of outer edge of selvage knuckle or twist. Comply with CLFMI Product Manual and with requirements indicated.

B. Manufacturer: Master Halco – 3010 Lyndon B Johnson Freeway, Dallas TX, www.masterhalco.com, or approved equal.

C. Fence fabric mesh size, gauge per Drawings.

1. Thermally fused vinyl coated steel chain link fence ASTM F668- Type 2B with a galvanized steel core in accordance with ASTM A-641-71A. Color Black.
   a. Location: Exterior trash enclosures
2. Galvanized (zinc) coated steel chain link fabric per ASTM A392
   a. Mesh size: 2”x2”
   b. Location: Exterior rooftop enclosures, exterior perimeter replacement fencing; interior storage enclosures; as indicated on drawings

2.2 PRIVACY SLATS

A. Manufacturer: Master Halco – 3010 Lyndon B Johnson Freeway, Dallas TX, www.masterhalco.com, or approved equal.

B. Slat Master color black.

2.3 FENCE FRAMING

A. Posts and Rails: Comply with ASTM F 1043 for framing, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thickness according to ASTM F 1043 based on Drawings. Coating to match chain link fence fabric. Color Black.

2.4 SWING GATES

A. General: ASTM F900 for gate posts and single or double swing gate types where indicated.

1. Gate Leaf Width: As indicated
2. Framework Member Sizes and Strength: Based on gate fabric height as indicated

B. Pipe and Tubing:

1. Zinc-Coated Steel: ASTM F1043 and ASTM F1083; protective coating and finish to match fence framework
2. Gate Posts: Round tubular steel
3. Gate Frames and Bracing: Round tubular steel

C. Frame Corner Construction: assembled with corner fittings.

D. Hardware:

1. Hinges: 180-degree outward

2. Latch: Permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate.
3. Padlock and Chain

2.5 FITTINGS

A. General: Comply with ASTM F 626. Provide coating to match chain link fence fabric.

B. Post Caps: Provide for each post.

1. Provide line post caps with loop to receive top rail.

C. Rail and Brace Ends: For each corner and end post.

D. Rail Fittings: Provide the following:

1. Top Rail Sleeves: Round-steel tubing not less than 6 inches long.
2. Rail Clamps: Line and corner boulevard clamps for connecting intermediate and bottom rails in the fence line-to-line posts.

E. Tension and Brace Bands: Pressed steel.

F. Tension Bars: Steel, length not less than 2 inches shorter than full height of chain-link fabric. Provide one bar for each gate and end post, and two for each corner and pull post, unless fabric is integrally woven into post.

G. Truss Rod Assemblies: Hot-dip galvanized rod and turnbuckle or other means of adjustment.

H. Tie Wires, Clips, and Fasteners: According to ASTM F 626.

1. Standard Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, complying with the following:
   a. Hot-Dip Galvanized Steel: 0.106-inch diameter wire; galvanized coating thickness matching coating thickness of chain-link fence fabric.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.

1. Do not begin installation before final grading is completed unless otherwise permitted by Architect.

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

3.2 PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.3 INSTALLATION, GENERAL

A. Install chain-link fencing to comply with ASTM F 567 and more stringent requirements indicated.

3.4 CHAIN-LINK FENCE INSTALLATION

A. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.

B. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.

1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.

C. Terminal Posts: Locate terminal end, and corner posts per ASTM F 567

D. Line Posts: Space line posts per Drawings.

E. Post Bracing and Intermediate Rails: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.

1. Locate horizontal braces at mid-height of fabric 72 inches or higher, on fences with top rail. Install so posts are plumb when diagonal rod is under proper tension.

F. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch diameter hog rings of same material and finish as fabric wire, spaced per Drawings. Install tension wire in locations indicated before stretching fabric. Provide horizontal tension wire at the following locations:

1. Extended along top and bottom of fence fabric. Install top tension wire through post cap loops. Install bottom tension wire within 6 inches of bottom of fabric and tie to each post with not less than same diameter and type of wire.

G. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.

H. Intermediate and Bottom Rails: Install and secure to posts with fittings.

I. Chain-Link Fabric: Apply fabric to outside of enclosing framework. Leave 2 inches between finish grade or surface and bottom selvage unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

J. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric per ASTM F 626. Bend ends of wire to minimize hazard to individuals and clothing. Each end of wire tie shall be wrapped around fabric at least 540 degrees.

1. Maximum Spacing: Tie fabric to line posts at dimension indicated on Drawings.

K. Privacy Slats: Install slats in direction indicated, securely locked in place.

3.5 GATE INSTALLATION

A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation.

3.6 CLEAN UP

A. Maintain the site in an orderly condition during the progress of work. Promptly remove debris and trash. Leave the site in a neat, orderly condition, broom clean.

END OF SECTION

SECTION 323115 - WOOD FENCES AND GATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Split rail fence.

2. Gate at split rail fence.

B. Related Requirements:

1. Section 031200 "Earthwork" for excavation and backfilling.

2. Section 03300 – “Cast-in-place Concrete” for concrete footings.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Fence posts, rails, gate frame, and fittings.

B. Samples: For each fence material.

1. Wood species: 1 inch (nom.) thickness x 5 inches width x 9 inches length, demonstrating natural character and finish.

1.4 INFORMATIONAL SUBMITTALS

A. Certificates indicating that wood products comply with forest certification requirements. Include evidence that manufacturer is certified for chain of custody by an FSC-accredited certification body.

B. Materials Certificates: For lumber specified to comply with minimum allowable unit stresses. Indicate species and grade selected for each use and design values approved by ALSC's Board of Review.

C. Certificates of Inspection: Issued by lumber grading agency for exposed wood products not marked with grade stamp.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Fabricator of products.

B. Forest Certification: Provide wood products obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store materials under cover and protected from weather and contact with damp or wet surfaces. Stack lumber flat with spacers between each bundle to provide air circulation. Provide for air circulation around stacks and under coverings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Lumber: Comply with DOC PS 20 and with applicable rules of grading agencies indicated. If no grading agency is indicated, provide lumber that complies with the applicable rules of any rules-writing agency certified by ALSC's Board of Review. Provide lumber graded by an agency certified by ALSC's Board of Review to inspect and grade lumber under the rules indicated.

1. For items that are exposed to view in the completed Work, omit grade stamp and provide certificates of grade compliance issued by grading agency.

2. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry wood products.

2.2 DIMENSION LUMBER

A. Maximum Moisture Content: 15 percent for 2-inch nominal thickness or less; 19 percent for more than 2-inch nominal thickness.

B. Fence and gate lumber including posts, rails, pickets and frames: No. 2 or better, rough-sawn, sizes as indicated on Drawings, of the following species:

1. Western Red Cedar, NLGA or WCLIB

2.3 GATE HARDWARE

A. Custom Pedestrian Gate at Split Rail Fence:

1. Hinges: “Rear Eye Hinge” sets (product no. 8324-S122) in galvanized finish; including 18-inch length strap, mounting plate and adjustable threaded pins.

2. Latch: “Irish Gate Latch” (product no. 8328-00).

3. All hardware hot-dip, zinc-coated steel complying with ASTM A 153.

4. As provided by Snug Cottage Hardware, LLC; Marysville, MI 48040, phone: (800) 637-5427 or approved equal.

2.4 Galvanized Welded Wire Mesh

A. Size: 2”x4”

B. Material: Galvanized steel - 14 gauge

2.5 FASTENERS

A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture. Provide nails or screws, in sufficient length, to penetrate not less than 1-1/2 inches into wood substrate.

1. Use stainless steel fasteners for exterior applications complying with ASME B18.2.1, ASTM F593.

B. Stainless Steel Nails: ASTM F 1667.

C. Power-Driven Fasteners: NES NER-272.

D. Stainless Steel Wood Screws: ASME B18.6.1.

E. Stainless-Steel Carriage Bolts: ASTM F 593, Alloy Group 1 or 2 with ASTM F 594, Alloy Group 1 or 2 hex nuts and, where indicated, flat washers.

2.6 MISCELLANEOUS MATERIALS

A. Concrete: Normal-weight, air-entrained, ready-mix concrete complying with requirements in Section 033000 "Cast-in-Place Concrete" with a minimum 28-day compressive strength of 3000 psi, 3-inch slump, and 1-inch maximum aggregate size.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

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

3.2 FENCE PREPARATION

A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler systems, underground structures, benchmarks, and property monuments.

B. Clean substrates of projections and substances detrimental to application.

C. Cut to required lengths.

3.3 FENCE INSTALLATION

A. Install fences by setting posts as indicated and fastening rails and infill panels to posts.

B. Post Excavation: Drill or hand-excavate holes for posts in firm, undisturbed soil. Excavate holes to a diameter and height as indicated on Drawings.

C. Post Set with Compacted Aggregate Backfill

1. Place 4-inch minimum depth of compacted, aggregate of type indicated on Drawings, in bottom of hole and tamp to compaction rate of 95% proctor density prior to placing of post.

2. Place post into hole and verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting.

3. Place aggregate backfill into hole in lifts of no greater than 6-inch depth, compacting each lift to rate of 95% proctor density until aggregate reaches height as indicated on Drawings.

4. Space posts uniformly at spacing indicated on Drawings.

D. Post setting: set posts in concrete or with mechanical anchors at spacing as indicated on Drawings.

1. Verify that posts are set plumb, aligned and at correct height and spacing and hold in position during setting as required.

2. Concrete Fill: place concrete around posts and vibrate or tamp for consolidation. Protect above ground portion of posts from concrete splatter. Extend concrete footing to height as indicated on Drawings.

3. Space posts uniformly at spacing indicated on Drawings.

E. Set or fasten rails to posts as indicated.

F. Fasten pickets to rails as indicated, level and plumb.

G. Fasten welded wire mesh as indicated on Drawings.

H. Apply stain to all exposed surfaces of lumber as indicated.

3.4 GATE INSTALLATION

A. Post installation: Install posts in same manner as fence posts noted above, with hole sizes and depths as indicated on Drawings.

B. Install gates and hardware according to manufacturer's written instructions, level and plumb and secure for full opening without interference. Adjust hardware for smooth operation and lubricate where necessary

END OF SECTION

SECTION 323223 CONCRETE SEGMENTAL RETAINING WALL SYSTEM

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Concrete segmental retaining wall units.

B. Geosynthetic reinforcement

C. Leveling pad base

D. Drainage aggregate

E. Reinforced Backfill

F. Drainage pipe

G. Pre-fabricated Drainage Composite

H. Geotextile Filter

I. Impervious Materials

J. Construction Adhesive

1.02 RELATED SECTIONS

A. Section 02200 - Earthwork: For finish grading.

1.02 REFERENCES

A. American Association of State Highway Transportation Officials (AASHTO)

1. AASHTO M288 Geotextile Specification for Highway Applications

2. AASHTO Standard Specifications for Highway Bridges

B. American Society for Testing and Materials (ASTM)

1. ASTM C140 Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units

2. ASTM C1262 Standard Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units

3. ASTM C1372 Standard Specification for Segmental Retaining Wall Units

4. ASTM D448 Standard Classification for Sizes of Aggregate for Road and Bridge Construction

5. ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/f3)(600 kN-m/m3)

6. ASTM D1556 Standard Test Method for Density and Unit Weight of Soil In Place by the Sand Cone Method

7. ASTM D1557 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/f3)(2700 kN-m/m3)

8. ASTM D2487 Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)

9. ASTM D2922 Standard Test Methods for Density of Soil and Soil-Aggregate In Place by Nuclear Methods (Shallow Depth)

10. ASTM D3034 Standard Specification for Type PSM Poly (Vinyl Chloride) (PVC) Sewer pipe and Fittings

11. ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

12. ASTM D4491 Standard Test Method for Water Permeability of Geotextiles by the Permittivity Method

13. ASTM D4595 Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method

14. ASTM D4873 Standard Guide for Identification, Storage and Handling of Geosynthetics 15. ASTM D5084 Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter.

16. ASTM D5262 Standard Test Method for Evaluating the Unconfined Tension Creep Behavior of Geosynthetics

17. ASTM D5321 Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method

18. ASTM D5818 Standard Practice for Obtaining Samples of Geosynthetics from a Test Section for Assessment of Installation Damage

19. ASTM D6637 Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method

20. ASTM D6638 Standard Test Method for Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units

21. ASTM D6706 Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil

22. ASTM F405 Standard Specification for Corrugated Polyethylene (PE) Tubings and Fittings

23. ASTM G51 Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing

C. Federal Highway Administration

` 1. Elias, V., Christopher, B., and Berg, R., “Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines”, Federal Highway Administration Report No. FHWA-NHI-00-043, March 2001.

2. Elias, V., Christopher, B., and Berg, R., "Corrosion/Degradation of Soil Reinforcements for Mechanically Stabilized Earth Walls and Reinforced Soil Slopes", Federal Highway Administration Report No. FHWA-NHI-00-044, March 2001.

D. National Concrete Masonry Association (NCMA)

1. NCMA Design Manual For Segmental Retaining Walls, Second Edition, Second Printing (1997)

2. NCMA SRWU-2 Determination of Shear Strength Between Segmental Concrete Units

1.03 DEFINITIONS

A. Concrete Segmental Retaining Wall (SRW) Units: Dry-stacked masonry units used as the retaining wall fascia.

B. Reinforced Backfill: Soil that is used as fill behind the SRW unit, and within the reinforced soil mass (if applicable).

C. Drainage Aggregate: Material used (if applicable) within, between, and directly behind the concrete retaining wall units.

D. Geotextile Filter: Material used for separation and filtration of dissimilar soil types.

E. Foundation Soil: Soil mass supporting the leveling pad and reinforced soil zone of the retaining wall system.

F. Geosynthetic Reinforcement: Polymeric material designed specifically to reinforce the soil mass.

G. Pre-fabricated Drainage Composite: three-dimensional geosynthetic drainage medium encapsulated in a geotextile filter, used to transport water.

H. Impervious Materials: Clay soil or low permeability geosynthetic used to prevent water percolation into the drainage zone behind the wall.

I. Global Stability: The general mass movement of a soil reinforced segmental retaining wall structure and adjacent soil mass.

J. Project Geotechnical Engineer: A registered engineer who provides site observations, recommendations for foundation support, and verifies soil shear strength parameters.

1.04 SUBMITTALS

Due to the design-build nature of Segmental Retaining Wall Systems, contractors shall provide a system specific submittal package to the Civil Engineer at least ten (10) days prior to bid for pre-approval. Incomplete or late submittal packages will not be permitted to bid on the project.

A. Submit the following at least ten (10) days prior to bid for pre-approval

1. Product Data

a. Material description and installation instructions for each manufactured product specified including Segmental Retaining Wall Units (SRW) and Geosynthetic Reinforcement.

b. Name and address of the production facility where the proposed SRW units will be

manufactured. All units to be manufactured at the same facility.

c. Notarized letter from the SRW manufacturer stating that the units supplied for this project are manufactured in complete compliance with Section 2.01 of this specification. The letter shall state that the SRW units shown in the attached test reports are representative samples of the plants normal mix design and regular production runs.

2. Samples:

a. Furnish one unit demonstrating the color, face pattern, and texture of the SRW unit if specified by the project Architect or Owner.

b. Furnish 12-inch square or larger piece of the geosynthetic reinforcement specified.

3. Test Reports:

a. Independent laboratory reports indicating compressive strength, moisture absorption and freeze-thaw durability of the concrete retaining wall units from the proposed production facility. Only test performed within the past 12 months will be considered current and valid.

b. Independent test reports verifying the long-term design strength properties (creep, installation damage, and durability) and soil interaction properties of the geosynthetic reinforcement.

c. Independent test reports verifying the connection capacity between the geosynthetic reinforcement and the concrete retaining wall units.

d. For projects with walls in excess of 25’ in height, a completed Highway Innovative Technology Evaluation Center (HITEC) report shall be required for the proposed system.

4. Wall Design Engineer Qualifications:

a. Current insurance policy verifying professional liability and errors and omissions insurance coverage for an aggregate and per claim limit of a minimum of one million dollars.

b. Notarized letter certifying the proposed SRW Design Engineer is a licensed professional engineer in the state of wall installation.

5. Retaining Wall Installer Qualifications:

a. The Retaining Wall Installer shall furnish five (5) project references of similar size and scope to this project including the wall(s) height and square footage. References shall include the contact information of Owner or General Contractor.

b. The Retaining Wall Company must have successfully completed the Segmental Retaining Wall training and exam of the National Concrete and Masonry Association.

B. Submit the following at least ten (10) days prior to start of construction for approval

1. Retaining Wall Final Design Submittals

a. Shop Drawings: Four (4) sets of the retaining all system design, including wall elevation views, geosynthetic reinforcement layout, pertinent details, and drainage provisions. A

registered professional engineer licensed in the state of wall installation shall sign and certify that the shop drawings are designed in accordance with the project civil plans and specifications.

b. Design Calculations: Four (4) sets of engineering design calculations prepared in accordance with the NCMA Design Manual For Segmental Retaining Walls, Second Edition, and Second Printing, 1997. Analysis shall include Internal, External, Global Stability, and Bearing Capacity Calculations.

1.05 DESIGN REQUIREMENTS

A. Designs for SRW's using extensible (geosynthetic) reinforcement shall be prepared according to design methodology presented in the NCMA "Design Manual for Segmental Retaining Walls, 1997, second edition, second printing" and conform to the minimum safety factors as specified in this specification section. Design submittals not meeting this design criteria or technical/administrative criteria as specified will be rejected in their entirety until complete compliance is achieved. Owner reserves all rights in determining compliance for plan approval and may reject any submittals.

B. Design of the SRW shall be based on the following soil parameters as determined during the geotechnical investigation

	Effective Friction Angle	Effective Cohesion	Unit Weight
Reinforced Backfill		NA	
Retained Backfill		NA	
Foundation			

The Design Engineer of Record shall be responsible for selecting and specifying reinforced fill material. The General Contractor is responsible for ensuring and documenting the reinforced fill meets the specified parameters for both strength and compaction. Compacted retained soil shall meet the minimum requirements specified.

C. Design Criteria for Retaining Wall Systems:

Unless otherwise indicated below, SRW design shall be performed in strict accordance with the procedures presented in the NCMA Design Manual for Segmental Retaining Walls.

1. Internal Stability:
   a. Minimum Factor of Safety on Tensile Overstress 1.0
   b. Minimum Factor of Safety on Geogrid Pullout (Peak load criterion) 1.5
   c. Minimum Factor of Safety on Geogrid Pullout (Serviceability criterion) 0.75 inches 1.0
   d. Minimum Factor of Safety on Facing Shear

(Peak load criterion) 1.5

e. Minimum Factor of Safety on Facing Shear
(Serviceability criterion) 2% of height of SRW units 1.0

f. Minimum Factor of Safety Connections
(Peak load criterion) 1.5

g. Minimum Factor of Safety Connections
(Serviceability criterion) 0.75 inches 1.0

h. Minimum Factor of Safety for Uncertainties 1.5

2. External Stability:

a. Minimum Factor of Safety Against Base Sliding
(Static condition) 1.5

b. Minimum Factor of Safety Against Overturning 2.0

c. Minimum Factor of Safety for Global Stability 1.3

d. Minimum Factor of Safety for Bearing Capacity 2.0

D. Design shall address hydrostatic loading, seismic loading, rapid drawdown, surcharge, and backslopes where appropriate. Minimum Design Live Load of 150 psf shall be used for all walls supporting parking areas. Minimum Design Live Load of 250 psf shall be used for walls supporting entrance drives, service drives and other areas subject to traffic.

