

**SECTION 01 2300
ALTERNATES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Description of Alternates.
- B. Documentation of changes to Contract Price and Contract Time.

1.02 ACCEPTANCE OF ALTERNATES

- A. Alternates quoted on Bid Forms will be reviewed and accepted or rejected at Owner's option. Accepted Alternates will be identified in the Owner-Contractor Agreement.
- B. Coordinate related work and modify surrounding work to integrate the Work of each Alternate.

1.03 DESCRIPTION OF ALTERNATES

Alternate No. 1 Replace flooring with LVT as show on the drawings in rooms 206 and 208.

Alternate No. 2 Remove and replace window frames, glazing and sills at the library as shown on the drawings.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION - NOT USED

END OF SECTION

SECTION 09 5100
ACOUSTICAL CEILINGS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Suspended metal grid ceiling system.
- B. Acoustical units.

1.02 REFERENCE STANDARDS

- A. ASTM C635/C635M - Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings; 2013a.
- B. ASTM E1264 - Standard Classification for Acoustical Ceiling Products; 2008e1.
- C. SCS Indoor Advantage Gold certification for air quality.
- D. Green Guard Gold certification for air quality.

1.03 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate grid layout and related dimensioning.
- C. Samples: Submit two samples illustrating material and finish of acoustical units.
- D. Provide documentation for recycled content of tile and grid.
- E. Provide GREENGUARD Gold Certification or SCS Advantage Gold Certification for ceiling tiles.

PART 2 PRODUCTS

2.01 ACOUSTICAL UNITS

- A. Manufacturers:
 - 1. Armstrong World Industries, Inc.
 - 2. CertainTeed Corporation
 - 3. USG
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Acoustical Units - General: ASTM E1264, Class A.
- C. Acoustical Panels – Classrooms & Offices:
Armstrong Cortega Lay-In or approved equal
 - 1. Size: 24 x 48 inches (610 x 1220 mm).
 - 2. Thickness: 5/8" inches.
 - 3. Composition: Wet felted.
 - 4. Edge: Square Lay-In 15/16 in.
 - 5. Surface Color: White.
 - 6. Suspension System: Exposed grid.
 - 7. Tiles to have a NRC of .70 minimum.
- C. Acoustical Panels – Corridors:
Armstrong Cortega Lay-In or approved equal
 - 1. Size: 24 x 24 inches (610 x 610 mm).
 - 2. Thickness: 5/8 inches.
 - 3. Composition: Wet felted.
 - 4. Edge: Square Lay-In 15/16 in.
 - 5. Surface Color: White.
 - 6. Suspension System: Exposed grid.
 - 7. Tiles to have a NRC of .70 minimum.

- D. Acoustical Panels – Restrooms and Kitchens:
Armstrong Optima Health Zone or approved equal.
1. Size: 24 x 24 inches (600 x 600 mm).
 2. Thickness: 15/16 inches.
 3. Composition: Fiberglass with DuraBrite scrim/ DuraBrite factory applied latex paint.
 4. Edge: Square.
 5. Surface Color: White.
 6. Suspension System: Exposed grid.
 7. Tiles to have a NRC of .95 minimum.

2.02 SUSPENSION SYSTEM(S)

- A. Suspension Systems - General: Complying with ASTM C635/C635M; die cut and interlocking components, with stabilizer bars, clips, splices, perimeter moldings, and hold down clips as required.
- B. Exposed Steel Suspension System: Formed steel, commercial quality cold rolled; intermediate-duty.
1. Profile: Tee; 15/16 inch (24 mm) wide face.
 2. Construction: Double web.
 3. Kitchen Grid to include aluminum cap.
 4. Finish: White painted.

2.03 ACCESSORIES

- A. Support Channels and Hangers: Galvanized steel; size and type to suit application, seismic requirements, and ceiling system flatness requirement specified.
- B. Perimeter Moldings: Same material and finish as grid.
1. At Exposed Grid: Provide L-shaped molding for mounting at same elevation as face of grid.
- C. Touch-up Paint: Type and color to match acoustical and grid units.