E. Minimum reinforcement length shall be 60 percent of the wall height. Reinforcement coverage at each layer shall be 100 percent (no gaps).

F. The maximum vertical distance between layers of soil reinforcement shall be limited to a maximum of 25” (inches) for systems that derive their connection capacity from friction and 31” (inches) for systems using a mechanical connection to derive their connection capacity (per NHI 043 and AASHTO).

G. Drainage Aggregate shall be placed within, between, and a minimum of 12” (inches) behind the segmental concrete facing units. Design Engineers can waive the drainage aggregate requirement ifthey independently evaluate the reinforced backfill and find it to have sufficient drainage properties. If waived, the Design Engineer shall design and require a suitable filter fabric between the SRW units and the reinforced backfill zone per the AASHTO M288 Design Guidelines. Any air voids between SRW units and the filter fabric shall be filled with drainage aggregate.

1.06 DELIVERY, STORAGE AND HANDLING

A. Concrete Retaining Wall Units and Accessories: Deliver, store, and handle materials in accordance with manufacturer's recommendations, in such a manner as to prevent damage. Check the materials upon delivery to asure that proper material has been received. Store above ground on wood pallets or blocking. Remove damaged or otherwise unsuitable material, when so determined, from the site.

1. Exposed faces of concrete wall units shall be free of chips, cracks, stains, and other imperfections detracting from their appearance, when viewed from a distance of 10 feet.

2. Prevent mud, wet cement, adhesives and similar materials that may harm appearance of units,

from coming in contact with system components.

B. Geosynthetics (including geosynthetic reinforcement, geotextile filter, pre-fabricated drainage composite) shall be delivered, stored, and handled in accordance with ASTM D4873.

1.07 EXTRA MATERIALS

A. Furnish Owner with 3 replacement units identical to those installed on the Project.

PART 2 PRODUCTS

2.01 MATERIALS

A. Segmental Retaining Wall units shall meet the following requirements:

- Physical Requirements

a. Compressive strength and Absorption: Concrete retaining wall units shall be tested in accordance with ASTM C140, Sections 6, 8 and 9. Concrete retaining wall units shall meet requirements of ASTM C1372, except the compressive strength requirements will be increased to a minimum of 3,500 psi and the maximum water absorption shall be limited to 7 percent, and unit height dimensions shall not vary more than plus or minus 1/16 inch from that specified in the ASTM reference, not including textured face. Test shall be performed within the past 6 months to be considered current and valid.

b. Freeze-Thaw Durability: Shall be tested in accordance with ASTM C1262 when required. Test shall be performed within the past 12 months to be considered current and valid.

Note to Specifier: In Subparagraph below, select appropriate entity, color, and face pattern geometry. Manufacturer of a particular Retaining Wall System can be listed here.

Per the Architec

c. Color: Natural Grey

d. Face Pattern Geometry: Straight

e. Texture: Split Rock Face that exposes the natural aggregates.

f. Batter: Include an integral batter control shear connector to provide a consistent setback for each wall course. Initial wall batter shall not exceed 12 degrees.

B. Geosynthetic Reinforcement shall be manufactured with high-tenacity polyester or HDPE in a grid or

textile structure. The geosynthetic reinforcement must meet the long-term design strength, soil interaction, and connection capacity requirements as required by the design of the retaining wall.

1. Long-term Design Strength: As determined in accordance with Method A of the NCMA DesignManual for Segmental Retaining Walls, Second Edition, Second Printing, 1997.

a. Ultimate Tensile Strength: The ultimate tensile strength of the geosynthetic reinforcement shall be determined in accordance with ASTM D4595 or ASTM D6637.

b. Creep: Creep testing of the geosynthetic shall be performed in accordance with ASTM D5262. The creep reduction factor shall be determined in accordance with FHWA-NHI-00-043.

c. Installation Damage: The installation damage reduction factor shall be determined in accordance with ASTM D5818 and FHWA-NHI-00-043.

d. Durability: The durability reduction factor shall be determined in accordance with FHWA-NHI-00-044.

2. Soil Interaction: The soil interaction properties include the coefficient of direct sliding and coefficient of interaction as determined through direct shear and pullout testing, respectively.

a. Pullout: Shall be determined in accordance with ASTM D6706.

b. Direct Sliding: Shall be tested in accordance with ASTM D5321.

3. Connection Capacity: As determined in accordance with ASTM D6638.

C. Leveling Pad Base

1. Aggregate Base: Crushed stone or granular fill meeting the following gradation as determined in accordance with ASTM D448:

Sieve Size	Percent Passing
1 inch	100
No. 4	35 to 70
No. 40	10 to 35
No. 200	3 to 10

a. Base Thickness: 6 inches (minimum compacted thickness).

b. Base Width: must extend 6 inches from the toe and heal of the block.

2. Concrete Base: Nonreinforced lean concrete base.

a. Base Thickness: At least 2 inches

D. Drainage Aggregate: Clean crushed stone or granular fill meeting the following gradation as determined in accordance with ASTM D448:

Sieve Size	Percent Passing
1 inch	100
3/4 inch	75 to 100
No. 4	0 to 60
No. 40	0 to 50
No. 200	0 to 5

E. Reinforced Backfill: Suitable reinforced backfill soils shall be free of organics and debris and consisting of either GP, GW, ML, SP, SW, or SM type, classified in accordance with ASTM D2487 and the USCS classification system. Soils classified as SC and CL are considered suitable soils for segmental retaining walls with a total height of less than 10 feet.

1. The Plasticity Index (PI) of the reinforced backfill soils shall not be greater than 20 as measured in accordance with ASTM D4318.

2. Unsuitable soils are organic soils and those soils classified as CH, OH, MH, OL, or PT.

3. The pH of the reinforced backfill shall be between 3 and 10 and be tested in accordance with ASTM G51.

F. Drainage Pipe: Perforated or slotted PVC or corrugated HDPE pipe manufactured in accordance with D3034 and/or ASTM F405. The pipe may be covered with a geotextile filter to prevent fines migration into the pipe.

G. Pre-fabricated Drainage Composite: The pre-fabricated drainage composite shall be Miradrain 5000, manufactured by Mirafi, or equal.

H. Geotextile Filter: The geotextile filter shall be in accordance with AASHTO M288 guidelines.

I. Impervious Material: Clay soil and/or low permeability geosynthetic shall have a coefficient of permeability of less than 10-7 cm/s as tested in accordance with ASTM D5084 or ASTM D4491, as applicable.

J. Construction Adhesive: Exterior grade adhesive as recommended by the retaining wall unit manufacturer.

PART 3 - EXECUTION

3.01 EXAMINATION

A. The installer shall examine the areas and conditions under which the retaining wall system is to be erected, and notify the Owner and Contractor in writing of conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

B. Promptly notify the wall design engineer of site conditions that may affect wall performance, soil conditions observed other than those assumed, or other conditions that may require a reevaluation of the wall design.

C. The General Contactor shall verify the location of existing structures and utilities prior to excavation.

3.02 PREPARATION

A. Ensure surrounding structures are protected from the effects of wall excavation.

B. Excavation support, if required, is the responsibility of the Contractor, including the stability of the excavation and it's influence on adjacent properties and structures.

3.03 EXCAVATION

A. Excavate to the lines and grades shown on the Drawings. The General Contactor shall replace any unsuitable soils discovered during excavation. Use care in excavating to prevent disturbance of the base beyond the lines shown.

3.04 FOUNDATION PREPARATION

A. Excavate foundation soil as required for footing or base dimension shown on the Drawings, or as directed by the Project geotechnical engineer.

B. Fill over-excavated areas with suitable compacted backfill, as recommended by the Project geotechnical engineer.

3.05 BASE COURSE PREPARATION

A. Place base materials to the depths and widths shown on the Drawings, upon undisturbed soils, or foundation soils prepared in accordance with Article 3.04.

1. Extend the leveling pad laterally at least 6 inches in front and behind the lowermost concrete retaining wall unit.

2. Provide aggregate base compacted to 6 inches thick (minimum).

3. The Contractor may at their option, provide a concrete leveling pad as specified in Subparagraph 2.01.C.2, in lieu of the aggregate base.

4. Where a reinforced footing is required by local codes, place footing below frost depth.

B. Compact aggregate base material to provide a level, hard surface on which to place the first course of units.

C. Prepare base materials to ensure complete contact with retaining wall units.

3.06 ERECTION

A. General: Erect units in accordance with manufacturer's instructions and recommendations, and as specified herein.

B. Place first course of concrete wall units on the prepared base material. Check units for level and alignment. Maintain the same elevation at the top of each unit within each section of the base course.

C. Ensure that foundation units are in full contact with natural or compacted soil base.

D. Place concrete wall units side-by-side for full length of wall alignment. Alignment may be accomplished by using a string line measuring from the back of the block.

E. Place 12 inches (minimum) of drainage aggregate directly behind the concrete wall units. Fill voids in and between retaining wall units with drainage aggregate. Provide a drainage zone behind the wall units to within 12 inches of the final grade. Cap the backfill and drainage aggregate zone with 6 inches ofimpervious material. Design Engineers can waive the drainage aggregate requirement if they independently evaluate the reinforced backfill and find it to have sufficient drainage properties. If waived, the Design Engineer shall design and

require a suitable filter fabric between the SRW units and the reinforced backfill zone per AASHTO M288 Design Guidelines.

F. Install drainage pipe at the lowest elevation possible, to maintain gravity flow of water to outside of the reinforced zone. Slope the main collection drainage pipe; located just behind the concrete retaining wall units, 2 percent (minimum) to provide gravity flow to the daylighted areas. Daylight the main collection drainage pipes to an appropriate location away from the wall system. The daylight drainage pipe should beplace at the lowest point and at 50-foot (maximum) intervals along the wall.

G. Remove excess fill from top of units and install next course. Ensure drainage aggregate and backfill are compacted before installation of next course.

H. Check each course for level and alignment. Adjust units as necessary to maintain level and alignment prior to proceeding with each additional course. Install alignment devices (pins) if required.

I. Install each succeeding course. Backfill as each course is completed. Pull the units forward until the locating surface of the unit contacts the locating surface/device of the units in the preceding course. Interlock wall segments that meet at corners by overlapping successive courses. Attach concrete retaining wall units at exterior corners with adhesive specified.

J. Install geosynthetic reinforcement in accordance with geosynthetic manufacturer's recommendations and the shop drawings.

1. Orient geosynthetic reinforcement with the highest strength axis perpendicular to the wall face.

2. Prior to geosynthetic reinforcement placement, place the backfill and compact to the elevation of the top of the wall units at the elevation of the geosynthetic reinforcement.

3. Place geosynthetic reinforcement at the elevations and to the lengths shown on the Drawings.

4. Lay geosynthetic reinforcement horizontally on top of the concrete retaining wall units and the compacted backfill soils. Place the geosynthetic reinforcement within one inch of the face of the concrete retaining wall units. Place the next course of concrete retaining wall units on top of the geosynthetic reinforcement.

5. The geosynthetic reinforcement shall be in tension and free from wrinkles prior to placement of the backfill soils. Pull geosynthetic reinforcement hand-taut and secure in place with staples, stakes, or by hand tensioning until the geosynthetic reinforcement is covered by 6 inches of loose fill.

6. The geosynthetic reinforcements shall be continuous throughout their embedment lengths. S plices in the geosynthetic reinforcement strength direction are not allowed.

7. Do not operate tracked construction equipment directly on the geosynthetic reinforcement.

At least 6 inches of compacted backfill soil is required prior to operation of tracked vehicles over the geosynthetic reinforcement. Keep turning of tracked construction equipment to a minimum.

8. Rubber-tired equipment may pass over the geosynthetic reinforcement at speeds of less than 5 miles per hour. Turning of rubber-tired equipment is not allowed on the geosynthetic reinforcement.

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3.07 BACKFILL PLACEMENT

A. Place reinforced backfill, spread and compact in a manner that will minimize slack in the reinforcement.

B. Place fill within the reinforced zone and compact in lifts not exceeding 6 to 8 inches (loose thickness) where hand-operated compaction equipment is used, and not exceeding 12 inches (loose thickness) where heavy, self-propelled compaction equipment is used.

1. Only lightweight hand-operated compaction equipment is allowed within 4 feet of the back of the

retaining wall units. If the specified compaction cannot be achieved within 4 feet of the back of the retaining wall units, replace the reinforced soil in this zone with drainage aggregate material.

C. Compaction testing shall be done in accordance with ASTM D1556 or ASTM D2922. Refer to Article 3.10 for compaction testing.

D. Minimum Compaction Requirements for Fill Placed in the Reinforced Zone

1. The minimum compaction requirement will be determined by the project geotechnical engineer. At no time shall the soil compaction requirements be less than 95 percent of the soil's standard Proctor maximum dry density (ASTM D698) [modified Proctor maximum dry density (ASTM D1557)] for the entire wall height

2. Utility Trench Backfill: Compact utility trench backfill in or below the reinforced soil zone to 98 percent of the soil's standard Proctor maximum dry density (ASTM D698) [modified Proctor maximum dry density (ASTM D1557)], or as recommended by the Project geotechnical engineer. If the height from the utility to finish grade is higher than 30 feet, increase compaction to 100 percent of the standard Proctor density [modified Proctor density].

a. Utilities must be properly designed (by others) to withstand all forces from the retaining wall units, reinforced soil mass, and surcharge loads, if any.

3. Moisture Content: Within 3 percentage points of the optimum moisture content for all wall heights.

4. These specifications may be changed based on recommendations by the Project geotechnical engineer.

a. If changes are required a monetary adjustment, the Contract Sum will be adjusted by written Change Order.

E. At the end of each day's operation, the wall installer shall slope the last level of compacted backfill away from the interior (concealed) face of the wall to direct surface water runoff away from the wall face.

1. The General Contractor is responsible for ensuring that the finished site drainage is directed away from the retaining wall system.

2. In addition, the General Contractor is responsible for ensuring that surface water runoff from adjacent construction areas is not allowed to enter the retaining wall area of the construction site.

3.08 CAP UNIT INSTALLATION

A. Apply adhesive to the top surface of the unit below and place the cap unit into desired position.

B. Cut cap units as necessary to obtain the proper fit.

C. Backfill and compact to top of cap unit.

3.09 SITE CONSTRUCTION TOLERANCES

A. Site Construction Tolerances

1. Vertical Alignment: Plus or minus 1-1/2 inches over any 10-foot distance, with a maximum differential of 3 inches over the length of the wall.

2. Horizontal Location Control From Grading Plan

a. Straight Lines: Plus or minus 1-1/2 inches over any 10-foot distance.

b. Corner and Radius Locations: Plus or minus 12 inches.

c. Curves and Serpentine Radii: Plus or minus 2 feet.

3. Immediate Post Construction Wall Batter: Within 2 degrees of the design batter of the concrete retaining wall units.

4. Bulging: Plus or minus 1-1/4 inches over any 10-foot distance.

3.10 FIELD QUALITY CONTROL

A. Installer is responsible for quality control of installation of system components.

B. The General Contractor, at their expense, shall retain a qualified independent testing agency to perform quality assurance checks, evaluation of foundation soils, and compaction testing of the installer's work.

C. Installer shall correct work that does not meet these specifications or the requirements shown on the Drawings at the installer's expense.

D. An independent testing agency, at the general contractors expense, shall be contracted to perform compaction testing of the reinforced backfill placed and compacted in the reinforced backfill zone.

1. Testing Frequency

a. One test for every 2 feet (vertical) of fill placed and compacted, for every 50 lineal feet of retaining wall.

b. Vary compaction test locations to cover the entire area of the reinforced soil zone, including the area compacted by the hand-operated compaction equipment.

3.11 ADJUSTING AND CLEANING

A. Replace damaged units with new units as the work progresses.

B. Remove debris caused by wall construction and broom clean adjacent paved areas.

Note to Specifier: Include Article 3.12 ONLY for municipal work when required

3.12 MEASUREMENT AND PAYMENT

A. Measurement of segmental retaining wall shall be on an installed square foot basis computed on the total face area of wall installed. Wall face area includes the bottom of the base course to the top of the wall, and the entire length of the wall.

B. Payment for the wall will be made on a square foot basis at the agreed upon Contract Unit Price.

1. Payment should be considered full compensation for labor, materials, and equipment required to install the wall in accordance with these specifications and the Drawings.

2. Quantities may vary from that shown on the Drawings depending on existing topography. Change to the total quantity of wall face area will be paid or withheld at the agreed upon Contract Unit Price.

END OF SECTION 323223

SECTION 329100 - PLANTING PREPARATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SECTION INCLUDES

A. The scope of work includes all labor, materials, tools, supplies, equipment, facilities, transportation and services necessary for, and incidental to performing all operations in connection with furnishing, delivery, and installation of Planting Soils. Scope of work includes, but is not limited to, sourcing, purchase, delivery and installation of Planting Soil and soil amendments and clean up and disposal of all excess and surplus material.

B. The specific soil types in this section include:

1. Planting Soil for plant beds and lawn

1.3 RELATED REQUIREMENTS

A. Section 311000 Site Clearing

B. Section 312000 Earthwork

C. Section 329200 Lawn

D. Section 329300 Plants

1.4 REFERENCE STANDARDS

A. In the event that the requirements of any of the referenced standards and specifications herein conflict with each other the more stringent requirement shall prevail. Where reference is made to one of the standards, the revision in effect at the time of bid opening shall apply.

B. American Society for Testing Materials (ASTM):
1. ASTM C33 – Gradation Requirements for Coarse Aggregates.
2. ASTM C602 Standard Specification for Agricultural Liming Materials.
3. ASTM D422 – Standard Test Method for Particle Size Analysis of Soils.
4. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.
5. ASTM D3385 – Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer.
6. ASTM D4972 – Standard Test Method for pH of Soils.
7. ASTM D5298 – Standard Specification for Topsoil Used for Landscaping Purposes.

8. ASTM D7481 – Standard Test Methods for Determining Loose and Tapped Bulk Densities of Powders using a Graduated Cylinder.
9. ASTM F1632 – Standard Test Method for Particle Size Analysis and Sand Shape Grading of Golf Course Putting Green and Sports Field Rootzone Mixes.
10. ASTM F1647 – Standard Test Methods for Organic Matter Content of Athletic Field Rootzone Mixes.
11. ASTM F1815 – Standard Test Methods for Saturated Hydraulic Conductivity, Water Retention, Porosity, and Bulk Density of Athletic Field Rootzones.

C. Other Standards:
1. U.S. Department of Agriculture (USDA), Natural Resources Conservation Service, Soil Texture Calculator.
2. USDA, Natural Resources Conservation Service, 2003. National Soil Survey Handbook, title 430-VI, current edition.
3. USDA Soil Survey Laboratory Methods Manual, Soil Survey Investigations Report, current edition.
4. Environmental Protection Agency (EPA) Section 503 Regulations.
5. Department of Environmental Protection (DEP), Pennsylvania Bulletin, Management of Fill, Clean Fill Policy, current edition.
6. U.S. Composting Council (USCC), Test Methods for the Examination of Composting and Compost (TMECC), current edition.
7. USCC, Landscape Architecture / Design Specifications for Compost Use, Planting Bed Establishment with Compost.
8. Association of Official Analytical Chemists (AOAC), Official Methods of Analysis, current edition.
9. Soil Science Society of America (SSSA), Methods of Soil Analysis, current edition.

1.5 DEFINITIONS

A. Bulk Density: is an indicator of soil compaction calculated as the dry weight of soil by its volume typically expressed in g/cm3.

B. Coarse Sand: sharp natural or manufactured fine aggregate and further defined in this specification.

C. Compacted soil: soil where the density of the soil is greater that the threshold for root limiting, and further defined in this specification.

D. Compost: Well decomposed stable organic material as defined by the US Composting Council and further defined in this specification.

E. Planting Soil: Planting soil shall harvested from fields or development sites or manufactured uniformly mixed individual soil components (Topsoil, Sand, Compost) or existing mineral soil at the locations of proposed planting meeting the criteria specified herein.

F. Topsoil: Naturally produced and harvested soil from the A horizon or upper layers or the soil as further defined in this specification.

G. Salvaged Topsoil: Topsoil stripped from the Project Site and prepared for reuse at the Project Site.

1.6 SUBMITTALS

A. Submit a list of materials to be provided for work under this Section including the name and address of the materials producer and the location from which the materials are to be obtained.

B. Submit dated certificates or letters, signed by the materials producer, stating that materials meet or exceed the specified requirements.

C. For each type of manufactured product, submit data and certificates that the product meets the specification requirements, signed by the product manufacturer, and complying with testing requirements and referenced standards and specific requested testing.

D. Laboratory soil testing requirements:
   1. Samples of soil(s) to be submitted to an approved soil testing laboratory for testing in accordance with specifications herein. Submit the soil testing laboratory for review and approval prior to commencing with any soil testing.
   2. Test results shall be submitted to the Landscape Architect for approval in conjunction with soil amendment products in accordance with soil testing laboratory recommendations.
   3. Submit soil test reports including test results for each criteria listed within the Products section herein for:
      a. Individual Components for Soil Mixes: Topsoil, Compost and Sand.
      b. Soil Mixes Using Individual Components.
      c. Test reports for Individual Components and Soil Mixes must be submitted concurrently.
      d. The source of supply for Individual Components for Soil Mixes and Soil Mixes Using Individual Components must be indicated on the test report submittals.
   4. Test reports must be the same material to be supplied and must be current within the period of time defined as follows unless approved otherwise by the Landscape Architect:
      a. Topsoil: no more than 6 months old.
      b. Salvaged Topsoil: no more than 6 months old.
      c. Compost: no more than 3 months old.
      d. Sand: no more than 6 months old.
      e. Planting Soil: test data must be no more than 1 month old.
      f. Sample test results shall be considered valid until the time of construction and for the material supplied.
   5. If tests fail to meet the specifications, obtain other sources of material, retest and resubmit until accepted by the Landscape Architect.
   6. Soils shall not contain any traces of hydrocarbons, petroleum products, chemically prohibited substances, or any other elements considered to be toxic to any vegetation that is used. Clean fill certification shall be submitted by the manufacturer.
   7. All soil testing will be at the expense of the Contractor.

E. Physical samples:
   1. All samples must be submitted simultaneously with the laboratory test reports. Samples are required for the following:
      a. Salvaged Topsoil
      b. Manufactured Planting Soil
   2. Provide one (1) one-gallon sample in a resealable plastic bag to the Landscape Architect.

1.7 On-site verification soil testing requirements:

A. Landscape Architect may require Compaction Testing:
   1. Maintain an up-to-date written report of compaction test results. Test compaction every 12-inch lift of soil for every 300 square feet of soil installed for each planting area designated on the Drawings. The Landscape Architect may review the written report at any time to confirm conformance with the specification. Submit final report at the completion of soil installation.

2. Maintain at the site at all times a soil cone penetrometer with pressure dial and a soil moisture meter to check soil compaction and soil moisture.
    a. Penetrometer shall be AgraTronix Soil Compaction Meter or approved equal.
    b. Moisture meter shall be “general digital soil moisture meter”.

B. Should any verification test results indicate soil material is not consistent with the approved submittals or requirements specified herein, the Contractor shall remove the installed soil and re-install soil at the Contractors expense until the Contract Document requirements are met.

1.8 Accompany each delivery of soil mixes, bulk materials, fertilizers and soil amendments provide the appropriate certificates and delivery tickets to the Landscape Architect. The soil supplier must be indicated on delivery tickets for all soil mix deliveries and the supplier must match the approved submittals.

1.9 Quality Assurance

A. All materials, methods of construction, and workmanship shall conform to applicable requirements of ASTM, PTM, PennDOT Standard Specifications and AASHTO Standards, PADEP Clean Fill Guidance, unless otherwise specified.

B. Soil Testing Laboratory Qualifications: The laboratory shall be an independent laboratory, recognized by the State Department of Agriculture. The testing laboratory must have experience in performing agronomic testing including physical and chemical properties of soil. Tests shall be made in strict compliance with the standards of the Association of Official Analytical Chemists and follow standards from the NRCS Soils Manual and ASTM testing methods applicable to the specific tests requested. Laboratory shall have staff fully qualified to review test results, and to make recommendations to amend samples based on what is planned to grow in the soil. American Association for Laboratory Accreditation (A2LA) certification is preferred.
    1. Compost that participates in the US Composting Council’s Seal of Testing Assurance (STA) Program and tested through an STA program lab, using appropriate test methods from the TMECC (Test Methods for the Examination of Compost and Composting) is preferred. Test data shall be presented on a Compost Technical Data Sheet.

C. Any fill or topsoil sources, disposal areas, or temporary offsite storage locations shall be subject to review and approval by the Landscape Architect and the University.

D. Installer Qualifications: The installer shall be a firm having at least five (5) years of experience of a scope similar to that required for the work.
    1. Installer Field Supervision: When any soil work is in progress, installer shall maintain, on-site, an experienced full-time supervisor.
    2. Installer’s field supervisor shall have a minimum of five (5) years experience as a field supervisor installing soil, shall be trained and proficient in the use of field surveying equipment to establish grades.

1.10 Delivery, Storage, and Handling

A. Preparation, amendment, and mixing of soils shall be performed at the soil supplier location.

B. Weather: Do not mix, deliver, place or grade soils when frozen or with moisture above field capacity. Soils shall not be handled, hauled, placed, or compacted when wet or frozen. Soil shall only be handled when the moisture content is between the specified ranges in percent water by volume.

C. Protect soil and soil stockpiles, including the stockpiles at the soil blender's yard, from wind, rain and washing that can erode soil or separate fines and coarse material, and contamination by chemicals, dust and debris that may be detrimental to plants or soil drainage. Once spread, soils shall be protected with staked erosion control blankets.

D. All manufactured packaged products and material shall be delivered to the site in unopened containers and stored in a dry enclosed space suitable for the material and meeting all environmental regulations. Biological additives shall be protected from extreme cold and heat. All products shall be freshly manufactured and dated for the year in which the products are to be used.

E. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.

F. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.

G. None of the soil materials shall be delivered to the site until sample certifications are approved by the Landscape Architect, however, such approval does not constitute final acceptance. Certification submittal shall include recommended soil amendment products if proposed to modify the soils. Any approval of soils made conditional upon utilizing one or more amendments shall be understood to afford to the Landscape Architect the right for further testing and refusal of materials that do not meet these Specifications.

PART 2 - PRODUCTS

2.1 Individual Components for Soil Mixes

A. Topsoil

1. Topsoil definition: Topsoil shall be a harvested from the Project Site or fields or development sites and shall be loose, friable mineral particles resulting from natural soil formation from the A, E and upper B horizons, or "solum" where most plant roots grow. Manufactured soils where sand, composted organic material, chemical additives or similar elements has been blended to meet the requirements of Topsoil is not acceptable. The soil shall be free of construction and trash debris, rocks, hydrocarbons, petroleum materials, herbicides, or other harmful contaminants that would impact plant growth.
   a. Topsoil shall comply with the following parameters:
      i) Organic matter (ASTM F1647, Method A): 1.5% minimum (by dry weight).
      ii) pH (1 soil : 1 water): 5.0 - 7.0.
   b. Stockpiled Existing Topsoil at the site meeting the above criteria may be acceptable.

B. Organic Amendment / Compost

1. Compost is as defined by the "US Composting Council Landscape Architecture / Design Specifications for Compost Use, Planting Bed Establishment with Compost". Compost shall be a well decomposed, stable, weed free organic matter source. It shall be derived from: agricultural, food, or industrial residuals; leaf litter and yard trimmings; or source-separated waste. The product shall contain no substances toxic to plants and shall be reasonably free (< 1% by dry weight) of man-made foreign matter. The compost will possess no objectionable odors and shall not resemble the raw material from which it was derived.
2. Compost shall comply with the following parameters:

a. pH: 6.0 - 8.0.
b. Soluble salt content (electrical conductivity, 1 soil : 2 water): maximum 5 dS/m (mmhos/cm).
c. Compost derived from stabilized mushroom soil compost may possess a maximum EC of 10 dS/m (1:2), if the maturity testing is a minimum of 95% and ammonia (NH4) content is a maximum of 250 ppm.
d. Moisture content %, wet weight basis: 30 – 60.
e. Organic Matter Content, % dry weight basis: 30 – 65.
f. Particle size, dry weight basis: 98% pass through 1/2 inch screen.
g. Stability carbon dioxide evolution rate: mg CO2-C/ g OM/ day ≤ 3.
h. Maturity, seed emergence and seedling vigor, % relative to positive control: minimum 80%.
i. Physical contaminants (inerts), %, dry weight basis: <0.5%.
j. Chemical contaminants, mg/kg (ppm): meet or exceed US EPA Class A standard, 40CFR § 503.13, Tables 3 levels.
k. Biological contaminants select pathogens fecal coliform bacteria, or salmonella, meet or exceed US EPA Class A standard, 40 CFR § 503.32(a) level requirements.

C. Coarse Sand

1. Sharp natural or manufactured fine aggregate shall be hard and durable and free of limestone (calcareous sand), shale and slate particles and free of harmful contaminants that would impact plant growth complying with the following parameters:
   a. pH shall be lower than 7.0.
   b. Sieve analysis:

Sieve	Percent passing (by mass)
3/8 inch (9.5 mm)	100
No 4 (4.75 mm)	95-100
No 8 (2.36 mm)	80-100
No 16 (1.18 mm)	50-85
No 30 (.60 mm)	25-75
No 50 (.30 mm)	5-40
No 100 (.15 mm)	2-20
No 200 (0.75 mm)	2-15

   c. Particle analysis must be per USDA classification, Sand.

Sand (2 - 0.05 mm):	≥88%
Silt (0.05 - 0.002 mm):	≤9%
Clay (< 0.002 mm):	≤3%

D. Chemical Amendments

1. Lime, ASTM C 602, agricultural limestone containing a minimum 80 percent calcium carbonate equivalent and as follows:
   a. Class: Class T, with a minimum 99 percent passing through No. 8 sieve and a minimum 75 percent passing through No. 60 sieve.
   b. Provide lime in form of dolomitic limestone.

2.2 Soil Mixes Using Individual Components

A. Definition

1. Manufactured uniformly mixed individual soil components (Salvaged Topsoil, Topsoil, Sand, Compost) meeting the criteria specified herein. Provide Soils at the locations indicated on the Drawings complying with the following parameters.

B. Planting Soil, Plant Beds and Lawn

1. Planting soil shall be manufactured from uniformly mixed individual soil components (Salvaged Topsoil, Sand, Compost) or existing mineral soil at the locations of proposed planting meeting the criteria specified herein.
2. Provide Planting Soil at the locations indicated on the Drawings complying with the following parameters:
   a. Particle analysis must be per USDA classification for loam, sandy loam, sandy clay loam, or silt loam within the following parameters using ASTM D422:
      Sand: 45 - 55%
      Silt: no more than 30%
      Clay: no more than 20%
      Gravel content larger than 2mm shall be less than 12%.
   b. pH (1 soil : 1 water): 6.0 - 7.2.
   c. Organic matter (ASTM F1647, Method A): 3 - 6% (by dry weight).
   d. Hydraulic conductivity (ASTM F1815) at 85% Proctor (ASTM D698): 1.0 in/hr +/- 0.5 in/hr
   e. Soluble salt content (electrical conductivity, 1 soil : 2 water): maximum 1.60 mmho/cm. Sodium (Na) salinity shall not exceed 700 ppm.
   f. Cation Exchange Capacity (CEC): >15 meq/100g.
   g. Nutrient analysis including macronutrients and micronutrients (Mehlich-3) with soil fertility interpretation and recommendations relevant to the specified plant species.
   h. Compost shall not be added at more than 30% by volume.

C. Erosion Control Mat
1. Straw Blanket
   a. For use on 4:1 to 3:1 slopes with moderate runoff conditions: utilize ECS-1 Single Net Straw Rolled Erosion Control Blanket, East Coast Erosion Blankets, 443 Bricker Road, Bernville, PA 19506, 800-582-4005, www.erosionblankets.com, or approved equal.
   b. Matting containing non-degradable plastic mesh is prohibited.
2. Straw Mulch:
   a. For use on slopes less than or equal 4:1 with minimal runoff conditions: utilize mildew-free and seed-free salt hay with a nonasphaltic liquid tackifier.

D. Amendments

1. At the time of final grading, add fertilizer if required to the Planting Soil at rates recommended by the testing results for the species of plants to be grown.

PART 3 - EXECUTION

3.1 SITE EXAMINATION

A. Prior to installation of soil, examine site to confirm that existing conditions are satisfactory for the work of this section to proceed. The Landscape Architect shall approve the condition of the subgrade and the previously installed subgrade preparation and the installation of subsurface drainage.

1. Confirm that the subgrade is at the proper elevation and compacted as required. Subgrade elevations shall slope toward the under drain lines as shown on the Drawings.
    a. Subgrade definition: surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing Planting Soil.
2. Confirm that all surface areas to be filled with Soil are free of construction debris, refuse, compressible or biodegradable materials, stones greater than 2 inches diameter, soil crusting films of silt or clay that reduces or stops drainage from the Soil into the subsoil; and/or standing water. Remove unsuitable material from the site.
    a. Debris definition: Elements including, but not limited to, concrete, concrete masonry, wood, excavated rock and rock fragments, rubble, overburden soils, abandoned utility structures, trash, refuse and litter.
3. Confirm that no adverse drainage conditions are present.
4. Confirm that no conditions are present which are detrimental to plant growth.

B. If unsatisfactory conditions are encountered, notify the Landscape Architect immediately to determine corrective action before proceeding.

3.2 SOIL INSTALLATION

A. All equipment utilized to install or grade Soils shall be wide track or balloon tire machines rated with a ground pressure of 4 psi or less. All grading and soil delivery equipment shall have buckets equipped with 6 inch long teeth to scarify any soil that becomes compacted.

B. In areas of soil installation above existing subsoil, scarify the subgrade material prior to installing Soil.

1. Scarify the subsoil of the subgrade to a depth of 3 – 6 inches with the teeth of the back hoe or loader bucket, tiller or other suitable device.
2. Immediately install the Planting Soil. Protect the loosened area from traffic. DO NOT allow the loosened subgrade to become compacted.
3. In the event that the loosened area becomes overly compacted, loosen the area again prior to installing the Planting Soil.

C. Install the Planting Soil in 6 inch lifts to the required depths. Minimum depth of planting soil in plant beds is 24 inches or as shown on the Drawings.

1. Apply compacting forces to each lift as required to attain the required compaction. Scarify the top of each lift prior to adding more Planting Soil by dragging the teeth of a loader bucket or backhoe across the soil surface to roughen the surface.
2. Approved compaction equipment includes a smooth drum roller or plate compactor. Typically one to three passes per lift will achieve the desired compaction. Contractor to test desired compaction methodology with actual soil to be installed to confirm installation method and material properties are compatible and will achieve the specified compaction rates.
3. Provide adequate equipment to achieve consistent and uniform compaction of the Soils. Use the smallest equipment that can reasonably perform the task of spreading and compaction. Use the same equipment and methods of compaction for the entire project area once soil, installation methodology, and compaction critieria have been coordinated and confirmed.

D. Do not pass motorized equipment over previously installed and compacted soil except as authorized below.

1. Light weight equipment such as trenching machines or motorized wheel barrows is permitted to pass over finished soil work.
2. If work after the installation and compaction of soil compacts the soil to levels greater than the above requirements, follow the requirements of Over Compaction Reduction herein.

E. Phase work such that equipment to deliver or grade soil does not have to operate over previously installed Planting Soil. Work in rows of lifts the width of the extension of the bucket on the loader. Install all lifts in one row before proceeding to the next. Work out from the furthest part of each bed from the soil delivery point to the edge of each bed area.

F. Where travel over installed soil is unavoidable, limit paths of traffic to reduce the impact of compaction in Planting Soil. Each time equipment passes over the installed soil it shall reverse out of the area along the same path with the teeth of the bucket dropped to scarify the soil. Comply with Over Compaction Reduction herein in the event that soil becomes over compacted. Access over finished grade soils shall be restricted. If access is required across placed soils, Contractor shall be required to rework compacted soil areas prior to fine grading to the full depth of the placed soils as directed by the Landscape Architect.

G. The depths and grades shown on the Drawings are the final grades after settlement and shrinkage of the compost material. The Contractor shall install the Planting Soil at a higher level to anticipate this reduction of Soil volume. A minimum settlement of approximately 10 - 15% of the soil depth is expected. All grade increases are assumed to be as measured prior to addition of surface Compost till layer, or mulch.

H. Maintain moisture conditions within the Soil during installation or modification to allow for satisfactory compaction.

1. Volumetric soil moisture level during installation shall be above permanent wilt point and below field capacity for each type of soil texture within the following ranges.

Soil texture	Permanent wilting point	Field capacity
Sand, Loamy sand, Sandy loam	5-8%	12-18%
Loam, Sandy clay, Sandy clay loam	14-25%	27-36%
Clay loam, Silt loam	11-22%	31-36%
Silty clay, Silty clay loam	22-27%	38-41%

2. The Contractor shall confirm the soil moisture levels with a moisture meter (Digital Soil Moisture Meter, DSMM500 by General Specialty Tools and Instruments, or approved equivalent). Suspend operations if the Soil becomes wet. Apply water if the soil is overly dry.

I. Installing Planting Soil with soil or mulch blowers or soil slingers is not permitted.

3.3 SOIL COMPACTION REQUIREMENTS FOR PLANT BEDS AND LAWN

A. The following are threshold levels of compaction as determined by each method for the subsoil surface and full profile of Planting Soil, testing each lift of Soil with a penetrometer. The same penetrometer and moisture meter shall be used to test installed soil throughout the work.