PART 3 EXECUTION

3.01 INSTALLATION - SUSPENSION SYSTEM

- A. Rigidly secure system, including integral mechanical and electrical components, for maximum deflection of 1:360.
- B. Install after major above-ceiling work is complete. Coordinate the location of hangers with other work.
- C. Hang suspension system independent of walls, columns, ducts, pipes and conduit. Where carrying members are spliced, avoid visible displacement of face plane of adjacent members.
- D. Where ducts or other equipment prevent the regular spacing of hangers, reinforce the nearest affected hangers and related carrying channels to span the extra distance.
- E. Do not support components on main runners or cross runners if weight causes total dead load to exceed deflection capability.
- F. Support fixture loads using supplementary hangers located within 6 inches (150 mm) of each corner, or support components independently.
- G. Do not eccentrically load system or induce rotation of runners.
- H. Perimeter Molding: Install at intersection of ceiling and vertical surfaces and at junctions with other interruptions.
1. Use longest practical lengths.
 2. Overlap and rivet corners.

3.02 INSTALLATION - ACOUSTICAL UNITS

- A. Install acoustical units in accordance with manufacturer's instructions.

- B. Fit acoustical units in place, free from damaged edges or other defects detrimental to appearance and function.
- C. Fit border trim neatly against abutting surfaces.
- D. Install units after above-ceiling work is complete.
- E. Install acoustical units level, in uniform plane, and free from twist, warp, and dents.
- F. Cutting Acoustical Units:
 - 1. Make field cut edges of same profile as factory edges.

3.03 TOLERANCES

- A. Maximum Variation from Flat and Level Surface: 1/8 inch in 10 feet (3 mm in 3 m).
- B. Maximum Variation from Plumb of Grid Members Caused by Eccentric Loads: 2 degrees.

3.04 ATTIC STOCK

- A. Provide the Owner with 10% attic stock (extra material) for future material replacement. Deliver to location indicated by the Owner's Representative.

END OF SECTION

**SECTION 09 6500
RESILIENT FLOORING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Resilient tile flooring (LVT).
- B. Resilient base.
- C. Installation accessories.

1.02 REFERENCE STANDARDS

- A. ASTM F1700 - Standard Specification for Solid Vinyl Floor Tile; 2013a.
- B. ASTM F1861 - Standard Specification for Resilient Wall Base; 2008 (Reapproved 2012)e1.

1.03 SUBMITTALS

- A. Product Data: Provide data on specified products, describing physical and performance characteristics; including sizes, patterns and colors available; and installation instructions.
- B. Selection Samples: Submit manufacturer's complete set of color samples for Architect's initial selection.

PART 2 PRODUCTS

2.01 SHEET FLOORING

2.02 TILE FLOORING

- A. Vinyl Tile: Solid vinyl with color and pattern throughout thickness.
 - 1. Manufacturers:
 - a. Armstrong.
 - b. Substitutions: Architect approved equivalent.
 - 2. Minimum Requirements: Comply with ASTM F1700, of Class corresponding to type specified.
 - 3. Tile Size: 12 inch by 12 inch
 - 4. Total Thickness: 0.10 inch.
 - 5. Pattern: as selected by the Architect to match existing
- B. Luxury Vinyl Tile: Solid vinyl with color and pattern throughout thickness.
 - 1. Manufacturers:
 - a. Tarkett.
 - b. Substitutions: Architect approved equivalent.
 - 2. Minimum Requirements: Comply with ASTM F1700, of Class corresponding to type specified.
 - 3. Tile Size: 18 inch by 18 inch
 - 4. Total Thickness: 0.10 inch.
 - 5. Pattern: as selected by the Architect to match existing

2.03 RESILIENT BASE

- A. Resilient Base: ASTM F1861, Type TS rubber, vulcanized thermoset; top set Style B, Cove.
 - 1. Manufacturers:
 - a. Burke Flooring; www.burkemercer.com.
 - b. Johnsonite, a Tarkett Company; www.johnsonite.com.
 - c. Roppe Corp; www.roppe.com.
 - d. Substitutions: Architect approved equivalent.
 - 2. Height: 4 inch (100 mm).
 - 3. Thickness: 0.125 inch (3.2 mm) thick.
 - 4. Finish: Satin.
 - 5. Color: Color as selected from manufacturer's standards.