1. Acceptable Compaction
   a. Standard Proctor Method – 75-85%.
   b. Penetration Resistance Method – about 75-250 psi.
   c. Soil below 75 psi soil becomes increasingly unstable and will settle excessively.

2. Unacceptable Compaction
   a. Standard Proctor Method – Above 85%.
   b. Penetration Resistance Method – Approximately above 300 psi
3. Prior to testing the soil with the penetrometer check the soil moisture. Penetrometer readings are impacted by soil moisture and excessively wet or dry soils will read significantly lower or higher than soils at optimum moisture.
4. The penetrometer readings shall be within 20% plus or minus of the specified levels.
5. Where the Standard Proctor Method is utilized, the following Bulk Density levels based on 75% minimum and 85% maximum standard Proctor indicate acceptable compaction.

Soil Texture	Bulk Density (g/cm^3)	
	Max.	Min.
Loamy Sand	1.80	1.65
Sandy Loam	1.65	1.45
Sandy Clay Loam	1.55	1.35
Loam	1.50	1.30
Silt Loam	1.45	1.25

3.4 OVER COMPACTION REDUCTION

A. Compacted soil: soil where the density of the soil, at each lift for the full profile, is greater that the threshold for root limiting, and further defined in this specification.

B. Any soil that becomes compacted to a density greater than the specified density shall be dug up and reinstalled. This requirement includes compaction caused by other sub-contractors after the Planting Soil is installed and approved.

C. Surface roto tilling shall not be considered adequate to reduce over compaction at levels 6 inches or greater below finished grade.

3.5 INSTALLATION OF CHEMICAL ADDITIVES

A. Following the installation of each soil and prior to fine grading and installation of the Compost till layer, apply chemical additives as recommended by the soil test, and appropriate to the soil and specific plants to be installed.

B. Types, application rates and methods of application shall be approved by the Landscape Architect prior to any applications.

3.6 FINE GRADING

A. Fine grading: The final grading of the soil to achieve exact contours and positive drainage, often accomplished by hand rakes or drag rakes other suitable devices, and further defined in this specification, and further defined in this specification.

B. The Landscape Architect shall approve all rough grading prior to the installation of Compost, fine grading

C. Grade the finish surface of all planted areas to meet the grades shown on the Drawings, allowing the finished grades to remain higher than the grades on the grading plan, as defined in paragraph Soil Installation, to anticipate settlement over the first year.

D. Utilize hand equipment, small garden tractors with rakes, or small garden tractors with buckets with teeth for fine grading to keep surface rough without further compaction. Do not use the flat bottom of a loader bucket to fine grade, as it will cause the finished grade to become overly smooth and or slightly compressed.

E. Provide for positive drainage from all areas toward the existing inlets, drainage structures and or the edges of planting beds. Adjust grades as directed to reflect actual constructed field conditions of paving, wall and inlet elevations. Notify the Landscape Architect in the event that conditions make it impossible to achieve positive drainage.

F. Provide smooth, rounded transitions between slopes of different gradients and direction. Modify the grade so that the finish grade before adding mulch and after settlement is one or two inches below all paving surfaces or as directed by the Drawings.

3.7 INSTALLATION OF IN-SITU COMPOST AMENDMENT

A. After Planting Soil is installed in planting bed areas, spread 2 – 3 inches of Compost over the beds and roto till into the top 4 - 6 inches of the Planting Soil. This step will raise grades slightly above the grades required in Fine Grading herein. This specification anticipates that the raise in grade due to this tilling will settle within a few months after installation as Compost breaks down. Additional settlement as defined in paragraph “Soil Installation” must still be accounted for in the setting of final grades.

B. Soil Tilling: Loosening the surface of the soil to the depths specified with a rotary tine tilling machine, roto tiller, (or spade tiller), and further defined in this specification.

3.8 PROTECTION

A. Protect areas of in-place soil from additional compaction, disturbance, and contamination. Prohibit the following practices within these areas except as required to perform planting operations:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Vehicle traffic.
4. Foot traffic.
5. Erection of sheds or structures.
6. Impoundment of water.
7. Excavation or other digging unless otherwise indicated.

B. If planting soil or subgrade is overcompacted, disturbed, or contaminated by foreign or deleterious materials or liquids, remove the planting soil and contamination; restore the subgrade as directed by the Landscape Architect and replace contaminated planting soil with new planting soil.

3.9 CLEANING

A. Protect areas adjacent to planting-soil preparation and placement areas from contamination. Keep adjacent paving and construction clean and work area in an orderly condition.

B. Remove surplus soil and waste material including excess subsoil, unsuitable materials, trash, and debris and legally dispose of them off Owner's property unless otherwise indicated.

END OF SECTION

SECTION 329200 - LAWN AND FINE GRADING

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. Seeding of lawns.

2. Maintenance of lawn areas until acceptance.

B. Related Sections:

1. Division 2 Section “Planting”.
2. Division 2 Section “Soil Preparation”.

1.3 DEFINITIONS

A. Finish Grade: Elevation of finished surface of planting soil.

B. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.

C. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.

D. Topsoil: Native or Imported topsoil. See Soil Preparation section.

E. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.

1.4 SUBMITTALS

A. Submit prior to delivery of materials to site.

1. Submit seed mixes for review.

B. Certifications: Submit certificate with names of materials and manufacturer.

1. Ground limestone: Include guaranteed analysis, and weight for packaged material.
2. Commercial fertilizers: Include guaranteed analysis.
3. Seed: include origin of seed.

C. Product data: Submit product literature or tear sheets with name of product, and manufacturer.
1. Commercial fertilizer, including type and application rate.

D. Source of supply: Submit in writing all proposed sources.

E. Test reports: Submit test reports at least three (3) weeks prior to delivery of materials to site.
1. Seed: Test for purity, proportion by weight, weed seed content and germination percentage of all seed mixture proposed for use. No seed shall be delivered until the test reports are approved. All seed shall be tested within six (6) months immediately preceding date of sowing. Seed must comply with all Commonwealth of Pennsylvania seed certifications.

A. Qualification Data: For qualified landscape Installer.

B. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of turf during a calendar year. Submit before expiration of required initial maintenance periods.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape Installer whose work has resulted in successful turf establishment.

1. Experience: Five (5) years' experience in turf installation in projects of similar complexity in addition to requirements in Division 1 Section "Quality Requirements."
2. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
3. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.
4. Pesticide Applicator: State licensed, commercial.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Packaged materials: Deliver packaged materials in clearly marked containers showing net weight, guaranteed analysis and name of manufacturer. Specified requirements for packaged materials apply to bulk shipments. Protect materials from deterioration during delivery and during storage at site.
1. Deliver fertilizer and limestone in waterproof bags.
2. All seed shall be labeled to show compliance with requirements of governmental agencies having jurisdiction. All bag tags of seed used shall be retained and if requested, submitted to Owner. Seed shall be kept in dry storage away from contaminants, insects and rodents.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.

2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.

1.7 PROJECT CONDITIONS

A. Protection of existing conditions adjacent to and within construction zone:

1. All necessary precautions for safety including barricades and other protection measures shall be taken during all work.

2. All heavy equipment shall be driven or parked on the site only where approved by Owner.

3. Existing pavements, lawns, structures, walls, etc. damaged or disturbed during construction shall be repaired or replaced to the satisfaction of the Owner.

4. Repair and replace all active utility lines, above and below grade, damaged in the course of construction operations.

5. Avoid damaging existing trees. Damage includes but is not limited to: cutting, breaking, skinning or compacting of roots, skinning and bruising of bark and breaking of branches and limbs.

a. Contractor shall not park or store equipment and supplies within four (4) feet of trunk of existing trees to remain.

B. Environmental requirements:

1. Seed only between April 1 - June 15 and September 1 - October 15, unless otherwise permitted by the Owner.

2. Do not seed during adverse weather, windy conditions or on wet or frozen ground.

PART 2 - PRODUCTS

2.1 SEED

A. Fresh, clean, new seed. Seed shall be packed in sealed 50 lb. bags showing net weight, composition of mix, date of germination tests and supplier's name. Germination test must be done within a nine-month period prior to sale of the seed.

1. Seed shall not contain in excess of 0.1% by weight weed seed, no more than 1.5% inert matter, and no more than 0.1% other crop seed and no noxious weed seed or undesirable grass species. Comply with state laws governing noxious weeds. Seed containing prohibited or restricted noxious weeds shall not be accepted.

2. Seed shall be Pennsylvania certified and blue tagged.

B. Composition of the mix shall be a turf-type tall fescue blend of 60% of at least three (3) varieties of turf-type tall fescue, 30% of Perennial Rye Grass, and no more than 10% Kentucky Bluegrass.

2.2 LIMESTONE

A. In accordance with soil test recommendations, provide ground, high magnesium limestone containing not less than 85% total carbonates, 95% passing a 20 mesh sieve, 40% passing a 60 mesh sieve and a minimum of 30% percent passing a 100 mesh sieve.

2.3 MULCH

A. Mulch shall consist of specially prepared wood cellulose processed into a uniform fibrous physical state. Wood cellulose fiber mulch shall be dyed green or contain a green dye in the package that will provide an appropriate color to facilitate visual inspection of the uniformly spread slurry. The fiber

mulch, including dye, shall contain no germination or growth inhibiting factors. The mulch material shall be manufactured and processed in such a manner that the wood cellulose fiber mulch will remain in uniform suspension in water under agitation and will blend with other additives to form a homogenous slurry. The mulch material shall form a blotter-like ground cover, on application, having moisture absorption and percolation properties and shall cover and hold grass seed in contact with the soil without inhibiting the growth of the grass seedlings.

B. Mulch shall contain no elements or compounds at concentration levels that will be phytotoxic. Wood cellulose fiber must conform to the following physical requirements:

1. fiber length to be approximately 10 mm
2. diameter approximately 1 mm
3. pH range of 4.0 to 8.5
4. ash content of 1.6% maximum
5. water holding capacity of 90% minimum

C. Slope stabilization: in areas where erosion may occur, use an organic tackifier such as CON-TACK or an erosion fabric or approved equal, in accordance with manufacturer's instructions.

2.4 WATER

A. Potable, clean fresh and free from harmful materials. Contractor shall provide all means of conveyance including hoses, sprinklers, tank trucks or other means which may be required to water lawns until accepted by Owner.

2.5 FERTILIZER

A. A standard complete slow release fertilizer. At least 50% by weight of the nitrogen content of the fertilizer shall be derived from organic materials with the remainder in urea form or equivalent. Fertilizer shall contain percent nitrogen, phosphorous, and potash by weight of ingredients dictated by the topsoil test results.

1. Fertilizer shall be in bags showing weight, analysis, and manufacturer's name

2.6 PESTICIDES

A. General: Pesticide, registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.

B. Pre-Emergent and Post-Emergent Herbicides (Selective and Non-Selective) shall only be used with written authorization by the Owner.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.

1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
2. Do not work soil in frozen, wet, or muddy conditions.
3. Uniformly moisten excessively dry soil that is not workable and which is too dusty.

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

C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Owner and replace with new planting soil as specified in Division 2 Section “Soil Preparation”.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 TURF AREA PREPARATION

A. Grass seed shall be applied to all disturbed areas a result of this project.

B. Preparation of surface for seeded areas (except within root zones of existing trees):

1. Vertically aerate soil if it has become compacted as a result of construction activities.
2. Prior to applying soil amenities, roll lawn area with a filled water roller. Correct any surface irregularities to prevent formation of low spots.
3. If required by soil test, evenly distribute ground limestone at the recommended rate. Work lightly into the top four (4) inches of topsoil at least one full week prior to applying fertilizer.
4. Spread starter fertilizer uniformly, at the rate determined by soil test for new lawns. Add organic matter 1" deep, if required by soil test.
5. Go over the entire area with a spike drag or rototiller and loosen surface at least 3" deep and then hand rake to a smooth, even surface.

C. Seeding

1. As soon as ground has been properly prepared, sow grass seed at the rate of 6 lbs. per 1,000 sq. ft. total. Distribute seed evenly over entire area by sowing equal quantity in two directions at right angles to each other.
   a. Use suitable mechanical seeder to sow by hand for small areas.
2. Cover seed with a thin layer of topsoil by light raking.
3. Roll seed in both directions very lightly with an empty water roller.
4. After seed application, apply mulch at a net dry weight of 1,500 lbs. per acre. Mulch shall be mixed with water and the mixture shall contain a maximum of 50 lbs. of wood cellulose fiber per 100 gallons of water. Use a slope stabilizing device in areas where erosion may occur.
5. Water with a fine spray immediately after seeding operations are completed.

a. Water all newly installed seeded areas as necessary to keep lawn healthy. Apply water in sufficient quantities so it penetrates four (4) inches into planting soil without puddling. Continue watering until seeded areas are accepted by the Owner.

6. Protect all newly seeded lawn areas from damage.

7. When seeding occurs after acceptable seeding dates, over winter protection shall consist of applying five bales clean straw per 1,000 sq. ft. and anchor mulch by commercial mulch netting or 20 lbs./1,000 sq. ft. cellulose fiber. Asphalt emulsion anchoring is not permitted.

3.4 TURF MAINTENANCE

A. Begin maintenance immediately after each lawn area is restored.

1. All lawn areas shall be watered and kept moist to maximize germination.

a. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch.

b. Seed: Water seeded areas as often as required to keep the top 1-inch of soil moist until the seed germinates. Avoid excessive water that will cause the seeds to rot. Once seedlings have germinated and established reduce watering frequency and increase volume for deeper watering. Continually adjust irrigation system until intervals have been stretched to the greatest extent practical.

2. All areas and spots which do not show a prompt catch of grass shall be reseeded and this operation repeated until complete coverage is obtained.

3. When the area does not need to be reseeded, it shall be thoroughly wetted every time the surface shows evidence of drying out and this shall continue through entire period of maintenance.

4. When the average height is 3-4" and the lawn areas are fully germinated, firmly rooted and secure in place, grass shall be cut to 2-3" or 1/3 of the grass blade. Any depressions or irregularities in the lawn surface shall be leveled off and reseeded.

5. Maintenance shall cease after the third mowing, provided all grass areas are properly established and free of washouts, depressions, bare spots, weeds and large off-color areas. If seeding is done in the autumn, the Contractor shall complete the three mowings in the following spring.

6. All lawns shall show a uniform, thick, well-developed stand of grass. If the grass stand is unsatisfactory, the Contractor's maintenance responsibility shall continue until an acceptable stand of grass is achieved.

3.5 SATISFACTORY LAWN

A. Seed installations shall meet the following criteria as determined by Owner:

1. Satisfactory Lawn: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.
2. Provide at minimum three (3) mowings in accordance with grass height requirements.

B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.

3.6 PESTICIDE APPLICATION

A. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with Owner's operations and others in proximity to the Work. Notify Owner before each application is performed.

B. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

C. Notification signage must be posted at every entrance in a highly visible location at least five (5) days in advance of application and maintained five (5) business days following application, or as recommended by the manufacturer's instructions, whereby it is then removed from the site.

1. Notification Signage shall be brightly colored, laminated and at least 8.5" by 11" format including the following information:

a. Date of Notification.
b. Date of Application.
c. Name of Chemical.
d. Reason for Chemical Application.
e. Information informing as to the precautions that must be taken including humans and pets.

3.7 CLEANUP AND PROTECTION

A. Do not allow soil and debris created by turf work onto permeable unit paving areas. Promptly clean up any soil or debris on impervious paving areas, such as concrete sidewalk or roadway paving. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.

B. Protection of newly planted lawn areas is critical to healthy establishment. Erect temporary protection fencing and warning signs to protect newly planted areas from traffic. Maintain fencing throughout initial maintenance period. Remove protection fencing only after lawn areas have become well established and are able to tolerate regular use. Install temporary protection fencing and signage in accordance with the following:

1. Temporary Protection Fencing

a. Fencing shall cordon off the entire perimeter of lawn area to prevent access.
b. Fencing shall be supported securely as required to remain erect for duration of site protection. Utilize heavy-duty 12 gauge minimum metal fence posts spaced at 6 to 8 feet on center, or as required. Posts shall be driven into the soil sufficient depth to support fencing against heavy wind load.
c. Fencing shall be at least 4-foot high. Secure fencing to posts at the top and bottom and in at least one location in the middle with zip or cable ties. Fencing may also be woven through each post and secured at the top only with a zip tie.

2. Signage: Notification signage shall be brightly colored, laminated and at least 8.5" by 11" format attached to fencing every 10 to 12 feet, including the following information.

a. “Please keep off lawn areas. Lawn will be available once protection fencing has been removed.”

C. If utilized, remove non-degradable erosion-control measures after grass establishment period.

END OF SECTION 329200

SECTION 329300 - PLANTS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes:
   1. Provide trees and groundcover and all necessary accessories.
   2. Maintenance and replacement during Establishment Period.

1.2 RELATED SECTIONS

A. Section 329100 – Planting Preparation

B. Section 329200 – Lawns and Fine Grading

1.3 REFERENCES

A. The following apply to work in this Section:

   1. ASNS: “American Standard for Nursery Stock,” latest edition, published by the American Nursery and Landscape Association.
   2. NAA: “National Arborist Association Standards for Pruning”, latest edition, published by the National Arborist Association.
   3. ANSI: “American National Standards Institute”, latest edition.

1.4 SUBMITTALS

A. Certifications: Submit certificate with names of materials and manufacturer.

   1. Plants: Furnish certificates of inspection as may be required by Federal, State or other authorities that plants are free of disease or hazardous insects.
   2. Commercial fertilizers: Include guaranteed analysis.
   3. Ground limestone: include guaranteed analysis and weight for packaged material.
   4. Commercial fertilizers: include guaranteed analysis.

B. Instructions: Submit planting and maintenance schedule.
   1. Submit the proposed planting installation schedule indicating dates for tagging and installation, dates and duration of plant storage at an off-site location, and a detailed program of Establishment Period maintenance.

C. Product data: Submit product literature or tear sheets with name of product, and manufacturer.
   1. Commercial fertilizer.
   2. Mulch.

E. Samples: Submit loose materials in sealed bags labeled with name of material and manufacturer.
   1. Mulch, 1/2 lb. bag.

F. Source of supply: Submit in writing all proposed sources.
   1. Locate trees and make all pre-selection arrangements at the source of supply required to ensure an efficient selection procedure. Landscape Architect, with Contractor present, will select plants at nursery on the basis of their compliance with the Drawings. Contractor shall inspect the selected plants on the basis that the plants are free of disease and otherwise conform to the requirements of the Contract Documents. The accuracy of the varieties of species specified for plant material shall be the Contractor's responsibility. Request visit at least 14 days in advance of desired inspection date.
      a. Trees will be inspected and approval given by Landscape Architect at the source for conformity to Specification requirements. Such approval shall not affect the right of inspection and rejection during delivery and installation.
      b. All trees specified as B&B must be in the ground at the growing source at the time of inspection. Pre-dug trees shall not be acceptable.

1.5 QUALITY ASSURANCE

A. Contractor shall have had experience with at least two (2) other projects of similar scope and complexity and shall perform work with personnel totally familiar with planting installation and general construction techniques under the supervision of an experienced landscape foreperson.

B. Plants: Meet or exceed applicable AAN standards.
   1. Plant List: Investigate sources of supply prior to submitting bid. Confirm that size, variety and quantity of plants specified on Plant List can be supplied. Failure to take this precaution shall not relieve the successful bidder from responsibility for furnishing and installing all plants in strict accordance with Contract requirements.
      a. Substitutions shall not be permitted unless substantiated written proof is supplied that a specified plant is not obtainable. In this situation a proposal to use the nearest equivalent size or variety with an equitable adjustment of Contract Price will be considered.
      b. Plant substitutions will be permitted only upon approval by the Owner and Landscape Architect.
      c. All plants shall be grown on their own roots. No grafted species shall be acceptable.
      d. Plants shall be of the quantity and quality indicated, true to name, properly labeled with botanical name and in accordance with the sizes and grades specified.

1.6 PROJECT CONDITIONS

A. Protection of existing conditions adjacent to and within construction zone:
   1. All necessary precautions for safety including barricades and other protection measures shall be taken during all work.
   2. All heavy equipment shall be driven or parked on the site only where approved by Owner.
   3. Existing pavements, structures, walls, etc. damaged or disturbed during construction shall be repaired or replaced to the satisfaction of the Owner.
   4. Repair and replace all active utility lines, above and below grade, damaged in the course of construction operations.
   5. Avoid damaging existing trees. Damage includes but is not limited to: cutting, breaking, skinning or compacting of roots, skinning and bruising of bark and breaking of branches and limbs.
      a. Contractor shall not park or store equipment and supplies within four (4) feet of trunk of existing trees to remain.

B. Environmental requirements:

1. Plant only within the following dates, weather permitting. Do not plant when ground is frozen, when the soil is excessively wet, when ambient air temperature exceeds 85 degrees or in otherwise unsatisfactory weather conditions.
    a. Plant between March 1 and June 15 and August 15 until the ground freezes.
    b. Plant trees known to be fall digging hazards only in the Spring.
2. Chemical Spraying Program: no spraying of herbicides, insecticides, fungicides, nematicides, fumigants or other chemicals shall be done without first submitting a spray program to the Owner.

1.7 DELIVERY, STORAGE AND HANDLING

A. Packaged materials: Deliver packaged materials in clearly marked containers showing net weight, guaranteed analysis and name of manufacturer. Specified requirements for packaged materials apply to bulk shipments. Protect materials from deterioration during delivery and during storage at site.
    1. Deliver fertilizer in waterproof bags.
    2. All seed shall be labeled to show compliance with requirements of governmental agencies having jurisdiction. All bag tags of seed used shall be retained and if requested, submitted to Owner. Seed shall be kept in dry storage away from contaminants, insects and rodents.

B. Plants: Notify Owner seven (7) days in advance of any delivery of plants to site.
    1. Dig and handle trees with care to prevent injury to trunks, branches and roots. Do not prune prior to delivery. Do not bend or bind-tie trees in such manner as to damage bark, break branches or destroy natural shape. Pack and ship to ensure arrival at site in good condition. Provide protective covering during delivery. Plants with cracked or broken root balls shall not be accepted.
    2. Deliver plants after preparation of planting areas has been completed and approved, install plants immediately.
        a. If planting is delayed more than eight (8) hours after delivery, set balled and burlapped plants on the ground well protected with soil, wet mulch or other acceptable material. Protect balls and roots, and container grown material from freezing, sun, drying winds and/or mechanical damage. Water as necessary until planted.
        b. Do not heel in plants for more than five business days.
    3. Immediately remove rejected plants from site.

1.8 INSPECTION FOR SUBSTANTIAL COMPLETION

A. Plants:
    1. All plants shall be alive, healthy and installed to be accepted.
    2. Guarantee Period for plants shall not begin until all items have been completed or corrected.

1.9 GUARANTEE / ESTABLISHMENT PERIOD FOR PLANTS

A. Contractor shall not be held responsible for acts of vandalism occurring after the beginning of Guarantee Period, nor shall Contractor be held responsible for deleterious effects caused by maintenance procedures performed by Owner without concurrence of Contractor.

B. Replace at no additional cost for a period of two growing seasons after the beginning date of Guarantee Period, any plants that have died or that are, in the opinion of Owner, in unhealthy or unsightly condition, or that have lost their natural shape due to dead branches, excessive pruning, excessive defoliation.
    1. A growing season is defined as the period during which plant growth takes place from last killing frost of Spring to the first killing frost of Autumn.
    2. Replace unacceptable plants no later than the next succeeding planting season. All replacements shall have a guarantee of one planting season from date of replacement.

a. Replace unacceptable plants in accordance with original Specification. Cost is considered to be included in the Bid and Contract Price.

PART 2 PRODUCTS

2.1 PLANTS

A. Provide freshly dug plants nursery grown in accordance with good horticultural practice.
1. Sound, healthy and vigorous, well-branched and fully foliated when in leaf, free from disease, insect pests, eggs or larvae with healthy well-developed root systems.

B Conform to measurements specified on Plant List. Plants shall be measured before pruning, with branches in normal position. Any necessary pruning shall be done at time of planting. Requirements for the measurement, branching, grading, quality, balling, and burlapping of plants shall be in accordance with standards specified in ASNS and conform to ANSI Z.60.1.

C. Provide B&B stock with a compact natural ball of earth, firmly wrapped and tied in burlap so that upon delivery the soil in the ball is still firm and compact about the small feeding roots. Root ball sizes shall be in accordance with standards specified in ASNS.

D. Furnish trees with rootballs measured from top of rootball which shall begin at root flare according to ANSI Z60.1. Root flare shall be visible before trees are dug to ensure proper rootball depth.

E. Plants shall be measured before pruning, with branches in normal position. Any necessary pruning shall be done at time of planting. Requirements for the measurement, branching, grading, quality, balling, and burlapping of plants shall be in accordance with standards specified in ASNS.

2.2 STAKING AND GUYING MATERIALS

A. Tree Stakes: 2” x 2” x 8' long wood posts, minimum 2 per tree, if required.

B. Guys: Nylon straps shall be used wrapped loosely around tree trunks and securely fastened to stakes.

2.4 LIMESTONE

A. In accordance with soil test recommendations, provide ground, high magnesium limestone containing not less than 85% total carbonates, 95% passing a 20 mesh sieve, 40% passing a 60 mesh sieve and a minimum of 30% percent passing a 100 mesh sieve.

2.6 MULCH

A. Double shredded hardwood bark. To be natural in color, free of dye.

2.7 WATER

A. Potable, clean fresh and free from harmful materials.

2.8 HERBICIDES

A. Herbicides, fungicides, and pesticides: Approved before use for type and rate of application by Owner and local, state and/or federal agencies with jurisdiction. Spraying of all herbicides shall be done in accordance with the Chemical Spraying Program.
   1. Non-selective herbicide shall be Round-Up as manufactured by Monsanto or approved equal.

B. A standard complete slow release fertilizer. At least 50% by weight of the nitrogen content of the fertilizer shall be derived from organic materials with the remainder in urea form or equivalent. Fertilizer shall contain percent nitrogen, phosphorous, and potash by weight of ingredients dictated by the topsoil test results.
   1. Fertilizer shall be in bags showing weight, analysis, and manufacturer's name.

2.9. PROTECTION MATERIALS

A. Wood stakes, suitable in length so that 30” minimally is exposed above ground.

B. Durable twine with fluorescent flagging.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that previously installed protection measures are in place.

B. Verify that excavation and grading is complete.

C. Do not begin planting and lawn work until all other work is complete. Planting areas shall be free of waste and debris generated by other construction activities.

D. Beginning installation means acceptance of existing conditions.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees from damage caused by seeding operations.

B. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

C. Planting Pits:
   1. Verify by testing that planting areas are free draining. If planting areas are not free draining notify Owner and submit alternative method of drainage for approval.
   2. Stake out location of trees.
      a. Completely layout planting areas before seeking approval by Landscape Architect and Owner.
   3. Planting pits in plant beds shall be excavated to the depth of the rootball and trees shall be planted on undisturbed soil.
      a. Tree pit excavations shall be circular with vertical sides.
      b. Install sand, as minimally required, to create a leveling bed under root balls of trees.
      c. Install 18" of planting soil continuously in plant beds or as indicated on Drawings.
   4. Remove all existing materials from tree pits and scarify bottom and sides of planting pits and beds.

5. If an impervious hard plan layer exists in the bottom of the pit after excavation, the pits shall be excavated to the depth of the hardpan or 36 inches below the bottom of the ball. Pit shall then receive a 6 inch layer of AASHTO 57 stone, covered with straw or similar material. Remainder of pit shall be backfilled with topsoil as specified.

3.3 PLANT INSTALLATION

A. Planting:
1. Do not plant until trees and planting pits have been approved by Owner and Landscape Architect.
2. Plant trees to a depth such that the bottom of the trunk flare is 1" above finished grade.
3. Plant upright and plumb and faced to give the best appearance or relationship to adjacent plants and structures.
4. Do not pull burlap out from under balls. Remove platforms, wire and surplus binding to the greatest extent possible. Remove burlap from the top and sides of the rootball to the greatest extent possible. Cleanly cut off all broken or frayed roots.
6. Remove all non-biodegradable materials from the planting area.
7. Carefully place planting soil in six (6) inch lifts to avoid injury to roots and to fill all voids. Firmly tamp each lift to prevent settlement.
8. When the planting area is nearly filled, water and allow to soak away. If planting soil settles after watering, add more planting soil to bring to required level.
9. Upon completion of planting operations, water plants thoroughly over the entire planting bed until fully saturated.
    a. Apply water slowly to ensure penetration into the entire root system.
10. Mulch within two (2) days of planting. Install two (2) inches of mulch over tree rootballs, and continuously over entire planting beds. Keep mulch at least 2 inches away from tree trunk.
11. Staking and guying shall be done immediately after trees are planted. Trees shall stand plumb after staking.
    a. Provide a minimum of two (2) stakes per tree.
12. Neatly prune trees to remove broken or badly bruised branches with a clean cut in accordance with NAA standards, and at the time designated by, and to the satisfaction of Owner.
    a. Preserve the plant's natural character,
    b. Perform pruning with clean, sharp tools.

3.4 PLANT MAINTENANCE PRIOR TO SUBSTANTIAL COMPLETION

A. Begin maintenance immediately after each planting area is installed.
1. Provide all care necessary to keep trees healthy including but not limited to: watering, mulching, weeding, fertilizing, pruning and spraying.
2. During periods of inadequate rainfall, as determined by the Owner, all plants shall be watered to maintain a constant suitable moisture level for good plant growth. Contractor shall provide all watering hoses and devices. Owner will provide water source.
3. Weed control shall be by mechanical or hand weeding.
4. Use of herbicides, insecticides, fungicides, nematicides, fumigants or other chemicals are only acceptable upon approval by the Owner.

B. Prior to inspection for Substantial Completion remove all excess soil and debris from site and repair damage resulting from planting operations.

3.7 PLANT GUARANTEE / ESTABLISHMENT PERIOD

A. The Establishment Period will begin upon notice of substantial completion by the Owner.

B. Contractor shall guarantee the plants against defects including death and unsatisfactory growth. Guarantee shall include the purchase of the plants, the rental of any required special equipment necessary to place the plants and the installation of the plants. Contractor shall not be liable for vandalism out of Contractor's control.

C. New plants installed during the Establishment Period shall carry a new establishment period guarantee equal to the original that begins at the time of acceptance of the replacements plant(s). Replacement and repair work shall be re-inspected by the Owner.

D. At the end of the Plant Establishment Period, Owner shall make an inspection to determine that all plants are living and healthy. Any replacement of plants at this time shall be made according to the specifications for that type of plant. New plants installed as part of the original two-year guarantee, shall carry a new one-year guarantee period that begins at the time of acceptance of the replacement plant(s). Any replacement and repair work that is required shall be re-inspected by the Owner.

3.8 PLANT MAINTENANCE DURING ESTABLISHMENT PERIOD

A. General: Perform procedures set forth in the submitted and approved maintenance program for the duration of Guarantee Period.
   1. Inspect all plants at least once a month to locate any disease or pest infestations. If infestation is present, submit a proposed method of control to Owner for approval prior to application of control measures.
   2. Remove dead plants within five (5) business days of notification by Owner or the Owner will remove the plants and bill the Contractor accordingly.
      a. Replacement plants may be installed during the next appropriate planting season.
      b. Replacement plants shall be of the same species and size as specified in the Plant List.
   3. Perform all maintenance procedures, including but not limited to: fertilizing, watering, weeding, and mulching.
      a. Prune, as necessary, to remove dead, diseased and damaged branches.
      b. During periods of inadequate rainfall, all plants shall be watered to maintain a constant suitable moisture level for adequate plant growth. Apply water slowly so as to penetrate the entire root zone. Contractor shall provide water hoses. The Owner shall provide the water source.
      c. Completely remove, by hand pulling, all weeds within mulch areas. Under no circumstances are weeds to attain more than two (2) inches of growth. Herbicide use is acceptable with Owner approval.
      d. Restore mulch around trees as necessary to preserve their appearance and to control weed growth.
      e. If refertilizing of trees is required, apply Ra-Pid-Gro at manufacturer's suggested rate.
      f. If any tree settles from its proper elevation, raise it to the proper level.
      g. If spraying to control insects, fungus, and other diseases is required seek approval from Owner before spraying. Furnish a spray program and product information on all sprays to be used to Owner for approval. After approval, application will only be permitted by licensed applicators. Applicators shall follow Notification requirements and report any Chemical Hypersensitivity Registries for the area.

3.9 FINAL ACCEPTANCE

A. At end of Establishment Period, submit a written request to the Owner for Inspection for Final Acceptance at least two (2) weeks prior to the day on which inspection is requested.

B. At the end of the Establishment Period, Owner and Contractor shall make an inspection to determine that all plants are living and healthy. Any plant that is dead or not in satisfactory condition, as determined by the Owner, shall be removed from the site and replaced in accordance with the specifications.

END OF SECTION

SECTION 330500 - COMMON WORK RESULTS FOR UTILITIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes the following:

1. Piping joining materials.
2. Transition fittings.
3. Dielectric fittings.
4. Sleeves.
5. Identification devices.
6. Grout.
7. Flowable fill.
8. Piped utility demolition.
9. Piping system common requirements.
10. Equipment installation common requirements.
11. Painting.
12. Concrete bases.
13. Metal supports and anchorages.

1.2 DEFINITIONS

A. Exposed Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions.

B. Concealed 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.

C. ABS: Acrylonitrile-butadiene-styrene plastic.

D. CPVC: Chlorinated polyvinyl chloride plastic.

E. PE: Polyethylene plastic.

F. PVC: Polyvinyl chloride plastic.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Dielectric fittings.
2. Identification devices.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.5 QUALITY ASSURANCE

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

B. Steel Piping 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. Comply with ASME A13.1 for lettering size, length of color field, colors, and viewing angles of identification devices.

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

B. Coordinate installation of identifying devices after completing covering and painting if devices are applied to surfaces.

C. Coordinate size and location of concrete bases. Formwork, reinforcement, and concrete requirements are specified in Section 033000 "Cast-in-Place Concrete."

PART 2 - PRODUCTS

2.1 PIPING JOINING MATERIALS

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

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum 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.
2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

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 B32, lead-free alloys. Include water-flushable flux according to ASTM B813.

E. 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.

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

G. Solvent Cements for Joining Plastic Piping:

1. ABS Piping: ASTM D2235.
2. CPVC Piping: ASTM F493.
3. PVC Piping: ASTM D2564. Include primer according to ASTM F656.
4. PVC to ABS Piping Transition: ASTM D3138.

H. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.2 TRANSITION FITTINGS

A. Transition Fittings, General: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

B. Transition Couplings NPS 1-1/2 and Smaller:

1. Underground Piping: Manufactured piping coupling or specified piping system fitting.
2. Aboveground Piping: Specified piping system fitting.

C. AWWA Transition Couplings NPS 2 and Larger:
1. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.

D. Plastic-to-Metal Transition Fittings:
1. Description: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint threaded end.

E. Plastic-to-Metal Transition Unions:
1. Description: MSS SP-107, CPVC and PVC -part union. Include brass or stainless-steel threaded end, solvent-cement-joint or threaded plastic end, rubber O-ring, and union nut.

F. Flexible Transition Couplings for Underground Nonpressure Drainage Piping:
1. Description: ASTM C1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

2.3 DIELECTRIC FITTINGS

A. Dielectric Fittings, General: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.

B. Dielectric Unions:
1. Description: Factory fabricated, union, NPS 2 and smaller.

a. Pressure Rating:[150 psig 180 deg F

b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded ferrous.

C. Dielectric Flanges:
1. Description: Factory-fabricated, bolted, companion-flange assembly, NPS 2-1/2 to NPS 4 and larger.

a. Pressure Rating: 150 psig

b. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Kits:
1. Description: Nonconducting materials for field assembly of companion flanges, NPS 2-1/2 and larger.

a. Pressure Rating: 150 psig

b. Gasket: Neoprene or phenolic.
c. Bolt Sleeves: Phenolic or polyethylene.
d. Washers: Phenolic with steel backing washers.

E. Dielectric Couplings:

1. Description: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining, NPS 3 and smaller.

    a. Pressure Rating: 300 psig at 225 deg F

    b. End Connections: Threaded.

F. Dielectric Nipples:

1. Description: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining.

    a. Pressure Rating: 300 psig at 225 deg F

    b. or grooved.

2.4 SLEEVES

A. Mechanical sleeve seals for pipe penetrations are specified in Section 220517 "Sleeves and Sleeve Seals for Plumbing Piping."

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

C. Steel Pipe Sleeves: ASTM A53/A53M, Type E, Grade B, Schedule 40, galvanized, plain ends.

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

E. Molded PVC Sleeves: Permanent, with nailing flange for attaching to wooden forms.

F. PVC Pipe Sleeves: ASTM D1785, Schedule 40.

G. Molded PE Sleeves: Reusable, PE, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.5 IDENTIFICATION DEVICES

A. General: Products specified are for applications referenced in other utilities Sections. If more than single type is specified for listed applications, selection is Installer's option.

B. Equipment Nameplates: Metal permanently fastened to equipment with data engraved or stamped.

1. Data: Manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and essential data.
2. Location: Accessible and visible.

C. Stencils: Standard stencils prepared with letter sizes complying with recommendations in ASME A13.1. Minimum letter height is 1-1/4 inches for ducts, and 3/4 for access door signs and similar operational instructions.

1. Material: Fiberboard
2. Stencil Paint: Exterior, oil-based, alkyd-gloss black enamel, unless otherwise indicated. Paint may be in pressurized spray-can form.
3. Identification Paint: Exterior, oil-based, alkyd enamel in colors according to ASME A13.1, unless otherwise indicated.

D. Snap-on Plastic Pipe Markers: Manufacturer's standard preprinted, semirigid, snap-on type. Include color-coding according to ASME A13.1, unless otherwise indicated.