6. Accessories: Premolded external corners.

2.04 ACCESSORIES

- A. Adhesives: Waterproof; types recommended by flooring manufacturer.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's written instructions.
- B. Spread only enough adhesive to permit installation of materials before initial set.
- C. Fit joints and butt seams tightly.
- D. Set flooring in place, press with heavy roller to attain full adhesion.

3.02 TILE FLOORING

- A. Mix tile from container to ensure shade variations are consistent when tile is placed, unless otherwise indicated in manufacturer's installation instructions.

3.03 RESILIENT BASE

- A. Fit joints tightly and make vertical. Maintain minimum dimension of 18 inches (45 mm) between joints.
- B. Install base on solid backing. Bond tightly to wall and floor surfaces.

3.04 CLEANING

- A. Remove excess adhesive from base, and wall surfaces without damage.
- B. Clean in accordance with manufacturer's written instructions.

END OF SECTION

SECTION 09 9000
PAINTING AND COATING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Surface preparation.
- B. Field application of paints, stains, varnishes, and other coatings.
- C. Scope: Finish all interior and exterior surfaces exposed to view, unless fully factory-finished
- D. Do Not Paint or Finish the Following Items:
 - 1. Items fully factory-finished unless specifically so indicated; materials and products having factory-applied primers are not considered factory finished.
 - 2. Items indicated to receive other finishes.
 - 3. Items indicated to remain unfinished.
 - 4. Fire rating labels, equipment serial number and capacity labels, and operating parts of equipment.
 - 5. Floors, unless specifically so indicated.
 - 6. Glass.
 - 7. Concealed pipes, ducts, and conduits.

1.02 REFERENCE STANDARDS

- A. 40 CFR 59, Subpart D - National Volatile Organic Compound Emission Standards for Architectural Coatings; U.S. Environmental Protection Agency; current edition.
- B. Green Seal GS-11 (current standard at time of project's notice to proceed) for paints, primers and anti-corrosive coatings applied within the building weatherproofing system.
- C. SCAQMD r1113 for all interior coatings.

1.03 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide complete list of all products to be used, with the following information for each:
 - 1. Manufacturer's name, product name and/or catalog number, and general product category (e.g. "alkyd enamel").
 - 2. MPI product number (e.g. MPI #47).
 - 3. Cross-reference to specified paint system(s) product is to be used in; include description of each system.
- C. Samples: Submit three paper "draw down" samples, 8-1/2 by 11 inches (216 by 279 mm) in size, illustrating range of colors available for each finishing product specified.
 - 1. Where sheen is specified, submit samples in only that sheen.

1.04 FIELD CONDITIONS

- A. Do not apply materials when surface and ambient temperatures are outside the temperature ranges required by the paint product manufacturer.
- B. Follow manufacturer's recommended procedures for producing best results, including testing of substrates, moisture in substrates, and humidity and temperature limitations.
- C. Provide lighting level of 80 ft. candles (860 lx) measured mid-height at substrate surface.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Provide all paint and coating products used in any individual system from the same manufacturer; no exceptions.
- B. Paints, stains and transparent finishes:
 - 1. Diamond Vogel Paints: www.diamondvogel.com.

2. Glidden Professional: www.gliddenprofessional.com.
 3. PPG Architectural Finishes, Inc: www.ppgaf.com.
 4. Pratt & Lambert Paints: www.prattandlambert.com.
 5. Sherwin-Williams Company: www.sherwin-williams.com.
- C. Primer Sealers: Same manufacturer as top coats
 - D. Block Fillers: Same manufacturer as top coats.
 - E. Substitutions: See Section 01 6000 - Product Requirements.
 - F. Paint colors: As indicated on drawings.