E. Pressure-Sensitive Pipe Markers: Manufacturer's standard preprinted, color-coded, pressure-sensitive-vinyl type with permanent adhesive.

F. Pipes with OD, Including Insulation, Less Than 6 Inches Full-band pipe markers, extending 360 degrees around pipe at each location.

G. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Either full-band or strip-type pipe markers, at least three times letter height and of length required for label.

H. Lettering: Manufacturer's standard preprinted captions as selected by Architect.

I. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.

1. Arrows: Either integrally with piping system service lettering to accommodate both directions of flow, or as separate unit on each pipe marker to indicate direction of flow.

J. Plastic Tape: Manufacturer's standard color-coded, pressure-sensitive, self-adhesive vinyl tape, at least 3 mils thick.
1. Width: 1-1/2 inches on pipes with OD, including insulation, less than 6 inches ; 2-1/2 inches (65 mm) for larger pipes.
2. Color: Comply with ASME A13.1, unless otherwise indicated.

K. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch sequenced numbers. Include 5/32-inch hole for fastener.

1. Material: 0.032-inch- (0.8-mm-) thick, polished brass or aluminum.

2. Material: 0.0375-inch- thick stainless steel.
3. Material: 3/32-inch- thick plastic laminate with 2 black surfaces and a white inner layer.
4. Material: Valve manufacturer's standard solid plastic.
5. Size: 1-1/2 inches in diameter, unless otherwise indicated.
6. Shape: As indicated for each piping system.

L. Valve Tag Fasteners: Brass, wire-link or beaded chain; or brass S-hooks.

M. Engraved Plastic-Laminate Signs: ASTM D709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white melamine subcore, unless otherwise indicated. Fabricate in sizes required for message. Provide holes for mechanical fastening.

1. Engraving: Engraver's standard letter style, of sizes and with terms to match equipment identification.

2. Thickness: 1/16 inch for units up to 20 sq. in. or 8 inches in length, and 1/8 inch for larger units.

3. Fasteners: Self-tapping, stainless-steel screws or contact-type permanent adhesive.

N. Plastic Equipment Markers: Manufacturer's standard laminated plastic, in the following color codes:
1. Green: Cooling equipment and components.
2. Yellow: Heating equipment and components.
3. Brown: Energy reclamation equipment and components.
4. Blue: Equipment and components that do not meet criteria above.
5. Hazardous Equipment: Use colors and designs recommended by ASME A13.1.
6. Terminology: Match schedules as closely as possible. Include the following:
a. Name and plan number.

b. Equipment service.
c. Design capacity.
d. Other design parameters such as pressure drop, entering and leaving conditions, and speed.

7. Size: 2-1/2 by 4 inches for control devices, dampers, and valves; 4-1/2 by 6 inches

O. : Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with mat finish suitable for writing.
   1. Size: 3-1/4 by 5-5/8 inches.
   2. Fasteners: Brass grommets and wire.
   3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.

P. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in piped utility identification with corresponding designations indicated. Use numbers, letters, and terms indicated for proper identification, operation, and maintenance of piped utility systems and equipment.

   1. Multiple Systems: Identify individual system number and service if multiple systems of same name are indicated.

2.6 GROUT

A. Description: ASTM C1107, 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.

2.7 FLOWABLE FILL

A. Description: Low-strength-concrete, flowable-slurry mix.
   1. Cement: ASTM C150, Type I, portland.
   2. Density: [115- to 145-lb/cu. ft.
   3. Aggregates: ASTM C33, natural sand, fine and crushed gravel or stone, coarse.
   4. Aggregates: ASTM C33, natural sand, fine.

   5. Admixture: ASTM C618, fly-ash mineral.
   6. Water: Comply with ASTM C94/C94M.
   7. Strength: 100 to 200 psig at 28 days.

PART 3 - EXECUTION

3.1 PIPED UTILITY DEMOLITION

A. Refer to Section 024119 "Selective Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove piped utility 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. Piping to Be Abandoned in Place: Drain piping. Fill abandoned piping with flowable fill, and cap or plug piping with same or compatible piping 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 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 DIELECTRIC FITTING APPLICATIONS

A. Dry Piping Systems: Connect piping of dissimilar metals with the following:
   1. NPS 2 and Smaller: Dielectric unions.
   2. NPS 2-1/2 to NPS 12): Dielectric flanges or dielectric flange kits.

B. Wet Piping Systems: Connect piping of dissimilar metals with the following:
   1. NPS 2 (DN 50) and Smaller: Dielectric couplings or dielectric nipples
   2. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Dielectric nipples.
   3. NPS 2-1/2 to NPS 8 (DN 65 to DN 200): Dielectric nipples[or dielectric flange kits.
   4. NPS 10 and NPS 12 (DN 250 and DN 300): Dielectric flange kits.

3.3 PIPING INSTALLATION

A. Install piping according to the following requirements and utilities 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 the Coordination Drawings.

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 to permit valve servicing.

E. Install piping at indicated slopes.

F. Install piping free of sags and bends.

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

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

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

J. Permanent sleeves are not required for holes formed by removable PE sleeves.

K. Install sleeves for pipes passing through concrete and masonry walls 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 equipment areas or other wet areas 2 inches above finished floor level.

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

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

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

L. Verify final equipment locations for roughing-in.

M. Refer to equipment specifications in other Sections for roughing-in requirements.

3.4 PIPING JOINT CONSTRUCTION

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

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

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

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. Grooved Joints: Assemble joints with grooved-end pipe coupling with coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

H. Soldered Joints: Apply ASTM B813 water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B828 or CDA's "Copper Tube Handbook," using lead-free solder alloy (0.20 percent maximum lead content) complying with ASTM B32.

I. 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.

J. Pressure-Sealed Joints: Assemble joints for plain-end copper tube and mechanical pressure seal fitting with proprietary crimping tool to according to fitting manufacturer's written instructions.

K. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F402 for safe-handling practice of cleaners, primers, and solvent cements.
2. ABS Piping: Join according to ASTM D2235 and ASTM D2661 appendixes.
3. CPVC Piping: Join according to ASTM D2846/D2846M Appendix.
4. PVC Pressure Piping: Join schedule number ASTM D1785, PVC pipe and PVC socket fittings according to ASTM D2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D2855.
5. PVC Nonpressure Piping: Join according to ASTM D2855.
6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D3138 Appendix.

L. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D3139.

M. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D3212.

N. Plastic Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D2657.

1. Plain-End PE Pipe and Fittings: Use butt fusion.
2. Plain-End PE Pipe and Socket Fittings: Use socket fusion.

O. Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.5 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. Install dielectric fittings at connections of dissimilar metal pipes.

3.6 EQUIPMENT INSTALLATION

A. Install equipment level and plumb, unless otherwise indicated.

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

C. Install equipment to allow right of way to piping systems installed at required slope.

3.7 PAINTING

A. Painting of piped utility systems, equipment, and components is specified in Section 099113 "Exterior Painting," Section 099123 "Interior Painting," and Section 099600 "High-Performance Coatings."

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

3.8 IDENTIFICATION

A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.

1. Stenciled Markers: According to ASME A13.1.
2. Plastic markers, with application systems. Install on insulation segment if required for hot noninsulated piping.
3. Locate pipe markers on exposed piping according to the following:

a. Near each valve and control device.
b. Near each branch, excluding short takeoffs for equipment and terminal units. Mark each pipe at branch if flow pattern is not obvious.
c. Near locations where pipes pass through walls or floors or enter inaccessible enclosures.
d. At manholes and similar access points that permit view of concealed piping.
e. Near major equipment items and other points of origination and termination.

B. Equipment: Install engraved plastic-laminate sign or equipment marker on or near each major item of equipment.

1. Lettering Size: Minimum 1/4 inch high for name of unit if viewing distance is less than 24 inches, 1/2 inch high for distances up to 72 inches, and proportionately larger lettering for greater distances. Provide secondary lettering two-thirds to three-fourths of size of principal lettering.
2. Text of Signs: Provide name of identified unit. Include text to distinguish among multiple units, inform user of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.

C. Adjusting: Relocate identifying devices that become visually blocked by work of this or other Divisions.

3.9 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 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 033000 "Cast-in-Place Concrete."

3.10 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Section 055000 "Metal Fabrications" for structural steel.

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

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

3.11 GROUTING

A. Mix and install grout for 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 330500

SECTION 333000 – FACILITY SANITARY SEWERS

PART 1 GENERAL

1.1. SUMMARY

A. Provide sanitary sewer systems for facility and buildings.

1.2. SUBMITTALS

A. Product Data: Submit manufacturer's product data and installation instructions for each material and product used.

1.3. QUALITY ASSURANCE

A. Comply with governing codes and regulations. Provide products of acceptable manufacturers, which have been in satisfactory use in similar service for three years. Use experienced installers. Deliver, handle, and store materials in accordance with manufacturer's instructions.

PART 2 PRODUCTS

2.1 DUCTILE-IRON, GRAVITY SEWER PIPE AND FITTINGS
Pipe: ASTM A746, for push-on joints.
Standard Fittings: AWWA C110/A21.10, ductile or gray iron, for push-on joints.
Compact Fittings: AWWA C153/A21.53, ductile iron, for push-on joints.
Gaskets: AWWA C111/A21.11, rubber.

2.2 PVC PIPE AND FITTINGS
PVC Gravity Sewer Piping:
Pipe and Fittings: ASTM F679, T-1 wall thickness, PVC gravity sewer pipe with bell-and-spigot ends and with integral ASTM F477, elastomeric seals for gasketed joints.

2.3 CONCRETE PIPE AND FITTINGS
Reinforced-Concrete Sewer Pipe and Fittings: ASTM C76 (ASTM C76M).
Bell-and-spigot ends for gasketed joints, with ASTM C443 (ASTM C443M), rubber gaskets.
Class II, Wall C.
Class III, Wall C.
Class IV Wall C.
Class V, Wall B.

2.4 CLEANOUTS

Cast-Iron Cleanouts:

Description: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.

Top-Loading Classification(s): Medium Duty, Heavy Duty, and Extra-Heavy Duty.
Sewer Pipe Fitting and Riser to Cleanout: ASTM A74, Service class, cast-iron soil pipe and fittings.

Cleanouts:

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

2.5 MANHOLES

Standard Precast Concrete Manholes:

Description: ASTM C478 (ASTM C478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.
Diameter: 48 inches (1200 mm) minimum unless otherwise indicated.
Ballast: Increase thickness of precast concrete sections or add concrete to base section, as required to prevent flotation.
Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (100-mm) minimum thickness for walls and base riser section; with separate base slab or base section with integral floor.
Riser Sections: 4-inch (100-mm) minimum thickness, of length to provide depth indicated.
Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated; with top of cone of size that matches grade rings.
Joint Sealant: ASTM C990 (ASTM C990M), bitumen or butyl rubber.
Resilient Pipe Connectors: ASTM C923 (ASTM C923M), cast or fitted into manhole walls, for each pipe connection.
Steps: Individual FRP steps, FRP ladder, or ASTM A615/A615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D4101, PP wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches (1500 mm).

Adjusting Rings: Interlocking HDPE rings, with level or sloped edge in thickness and diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.
Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, with diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope.

Designed Precast Concrete Manholes:

Description: ASTM C913; designed according to ASTM C890 for A-16 (ASSHTO HS20-44 in AASHTO HL), heavy-traffic, structural loading; of depth, shape, and dimensions indicated, with provision for sealant joints.
Ballast: Increase thickness of one or more precast concrete sections or add concrete to manhole as required to prevent flotation.
Joint Sealant: ASTM C990 (ASTM 990M), bitumen or butyl rubber.
Resilient Pipe Connectors: ASTM C923 (ASTM C923M), cast or fitted into manhole walls, for each pipe connection.
Steps: Individual FRP steps, FRP ladder, or ASTM A615/A615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D4101, PP wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches (1500 mm).

Adjusting Rings: Interlocking HDPE rings, with level or sloped edge in thickness and diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.

Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, with diameter matching manhole frame and cover, and with height as required to adjust manhole frame and cover to indicated elevation and slope.

Manhole Frames and Covers:

Description: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser, with 4-inch- (100-mm-) minimum-width flange and 26-inch- (660-mm-) diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "SANITARY SEWER."
Material: ASTM A536, Grade 60-40-18 ductile iron unless otherwise indicated.

Manhole-Cover Inserts:

Description; Manufactured, plastic form, of size to fit between manhole frame and cover and designed to prevent stormwater inflow. Include handle for removal and gasket for gastight sealing.

Type: Solid

2.6 CONCRETE

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

Cement: ASTM C150/C150M, Type II.
Fine Aggregate: ASTM C33/C33M, sand.
Coarse Aggregate: ASTM C33/C33M, crushed gravel.
Water: Potable.

Portland Cement Design Mix: 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio.

Reinforcing Fabric: ASTM A1064/A1064M, steel, welded wire fabric, plain.
Reinforcing Bars: ASTM A615/A615M, Grade 60 (420-MPa) deformed steel.

Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.

Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.

Invert Slope: 1 percent through manhole.

Benches: Concrete, sloped to drain into channel.

Slope: 4 percent.

Ballast and Pipe Supports: Portland cement design mix, 3000 psi (20.7 MPa) minimum, with 0.58 maximum water/cementitious materials ratio.

Reinforcing Fabric: ASTM A1064/A1064M, steel, welded wire fabric, plain.
Reinforcing Bars: ASTM A615/A615M, Grade 60 (420-MPa) deformed steel.

PART 3 EXECUTION

3.1. DELIVERY, STORAGE, AND HANDLING

Do not store plastic manholes, pipe, and fittings in direct sunlight.
Protect pipe, pipe fittings, and seals from dirt and damage.
Handle manholes according to manufacturer's written rigging instructions.

3.2. FIELD CONDITIONS

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

Notify Architect and Owner no fewer than two days in advance of proposed interruption of service.
Do not proceed with interruption of service without Architect's or Owner's written permission.

3.3. EARTHWORK

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

3.4. PIPING INSTALLATION

General Locations and Arrangements: Drawing plans and details to indicate general location and arrangement of underground sanitary sewer piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.

Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.

Install gravity-flow, nonpressure, drainage piping according to the following:

Install piping pitched down in direction of flow, at minimum slope of 1 percent unless otherwise indicated.
Install piping 8 inches and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place-concrete supports or anchors.
Install piping with 48-inch (1220-mm) minimum cover.
Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."

Install hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
Install ductile-iron, gravity sewer piping according to ASTM A746.
Install ABS sewer piping according to ASTM D2321 and ASTM F1668.
Install PVC cellular-core sewer piping according to ASTM D2321 and ASTM F1668.
Install PVC corrugated sewer piping according to ASTM D2321 and ASTM F1668.
Install PVC profile sewer piping according to ASTM D2321 and ASTM F1668.
Install PVC Type PSM sewer piping according to ASTM D2321 and ASTM F1668.
Install PVC gravity sewer piping according to ASTM D2321 and ASTM F1668.
Install fiberglass sewer piping according to ASTM D3839 and ASTM F1668.
Install nonreinforced-concrete sewer piping according to ASTM C1479 and ACPA's "Concrete Pipe Installation Manual."
Install reinforced-concrete sewer piping according to ASTM C1479 and ACPA's "Concrete Pipe Installation Manual."

Clear interior of piping and manholes of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.

3.5. PIPE JOINT CONSTRUCTION

Join gravity-flow, nonpressure, drainage piping according to the following:

Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
Join ductile-iron, gravity sewer piping according to AWWA C600 for push-on joints.
Join ABS sewer piping according to ASTM D2321 for elastomeric-seal joints.
Join PVC cellular-core sewer piping according to ASTM D2321 and ASTM F891 for solvent-cemented joints.
Join PVC corrugated sewer piping according to ASTM D2321.
Join PVC profile sewer piping according to ASTM D2321 for elastomeric-seal joints or ASTM F794 for gasketed joints.
Join PVC Type PSM sewer piping according to ASTM D2321 and ASTM D3034 for elastomeric-seal joints or ASTM D3034 for elastomeric-gasket joints.
Join PVC gravity sewer piping according to ASTM D2321 and ASTM D3034 for elastomeric-seal joints or ASTM D3034 for elastomeric-gasket joints.
Join fiberglass sewer piping according to ASTM D4161 for elastomeric-seal joints.
Join nonreinforced-concrete sewer piping according to ASTM C14 (ASTM C14M) and ACPA's "Concrete Pipe Installation Manual" for rubber-gasket joints.
Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasket joints.
Join dissimilar pipe materials with nonpressure-type, flexible couplings.

3.6. MANHOLE INSTALLATION
General: Install manholes complete with appurtenances and accessories indicated.
Install precast concrete manhole sections with sealants according to ASTM C891.
Install FRP manholes according to manufacturer's written instructions.
Form continuous concrete channels and benches between inlets and outlet.

Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches (76 mm) above finished surface elsewhere unless otherwise indicated.
Install manhole-cover inserts in frame and immediately below cover.

3.7. CONCRETE PLACEMENT

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

3.8. CLEANOUT INSTALLATION

Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts, and use cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.

Use Medium-Duty, top-loading classification cleanouts in earth or paved foot-traffic areas.
Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.
Use Extra-Heavy-Duty, top-loading classification cleanouts in roads.

Set cleanout frames and covers in earth in cast-in-place-concrete block, 18 by 18 by 12 inches (450 by 450 by 300 mm) deep. Set with tops 1 inch (25 mm) above surrounding grade.

Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

3.9. CONNECTIONS

Connect nonpressure, gravity-flow drainage piping to building's sanitary building drains specified in Section 221316 "Sanitary Waste and Vent Piping."

Connect force-main piping to building's sanitary force mains specified in Section 221316 "Sanitary Waste and Vent Piping." Terminate piping where indicated.

Make connections to existing piping and underground manholes.

Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye fitting plus 6-inch (150-mm) overlap with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
Make branch connections from side into existing piping, NPS 4 to NPS 20 (DN 100 to DN 500). Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than 6 inches (150 mm) of concrete with 28-day compressive strength of 3000 psi (20.7 MPa).
Make branch connections from side into existing piping, NPS 21 (DN 525) or larger, or to underground manholes by cutting opening into existing unit large enough to allow 3 inches (76 mm) of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of, and be flush with, inside wall unless otherwise indicated. On outside of pipe or manhole wall, encase entering connection in 6 inches (150 mm) of concrete for minimum length of 12 inches (300 mm) to provide additional support of collar from connection to undisturbed ground.

Use concrete that will attain a minimum 28-day compressive strength of 3000 psi (20.7 MPa) unless otherwise indicated.
Use epoxy-bonding compound as interface between new and existing concrete and piping materials.

Protect existing piping and manholes to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

3.10. CLOSING ABANDONED SANITARY SEWER SYSTEMS

Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:

Close open ends of piping with at least 8-inch- (203-mm-) thick, brick masonry bulkheads.
Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.

Abandoned Manholes: Excavate around manhole as required and use either procedure below:

Remove manhole and close open ends of remaining piping.
Remove top of manhole down to at least 36 inches (915 mm) below final grade. Fill to within 12 inches (300 mm) of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.

Backfill to grade according to Section 312000 "Earth Moving."

3.11. IDENTIFICATION

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

Use detectable warning tape over ferrous piping.
Use detectable warning tape over nonferrous piping and over edges of underground manholes.

3.12. FIELD QUALITY CONTROL

Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (600 mm) of backfill is in place, and again at completion of Project.

Submit separate report for each system inspection.
Defects requiring correction include the following:

Alignment: Less than full diameter of inside of pipe is visible between structures.
Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
Damage: Crushed, broken, cracked, or otherwise damaged piping.
Infiltration: Water leakage into piping.
Exfiltration: Water leakage from or around piping.

Replace defective piping using new materials, and repeat inspections until defects are within allowances specified. Reinspect and repeat procedure until results are satisfactory.

Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

Do not enclose, cover, or put into service before inspection and approval.
Test completed piping systems according to requirements of authorities having jurisdiction.
Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.

Submit separate report for each test.

Hydrostatic Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:

Fill sewer piping with water. Test with pressure of at least 10-foot (3-m) head of water, and maintain such pressure without leakage for at least 15 minutes.
Close openings in system and fill with water.
Purge air and refill with water.
Disconnect water supply.
Test and inspect joints for leaks.

Air Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction, UNI-B-6, and the following:

Test plastic gravity sewer piping according to ASTM F1417.
Test concrete gravity sewer piping according toASTM C1628.

Ductile-Iron Piping: Test according to AWWA C600, "Hydraulic Testing" Section.
PVC Piping: Test according to AWWA M23, "Testing and Maintenance" Chapter.

Manholes: Perform hydraulic test according to ASTM C969 (ASTM C969M).

Leaks and loss in test pressure constitute defects that must be repaired.

Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.13. CLEANING

Clean dirt and superfluous material from interior of piping. Flush with potable water.

END OF SECTION 33300

SECTION 334100 - STORM UTILITY DRAINAGE PIPING

1.1 SUMMARY

A. Section Includes:

1. Pipe and fittings.
2. Nonpressure transition couplings.
3. Pressure pipe couplings.
4. Expansion joints and deflection fittings.
5. Backwater valves.
6. Cleanouts.
7. Drains.
8. Encasement for piping.
9. Manholes.
10. Channel drainage systems.
11. Catch basins.
12. Stormwater inlets.
13. Stormwater detention structures.
14. Pipe outlets.
15. Dry wells.
16. Stormwater disposal systems.

1.2 DEFINITIONS

A. FRP: Fiberglass-reinforced plastic.

1.3 ACTION SUBMITTALS

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

B. Shop Drawings:

1. Manholes: Include plans, elevations, sections, details, frames, and covers.
2. Catch basins, stormwater inlets, and dry wells. Include plans, elevations, sections, details, frames, covers, and grates.
3. Stormwater Detention Structures: Include plans, elevations, sections, details, frames, covers, design calculations, and concrete design-mix reports.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from storm drainage system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.

B. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than 1 inch equals 50 feet (1:500) and vertical scale of not less than 1 inch equals 5 feet (1:50). Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing system piping.

C. Product Certificates: For each type of cast-iron soil pipe and fitting, from manufacturer.

D. Field quality-control reports.

1.5 DELIVERY, STORAGE, AND HANDLING

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

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

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

D. Handle catch basins and stormwater inlets according to manufacturer's written rigging instructions.

1.6 PROJECT CONDITIONS

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

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

PART 2 - PRODUCTS

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

A. Pipe and Fittings: ASTM A 74, Service and Extra-Heavy classes

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.2 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. CISPI-Trademarked, Shielded Couplings:
1. Description: ASTM C 1277 and CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

C. Heavy-Duty, Shielded Couplings:
1. Description: ASTM C 1277 and ASTM C 1540, with stainless-steel shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.

D. Cast-Iron, Shielded Couplings:
   1. Description: ASTM C 1277 and ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.

2.3 DUCTILE-IRON, CULVERT PIPE AND FITTINGS

A. Pipe: ASTM A 716, for push-on joints.

B. Standard Fittings: AWWA C110, ductile or gray iron, for push-on joints.

C. Compact Fittings: AWWA C153, for push-on joints.

D. Gaskets: AWWA C111, rubber.

2.4 DUCTILE-IRON, PRESSURE PIPE AND FITTINGS

A. Push-on-Joint Piping:

   1. Pipe: AWWA C151, for push-on joints.
   2. Standard Fittings: AWWA C110, ductile or gray iron, for push-on joints.
   3. Compact Fittings: AWWA C153, for push-on joints.
   4. Gaskets: AWWA C111, rubber, of shape matching pipe and fittings.

B. Mechanical-Joint Piping:

   1. Pipe: AWWA C151, with bolt holes in bell.
   2. Standard Fittings: AWWA C110, ductile or gray iron, with bolt holes in bell.
   3. Compact Fittings: AWWA C153, with bolt holes in bells.
   4. Glands: Cast or ductile iron, with bolt holes and high-strength, cast-iron or high-strength, low-alloy steel bolts and nuts.
   5. Gaskets: AWWA C111, rubber, of shape matching pipe, fittings, and glands.

2.5 STEEL PIPE AND FITTINGS

A. Corrugated-Steel Pipe and Fittings: ASTM A 760/A 760M, Type I with fittings of similar form and construction as pipe.

   1. Special-Joint Bands: Corrugated steel with O-ring seals.
   2. Standard-Joint Bands: Corrugated steel.
   3. Coating: Aluminum

2.6 ALUMINUM PIPE AND FITTINGS

A. Corrugated Aluminum Pipe and Fittings: ASTM B 745/B 745M, Type I with fittings of similar form and construction as pipe.

   1. Special-Joint Bands: Corrugated steel with O-ring seals.
   2. Standard-Joint Bands: Corrugated steel.

2.7 ABS PIPE AND FITTINGS

A. ABS Sewer Pipe and Fittings: ASTM D 2751, with bell-and-spigot ends for gasketed joints.

1. NPS 3 to NPS 6 SDR 35.
2. NPS 8 to NPS 12 SDR 42.

B. Gaskets: ASTM F 477, elastomeric seals.

2.8 PE PIPE AND FITTINGS

A. Corrugated PE Drainage Pipe and Fittings NPS 3 to NPS 10, AASHTO M 252M, Type S, with smooth waterway for coupling joints.

1. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with tube and fittings.
2. Soiltight Couplings: AASHTO M 252M, corrugated, matching tube and fittings.

B. Corrugated PE Pipe and Fittings NPS 12 to NPS 60 AASHTO M 294M, Type S, with smooth waterway for coupling joints.

1. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings.
2. Soiltight Couplings: AASHTO M 294M, corrugated, matching pipe and fittings.

2.9 PVC PIPE AND FITTINGS

A. PVC Cellular-Core Piping:

1. PVC Cellular-Core Pipe and Fittings: ASTM F 891, Sewer and Drain Series, PS 50 minimum stiffness, PVC cellular-core pipe with plain ends for solvent-cemented joints.
2. Fittings: ASTM D 3034, SDR 35 PVC socket-type fittings.

B. PVC Corrugated Sewer Piping:

1. Pipe: ASTM F 949, PVC, corrugated pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM F 949, PVC molded or fabricated, socket type.
3. Gaskets: ASTM F 477, elastomeric seals.

C. PVC Profile Sewer Piping:

1. Pipe: ASTM F 794, PVC profile, gravity sewer pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM D 3034, PVC with bell ends.
3. Gaskets: ASTM F 477, elastomeric seals.

D. PVC Type PSM Sewer Piping:

1. Pipe: ASTM D 3034**,** SDR 35 PVC Type PSM sewer pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: ASTM D 3034, PVC with bell ends.
3. Gaskets: ASTM F 477, elastomeric seals.

E. PVC Gravity Sewer Piping:

1. Pipe and Fittings: ASTM F 679, [T-1] wall thickness, PVC gravity sewer pipe with bell-and-spigot ends and with integral ASTM F 477, elastomeric seals for gasketed joints.

F. PVC Pressure Piping:

1. Pipe: AWWA C900, [Class 100] [Class 150] [and] [Class 200] PVC pipe with bell-and-spigot ends for gasketed joints.
2. Fittings: AWWA C900, [Class 100] [Class 150] [and] [Class 200] PVC pipe with bell ends
3. Gaskets: ASTM F 477, elastomeric seals.

G. PVC Water-Service Piping:

1. Pipe: ASTM D 1785, Schedule 40 and Schedule 80 PVC, with plain ends for solvent-cemented joints.
2. Fittings: ASTM D 2466, Schedule 40 and ASTM D 2467, Schedule 80 PVC, socket type.

2.10 CONCRETE PIPE AND FITTINGS

A. Nonreinforced-Concrete Sewer Pipe and Fittings: ASTM C 14 Class 1 bell-and-spigot or [tongue-and-groove] ends and [gasketed joints with ASTM C 443 (ASTM C 443M), rubber gaskets] [sealant joints with ASTM C 990 (ASTM C 990M), bitumen or butyl-rubber sealant].

B. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76 (ASTM C 76M).

1. [Bell-and-spigot] [or] [tongue-and-groove] ends and [gasketed joints with ASTM C 443 (ASTM C 443M), rubber gaskets] [sealant joints with ASTM C 990 (ASTM C 990M), bitumen or butyl-rubber sealant]
2. Class I, Wall A
3. Class II, Wall A
4. Class III, Wall A
5. Class IV, Wall A
6. Class V, Wall A

2.11 NONPRESSURE TRANSITION COUPLINGS

A. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

B. Sleeve Materials:

1. For Concrete Pipes: ASTM C 443 rubber.
2. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
3. For Fiberglass Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
4. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
5. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

C. Unshielded, Flexible Couplings:

1. Description: Elastomeric sleeve with stainless-steel shear ring and corrosion-resistant-metal tension band and tightening mechanism on each end.

D. Shielded, Flexible Couplings:
1. Description: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

E. Ring-Type, Flexible Couplings:
1. Description: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.

2.12 PRESSURE PIPE COUPLINGS

A. Description: AWWA C219, tubular-sleeve coupling, with center sleeve, gaskets, end rings, and bolt fasteners.

B. Metal, bolted, sleeve-type, reducing or transition coupling, for joining underground pressure piping. *Include **150-psig*** minimum pressure rating and ends sized to fit adjoining pipes.

C. Center-Sleeve Material: Manufacturer's standard

D. Gasket Material: Natural or synthetic rubber.

E. Metal Component Finish: Corrosion-resistant coating or material.

2.13 EXPANSION JOINTS AND DEFLECTION FITTINGS

A. Ductile-Iron Flexible Expansion Joints:
1. Description: Compound fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-joint sections and one or more gasketed sleeve sections, rated for 250-psig (1725-kPa) minimum working pressure and for offset and expansion indicated.

B. Ductile-Iron Expansion Joints:
1. Description: Three-piece assembly of telescoping sleeve with gaskets and restrained-type, ductile-iron or steel with protective coating, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Include rating for 250-psig (1725-kPa) minimum working pressure and for expansion indicated.

C. Ductile-Iron Deflection Fittings:
1. Description: Compound-coupling fitting, with ball joint, flexing section, gaskets, and restrained-joint ends, complying with AWWA C110 or AWWA C153. Include rating for 250-psig (1725-kPa) minimum working pressure and for up to 15 degrees of deflection.

2.14 BACKWATER VALVES

A. Cast-Iron Backwater Valves:
1. Description: ASME A112.14.1, gray-iron body and bolted cover, with bronze seat.
2. Horizontal type; with swing check valve and hub-and-spigot ends.

3. Combination horizontal and manual gate-valve type; with swing check valve, integral gate valve, and hub-and-spigot ends.
4. Terminal type; with bronze seat, swing check valve, and hub inlet.

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

2.15 CLEANOUTS

A. Cast-Iron Cleanouts:

1.
2. Description: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.
3. Top-Loading Classification(s): [Light Duty] [Medium Duty] [Heavy Duty] [and] [Extra-Heavy Duty].
4. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.

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

2.16 DRAINS

A. Cast-Iron Area Drains: N/A

B. Cast-Iron Trench Drains: N/A

C. Steel Trench Drains: N/A

2.17 ENCASEMENT FOR PIPING

A. Standard: ASTM A 674 or AWWA C105.

B. Material: [Linear low-density polyethylene film of 0.008-inch (0.20-mm)] [or] [high-density, cross-laminated polyethylene film of 0.004-inch (0.10-mm)] minimum thickness.

C. Form: Sheet or tube.

D. Color: Black or natural

2.18 MANHOLES

A. Standard Precast Concrete Manholes:

1. Description: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.
2. Diameter: 48 inches (1200 mm) minimum unless otherwise indicated.

3. Ballast: Increase thickness of precast concrete sections or add concrete to base section as required to prevent flotation.
4. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (102-mm) minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
5. Riser Sections: 4-inch (102-mm) minimum thickness, and lengths to provide depth indicated.
6. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated, and top of cone of size that matches grade rings.
7. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
8. Resilient Pipe Connectors: ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.
9. Steps: Individual FRP steps or FRP ladder deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches (1500 mm) Retain one of two subparagraphs below if required to raise top of manhole to grade.
10. Adjusting Rings: Interlocking HDPE rings with level or sloped edge in thickness and diameter matching manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.
11. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover, and height as required to adjust manhole frame and cover to indicated elevation and slope.

B. Designed Precast Concrete Manholes:

1. Description: ASTM C 913; designed according to ASTM C 890 for A-16 (AASHTO HS20-44), heavy-traffic, structural loading; of depth, shape, and dimensions indicated, with provision for sealant joints.
2. Ballast: Increase thickness of one or more precast concrete sections or add concrete to manhole as required to prevent flotation.
3. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
4. Resilient Pipe Connectors: ASTM C 923 (ASTM C 923M), cast or fitted into manhole walls, for each pipe connection.
5. Steps: Individual FRP steps or FRP ladder 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of manhole to finished grade is less than 60 inches (1500 mm).
6. Adjusting Rings: Interlocking HDPE rings with level or sloped edge in thickness and diameter matching manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.
7. Grade Rings: Reinforced-concrete rings, 6- to 9-inch (150- to 225-mm) total thickness, to match diameter of manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope.

C. Manhole Frames and Covers:

1. Description: Ferrous; 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch- (102-mm-) minimum width flange and 26-inch- (660-mm-) diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."

2. Material: [ASTM A 536, Grade 60-40-18 ductile] [ASTM A 48/A 48M, Class 35 gray] iron unless otherwise indicated.

2.19 CONCRETE

A. General: Cast-in-place concrete according to ACI 318, ACI 350/350R (ACI 350M/350RM), and the following:

1. Cement: ASTM C 150, Type II.
2. Fine Aggregate: ASTM C 33, sand.
3. Coarse Aggregate: ASTM C 33, crushed gravel.
4. Water: Potable.

B. Portland Cement Design Mix: 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

C. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, 4000 psi (27.6 MPa) minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.

1. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.

a. Invert Slope: 1 percent through manhole.

2. Benches: Concrete, sloped to drain into channel.

a. Slope: 4 percent.

D. Ballast and Pipe Supports: Portland cement design mix, 3000 psi (20.7 MPa) minimum, with 0.58 maximum water/cementitious materials ratio.

1. Reinforcing Fabric: ASTM A 185/A 185M, steel, welded wire fabric, plain.
2. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

2.20 POLYMER-CONCRETE, CHANNEL DRAINAGE SYSTEMS

A. General Requirements for Polymer-Concrete, Channel Drainage Systems: Modular system of precast, polymer-concrete channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling. Include quantity of units required to form total lengths indicated.

B. Sloped-Invert, Polymer-Concrete Systems:

1. Channel Sections:

a. Interlocking-joint, precast, modular units with end caps.

b. 4-inch (102-mm) inside width and deep, rounded bottom, with built-in invert slope of 0.6 percent and with outlets in quantities, sizes, and locations indicated.
c. Extension sections necessary for required depth.
d. Frame: Include gray-iron or steel frame for grate.

2. Grates:

a. Manufacturer's designation " Medium Duty," with slots or perforations that fit recesses in channels.
b. Material: Galvanized steel or Stainless steel

3. Covers: Solid gray iron if indicated.
4. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

C. Narrow-Width, Level-Invert, Polymer-Concrete Systems:

1. Channel Sections:

a. Interlocking-joint, precast, modular units with end caps.
b. 5-inch (127-mm) inside width and 9-3/4-inch- (248-mm-) deep, rounded bottom, with level invert and with NPS 4 (DN 100) outlets in quantities, sizes, and locations indicated.

2. Grates:

a. Slots or perforations that fit recesses in channels.
b. Material: Galvanized steel or Gray iron

3. Covers: Solid gray iron if indicated.
4. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

D. Wide-Width, Level-Invert, Polymer-Concrete Systems:

1. Channel Sections:

a. Interlocking-joint, precast, modular units with end caps.
b. 8-inch (203-mm) inside width and 13-3/4-inch- (350-mm-) deep, rounded bottom, with level invert and with outlets in quantities, sizes, and locations indicated.

2. Grates:

a. Slots or other openings that fit recesses in channels.
b. Material: **Gray iron**.

3. Covers: Solid gray iron if indicated.
4. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.

E. Drainage Specialties: Precast, polymer-concrete units.

1. Large Catch Basins:

a. 24-by-12-inch (610-by-305-mm) polymer-concrete body, with outlets in quantities and sizes indicated.
b. Gray-iron slotted grate.

c. Frame: Include gray-iron or steel frame for grate.

2. Small Catch Basins:

a. 19- to 24-inch by approximately 6-inch (483- to 610-mm by approximately 150-mm) polymer-concrete body, with outlets in quantities and sizes indicated.
b. Gray-iron slotted grate.
c. Frame: Include gray-iron or steel frame for grate.

3. Oil Interceptors:

4. Sediment Interceptors:

a. 27-inch- (686-mm-) square, polymer-concrete body, with outlets in quantities and sizes indicated.
b. 24-inch- (610-mm-) square, gray-iron frame and slotted grate.

F. Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.

G. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

2.21 PLASTIC, CHANNEL DRAINAGE SYSTEMS

A. General Requirements for Plastic, Channel Drainage Systems:

1. Modular system of plastic channel sections, grates, and appurtenances.
2. Designed so grates fit into frames without rocking or rattling.
3. Number of units required to form total lengths indicated.

B.

C. Fiberglass Systems: N/A

D. PE Systems:

1. Channel Sections: Interlocking-joint, PE modular units, 4 inches (102 mm) wide, with end caps. Include rounded bottom, with level invert and with outlets in quantities, sizes, and locations indicated.
2. Grates: PE, ladder shaped; with stainless-steel screws.
3. Color: Gray unless otherwise indicated.
4. Drainage Specialties: Include the following PE components:

a. Drains: 4-inch- (102-mm-) diameter, round, slotted top; with NPS 4 (DN 100) bottom outlet.
b. Drains: 8-inch- (203-mm-) diameter, round, slotted top; with NPS 6 (DN 150) bottom outlet.
c. Drains: 4-inch- (102-mm-) square, slotted top; with NPS 3 (DN 80) bottom outlet.
d. Drains: 8-inch- (203-mm-) square, slotted top; with NPS 6 (DN 150) bottom outlet.
e. Catch Basins: 12-inch- (305-mm-) square plastic body, with outlets in quantities and sizes indicated. Include PE slotted grate 11-3/4 inches (298 mm) square by 1-1/8 inches (28.6 mm) thick.

E. Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.

F. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

2.22 CATCH BASINS

A. Standard Precast Concrete Catch Basins:

1. Description: ASTM C 478 (ASTM C 478M), precast, reinforced concrete, of depth indicated, with provision for sealant joints.
2. Base Section: 6-inch (150-mm) minimum thickness for floor slab and 4-inch (102-mm) minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
3. Riser Sections: 4-inch (102-mm) minimum thickness, 48-inch (1200-mm) diameter, and lengths to provide depth indicated.
4. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
5. Joint Sealant: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
6. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.
7. Grade Rings: Include two or three reinforced-concrete rings, of 6- to 9-inch (150- to 225-mm) total thickness, that match 24-inch- (610-mm-) diameter frame and grate.
8. Steps: Individual FRP steps or FRP ladder 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of catch basin to finished grade is less than [60 inches (1500 mm).
9. Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section.

B. Designed Precast Concrete Catch Basins: ASTM C 913, precast, reinforced concrete; designed according to ASTM C 890 for A-16 (ASSHTO HS20-44), heavy-traffic, structural loading; of depth, shape, and dimensions indicated, with provision for joint sealants.

1. Joint Sealants: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
2. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.
3. Grade Rings: Include two or three reinforced-concrete rings, of 6- to 9-inch (150- to 225-mm) total thickness, that match 24-inch- (610-mm-) diameter frame and grate.
4. Steps: Individual FRP steps or FRP ladder deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of catch basin to finished grade is less than [60 inches (1500 mm)]
5. Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section.

C. Frames and Grates: ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include flat grate with small square or short-slotted drainage openings.

1. Size: 24 by 24 inches (610 by 610 mm) minimum unless otherwise indicated.
2. Grate Free Area: Approximately 50 percent unless otherwise indicated.

D. Frames and Grates: ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch (102-mm) minimum width flange, and 26-inch- (660-mm-) diameter flat grate with small square or short-slotted drainage openings.

1. Grate Free Area: Approximately 50 percent unless otherwise indicated.

2.23 STORMWATER INLETS

A. Curb Inlets: Made with vertical curb opening[, of materials and dimensions according to utility standards].

B. Gutter Inlets: Made with horizontal gutter opening[, of materials and dimensions according to utility standards]. Include heavy-duty frames and grates.

C. Combination Inlets: Made with vertical curb and horizontal gutter openings[, of materials and dimensions according to utility standards]. Include heavy-duty frames and grates.

D. Frames and Grates: Heavy duty[, according to utility standards.

2.24 STORMWATER DETENTION STRUCTURES

A. Cast-in-Place Concrete, Stormwater Detention Structures: Constructed of reinforced-concrete bottom, walls, and top; designed according to ASTM C 890 for A-16 (AASHTO HS20-44), heavy-traffic, structural loading; of depth, shape, dimensions, and appurtenances indicated.

1. Ballast: Increase thickness of concrete as required to prevent flotation.
2. Grade Rings: Include two or three reinforced-concrete rings, of 6- to 9-inch (150- to 229-mm) total thickness, that match 24-inch- (610-mm-) diameter frame and cover.
3. Steps: Individual FRP steps or FRP ladder , 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP] [ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP], wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of structure to finished grade is less than 60 inches (1500 mm).

B. Manhole Frames and Covers: ASTM A 536, Grade 60-40-18, ductile-iron castings designed for heavy-duty service. Include 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch (102-mm) minimum width flange, and 26-inch- (660-mm-) diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."

2.25 PIPE OUTLETS

A. Head Walls: Cast-in-place reinforced concrete, with apron and tapered sides.

B. Riprap Basins: Broken, irregularly sized and shaped, graded stone according to NSSGA's "Quarried Stone for Erosion and Sediment Control."

1. Average Size: NSSGA No. R-3, screen opening 2 inches (51 mm).
2. Average Size: NSSGA No. R-4, screen opening 3 inches (76 mm).
3. Average Size: NSSGA No. R-5, screen opening 5 inches (127 mm).

C. Filter Stone: According to NSSGA's "Quarried Stone for Erosion and Sediment Control," No. FS-2, No. 4 screen opening, average-size graded stone.

D. Energy Dissipaters: According to NSSGA's "Quarried Stone for Erosion and Sediment Control," No. A-1, 3-ton (2721-kg) average weight armor stone, unless otherwise indicated.

2.26 DRY WELLS

A. Description: ASTM C 913, precast, reinforced, perforated concrete rings. Include the following:

1. Floor: Cast-in-place concrete.
2. Cover: Liftoff-type concrete cover with cast-in lift rings.
3. Wall Thickness: 4 inches (102 mm) minimum with 1-inch (25-mm) diameter or 1-by-3-inch- (25-by-76-mm-) maximum slotted perforations arranged in rows parallel to axis of ring.
    a. Total Free Area of Perforations: Approximately 15 percent of ring interior surface.
    b. Ring Construction: Designed to be self-aligning.
4. Filtering Material: ASTM D 448, Size No. 24, 3/4- to 2-1/2-inch (19- to 63-mm) washed, crushed stone or gravel.

B. Description: Manufactured PE side panels and top cover that assemble into 50-gal. (190-L) storage capacity units.
1. Side Panels: With knockout ports for piping and seepage holes.
2. Top Cover: With knockout port for drain.
3. Filter Fabric: As recommended by unit manufacturer.
4. Filtering Material: ASTM D 448, Size No. 24, 3/4- to 2-1/2-inch (19- to 63-mm) washed, crushed stone or gravel.

C. Description: Constructed-in-place aggregate type. Include the following:

1. Lining: Clay or concrete bricks.
2. Lining: Concrete blocks or precast concrete rings with notches or weep holes.
3. Filtering Material: ASTM D 448, Size No. 24, 3/4- to 2-1/2-inch (19- to 63-mm) washed, crushed stone or gravel.
4. Cover: Precast, reinforced-concrete slab, designed for structural loading according to ASTM C 890 and made according to ASTM C 913. Include slab dimensions that will extend 12 inches (300 mm) minimum beyond edge of excavation, with bituminous coating over entire surface. Cast cover with opening for manhole in center.
5. Manhole: 24-inch- (610-mm-) diameter, reinforced-concrete access lid with steel lift rings. Include bituminous coating over entire surface.

2.27 STORMWATER DISPOSAL SYSTEMS

A. Chamber Systems:

1. Storage and Leaching Chambers: Molded PE with perforated sides and open bottom. Include number of chambers, distribution piping, end plates, and other standard components as required for system total capacity.
2. Filtering Material: ASTM D 448, Size No. 24, 3/4- to 2-1/2-inch (19- to 63-mm) washed, crushed stone or gravel.
3. Filter Mat: Geotextile woven or spun filter fabric, in one or more layers, for minimum total unit weight of 4 oz./sq. yd. (135 g/sq. m).

B. Pipe Systems: Perforated manifold, header, and lateral piping complying with AASHTO M 252M for NPS 10 (DN 250) and smaller, AASHTO M 294M for NPS 12 to NPS 60 (DN 300 to DN 1500). Include proprietary fittings, couplings, seals, and filter fabric.

PART 3 - EXECUTION

3.1 EARTHWORK

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

3.2 PIPING INSTALLATION

A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.

B. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.

C. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.

D. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.

E. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.

F. Install gravity-flow, nonpressure drainage piping according to the following:

1. Install piping pitched down in direction of flow.
2. Install piping [NPS 6 (DN 150) and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place concrete supports or anchors.
3. Install piping with 48-inch (1220-mm) minimum cover.
4. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."

5. Install hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
6. Install ductile-iron piping and special fittings according to AWWA C600 or AWWA M41.
7. Install corrugated steel piping according to ASTM A 798/A 798M.
8. Install corrugated aluminum piping according to ASTM B 788/B 788M.
9. Install ABS sewer piping according to ASTM D 2321 and ASTM F 1668.
10. Install PE corrugated sewer piping according to ASTM D 2321.
11. Install PVC cellular-core piping according to ASTM D 2321 and ASTM F 1668.
12. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.
13. Install PVC profile gravity sewer piping according to ASTM D 2321 and ASTM F 1668.
14. Install PVC water-service piping according to ASTM D 2321 and ASTM F 1668.
15. Install fiberglass sewer piping according to ASTM D 3839 and ASTM F 1668.
16. Install nonreinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."
17. Install reinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."

G. Install force-main pressure piping according to the following:

1. Install piping with restrained joints at tee fittings and at horizontal and vertical changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place concrete supports or anchors.
2. Install piping with 48-inch (1220-mm) minimum cover.
3. Install ductile-iron pressure piping according to AWWA C600 or AWWA M41.
4. Install ductile-iron special fittings according to AWWA C600.
5. Install PVC pressure piping according to AWWA M23, or ASTM D 2774 and ASTM F 1668.
6. Install PVC water-service piping according to ASTM D 2774 and ASTM F 1668.

H. Install corrosion-protection piping encasement over the following underground metal piping according to ASTM A 674 or AWWA C105:

1. Hub-and-spigot, cast-iron soil pipe and fittings.
2. Hubless cast-iron soil pipe and fittings.
3. Ductile-iron pipe and fittings.
4. Expansion joints and deflection fittings.

3.3 PIPE JOINT CONSTRUCTION

A. Join gravity-flow, nonpressure drainage piping according to the following:

1. Join hub-and-spigot, cast-iron soil piping with gasketed joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
2. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
3. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
4. Join ductile-iron culvert piping according to AWWA C600 for push-on joints.
5. Join ductile-iron piping and special fittings according to AWWA C600 or AWWA M41.
6. Join corrugated steel sewer piping according to ASTM A 798/A 798M.
7. Join corrugated aluminum sewer piping according to ASTM B 788/B 788M.
8. Join ABS sewer piping according to ASTM D 2321 and ASTM D 2751 for elastomeric-seal joints.
9. Join corrugated PE piping according to ASTM D 3212 for push-on joints.

10. Join PVC cellular-core piping according to ASTM D 2321 and ASTM F 891 for solvent-cemented joints.
11. Join PVC corrugated sewer piping according to ASTM D 2321 for elastomeric-seal joints.
12. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasketed joints.
13. Join PVC profile gravity sewer piping according to ASTM D 2321 for elastomeric-seal joints or ASTM F 794 for gasketed joints.
14. Join fiberglass sewer piping according to ASTM D 3839 for elastomeric-seal joints.
15. Join nonreinforced-concrete sewer piping according to ASTM C 14 (ASTM C 14M) and ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
16. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
17. Join dissimilar pipe materials with nonpressure-type flexible couplings.

B. Join force-main pressure piping according to the following:

1. Join ductile-iron pressure piping according to AWWA C600 or AWWA M41 for push-on joints.
2. Join ductile-iron special fittings according to AWWA C600 or AWWA M41 for push-on joints.
3. Join PVC pressure piping according to AWWA M23 for gasketed joints.
4. Join PVC water-service piping according to ASTM D 2855 for solvent-cemented joints.
5. Join dissimilar pipe materials with pressure-type couplings.

3.4 BACKWATER VALVE INSTALLATION

A. Install horizontal-type backwater valves in piping where indicated.

B. Install combination horizontal and manual gate-valve type in piping and in manholes where indicated.

C. Install terminal-type backwater valves on end of piping and in manholes where indicated.

3.5 CLEANOUT INSTALLATION

A. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.

1. Use Light-Duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
2. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.
3. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.
4. Use Extra-Heavy-Duty, top-loading classification cleanouts in roads

B. Set cleanout frames and covers in earth in cast-in-place concrete block, 18 by 18 by 12 inches (450 by 450 by 300 mm) deep. Set with tops 1 inch (25 mm) > above surrounding earth grade.

C. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.

3.6 DRAIN INSTALLATION

A. Install type of drains in locations indicated.

1. Use Light-Duty, top-loading classification drains in earth or unpaved foot-traffic areas.
2. Use Medium-Duty, top-loading classification drains in paved foot-traffic areas.
3. Use Heavy-Duty, top-loading classification drains in vehicle-traffic service areas.
4. Use Extra-Heavy-Duty, top-loading classification drains in roads.

B. Embed drains in 4-inch (102-mm) minimum concrete around bottom and sides.

C. Fasten grates to drains if indicated.

D. Set drain frames and covers with tops flush with pavement surface.

E. Assemble trench sections with flanged joints.

F. Embed trench sections in 4-inch (102-mm) minimum concrete around bottom and sides.

3.7 MANHOLE INSTALLATION

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

B. Install precast concrete manhole sections with sealants according to ASTM C 891.

C. Where specific manhole construction is not indicated, follow manhole manufacturer's written instructions.

D. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches (76 mm) above finished surface elsewhere unless otherwise indicated.

3.8 CATCH BASIN INSTALLATION

A. Construct catch basins to sizes and shapes indicated.

B. Set frames and grates to elevations indicated.

3.9 STORMWATER INLET AND OUTLET INSTALLATION

A. Construct inlet head walls, aprons, and sides of reinforced concrete, as indicated.

B. Construct riprap of broken stone, as indicated.

C. Install outlets that spill onto grade, anchored with concrete, where indicated.

D. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.

E. Construct energy dissipaters at outlets, as indicated.

3.10 DRY WELL INSTALLATION

A. Excavate hole to diameter of at least 6 inches (150 mm) greater than outside of dry well. Do not extend excavation into ground-water table.

B. Install precast, concrete-ring dry wells according to the following:

1. Assemble rings to depth indicated.
2. Extend rings to height where top of cover will be approximately 8 inches (203 mm) below finished grade.
3. Backfill bottom of inside of rings with filtering material to level at least 12 inches (300 mm) above bottom.
4. Extend effluent inlet pipe 12 inches (300 mm) into rings and terminate into side of tee fitting.
5. Backfill around outside of rings with filtering material to top level of rings.
6. Install cover over top of rings.

C. Install manufactured, PE dry wells according to manufacturer's written instructions and the following:

1. Assemble and install panels and cover.
2. Backfill bottom of inside of unit with filtering material to level at least 12 inches (300 mm) above bottom.
3. Extend effluent inlet pipe 12 inches (300 mm) into unit and terminate into side of tee fitting.
4. Install filter fabric around outside of unit.
5. Install filtering material around outside of unit.

D. Install constructed-in-place dry wells according to the following:

1. Install brick lining material dry and laid flat, with staggered joints for seepage. Build to diameter and depth indicated.
2. Install block lining material dry, with staggered joints and 20 percent minimum of blocks on side for seepage. Install precast concrete rings with notches or weep holes for seepage. Build to diameter and depth indicated.
3. Extend lining material to height where top of manhole will be approximately **8 inches (203 mm)** below finished grade.
4. Backfill bottom of inside of lining with filtering material to level at least **12 inches (300 mm)** above bottom.
5. Extend effluent inlet pipe **12 inches (300 mm)**into lining and terminate into side of tee fitting.
6. Backfill around outside of lining with filtering material to top level of lining.
7. Install manhole over top of dry well. Support cover on undisturbed soil. Do not support cover on lining.

3.11 CONCRETE PLACEMENT

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

3.12 CHANNEL DRAINAGE SYSTEM INSTALLATION

A. Install with top surfaces of components, except piping, flush with finished surface.

B. Assemble channel sections to form slope down toward drain outlets. Use sealants, adhesives, fasteners, and other materials recommended by system manufacturer.

C. Embed channel sections and drainage specialties in 4-inch (102-mm) minimum concrete around bottom and sides.

D. Fasten grates to channel sections if indicated.

E. Assemble channel sections with flanged or interlocking joints.

F. Embed channel sections in 4-inch (102-mm) concrete around bottom and sides.

3.13 STORMWATER DISPOSAL SYSTEM INSTALLATION

A. Chamber Systems: Excavate trenches of width and depth, and install system and backfill according to chamber manufacturer's written instructions. Include storage and leaching chambers, filtering material, and filter mat.

B. Piping Systems: Excavate trenches of width and depth, and install piping system, filter fabric, and backfill, according to piping manufacturer's written instructions.

3.14 CONNECTIONS

A. Connect nonpressure, gravity-flow drainage piping in building's storm building drains specified in Section 221413 "Facility Storm Drainage Piping."

B. Connect force-main piping to building's storm drainage force mains specified in Section 221413 "Facility Storm Drainage Piping." Terminate piping where indicated.

C. Make connections to existing piping and underground manholes.

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

D. Connect to sediment interceptors specified in Section 221323 "Sanitary Waste Interceptors."

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

1. Use nonpressure-type flexible couplings where required to join gravity-flow, nonpressure sewer piping unless otherwise indicated.

    a. Shielded flexible couplings for same or minor difference OD pipes.
    b. Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
    c. Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.

2. Use pressure-type pipe couplings for force-main joints.

3.15 CLOSING ABANDONED STORM DRAINAGE SYSTEMS

A. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:

1. Close open ends of piping with at least [8-inch- (203-mm-)] <Insert dimension> thick, brick masonry bulkheads.
2. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.

B. Abandoned Manholes and Structures: Excavate around manholes and structures as required and use one procedure below:

1. Remove manhole or structure and close open ends of remaining piping.
2. Remove top of manhole or structure down to at least 36 inches (915 mm) final grade. Fill to within 12 inches (300 mm) of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.

C. Backfill to grade according to Section 312000 "Earth Moving."

3.16 IDENTIFICATION

A. Materials and their installation are specified in Section 312000 "Earth Moving." Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.

1. Use warning tape or detectable warning tape over ferrous piping.
2. Use detectable warning tape over nonferrous piping and over edges of underground structures.

3.17 FIELD QUALITY CONTROL

A. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches (610 mm) of backfill is in place, and again at completion of Project.

1. Submit separate reports for each system inspection.
2. Defects requiring correction include the following:

a. Alignment: Less than full diameter of inside of pipe is visible between structures.
b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
d. Infiltration: Water leakage into piping.
e. Exfiltration: Water leakage from or around piping.

3. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
4. Reinspect and repeat procedure until results are satisfactory.

B. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.

1. Do not enclose, cover, or put into service before inspection and approval.
2. Test completed piping systems according to requirements of authorities having jurisdiction.
3. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
4. Submit separate report for each test.
5. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:

a. Exception: Piping with soiltight joints unless required by authorities having jurisdiction.
b. Option: Test plastic piping according to ASTM F 1417.
c. Option: Test concrete piping according to ASTM C 924 (ASTM C 924M).

6. Force-Main Storm Drainage Piping: Perform hydrostatic test after thrust blocks, supports, and anchors have hardened. Test at pressure not less than 1-1/2 times the maximum system operating pressure, but not less than 150 psig (1035 kPa)

a. Ductile-Iron Piping: Test according to AWWA C600, "Hydraulic Testing" Section.
b. PVC Piping: Test according to AWWA M23, "Testing and Maintenance" Chapter.

C. Leaks and loss in test pressure constitute defects that must be repaired.

D. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

3.18 CLEANING

A. Clean interior of piping of dirt and superfluous materials. Flush with potable water.

END OF SECTION 334100