2.02 PAINTS AND COATINGS - GENERAL

- A. Paints and Coatings: Ready mixed, unless intended to be a field-catalyzed coating.
 1. Provide paints and coatings of a soft paste consistency, capable of being readily and uniformly dispersed to a homogeneous coating, with good flow and brushing properties, and capable of drying or curing free of streaks or sags.
 2. Supply each coating material in quantity required to complete entire project's work from a single production run.
 3. Do not reduce, thin, or dilute coatings or add materials to coatings unless such procedure is specifically described in manufacturer's product instructions.
- B. Primers: Where the manufacturer offers options on primers for a particular substrate, use primer categorized as "best" by the manufacturer.
- C. Volatile Organic Compound (VOC) Content: Comply with Section 01 8113.

2.03 PAINT SYSTEMS - EXTERIOR

- A. Paint - Ferrous Metals, Primed, Alkyd, 2 Coat:
 1. Touch-up with rust-inhibitive primer recommended by top coat manufacturer.
 2. Semi-gloss: Two coats of alkyd enamel;
- B. Paint - Galvanized Metals, Alkyd, 3 Coat:
 1. One coat galvanize primer.
 2. Semi-gloss: Two coats of alkyd enamel;

2.04 PAINT SYSTEMS - INTERIOR

- A. Paint - Medium Duty Vertical/Overhead: Including gypsum board, uncoated steel, shop primed steel, galvanized steel, and wood.
 1. Two top coats and one coat primer.
 2. Top Coat(s): MPI High Performance Architectural Interior Latex; MPI #138-141.
 3. Satin: MPI gloss level 4; use this sheen at all locations.
 4. Primer(s): As recommended by manufacturer of top coats.
- B. Polyurethane Varnish System on Interior Wood:
 1. Prime Coat: matching topcoat
 2. Intermediate Coat: matching topcoat
 3. Topcoat: Varnish, interior, polyurethane, oil-modified, satin (MPI Gloss Level 4), MPI #57
 2. Topcoat: Varnish, interior, polyurethane, oil-modified, gloss (MPI Gloss Level 6), MPI #56

2.05 ACCESSORY MATERIALS

- A. Accessory Materials: Provide all primers, sealers, cleaning agents, cleaning cloths, sanding materials, and clean-up materials required to achieve the finishes specified whether specifically indicated or not; commercial quality.
- B. Patching Material: Latex filler.
- C. Fastener Head Cover Material: Latex filler.

PART 3 EXECUTION

3.01 PREPARATION

- A. Clean surfaces thoroughly and correct defects prior to coating application.
- B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.
- C. Remove or mask surface appurtenances, including electrical plates, hardware, light fixture trim, escutcheons, and fittings, prior to preparing surfaces or finishing.
- D. Seal surfaces that might cause bleed through or staining of topcoat.
- E. Remove mildew from impervious surfaces by scrubbing with solution of tetra-sodium phosphate and bleach. Rinse with clean water and allow surface to dry.

3.02 APPLICATION

- A. Apply products in accordance with manufacturer's instructions.
- B. Do not apply finishes to surfaces that are not dry. Allow applied coats to dry before next coat is applied.
- C. Apply each coat to uniform appearance.
- D. Vacuum clean surfaces of loose particles. Use tack cloth to remove dust and particles just prior to applying next coat.
- E. Reinstall electrical cover plates, hardware, light fixture trim, escutcheons, and fittings removed prior to finishing.

3.03 CLEANING

- A. Collect waste material that could constitute a fire hazard, place in closed metal containers, and remove daily from site.

3.04 ATTIC STOCK

- A. Provide the Owner with 10% attic stock (extra material) in full containers, marked with contents/color. Deliver to location indicated by the Owner's Representative.

END OF SECTION

SECTION 22 0529

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Pipe stands.

1.3 DEFINITIONS

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

1.4 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 PIPE STANDS

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. High-Type, Single-Pipe Stand:
 - 1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - 2. Base: Plastic.
 - 3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 - 4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
- B. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- C. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- D. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- E. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.

3.2 ADJUSTING

- A. Hanger Adjustments: Provide hangers fabricated to allow adequate vertical adjustment of 1.5 inches minimum after installation while still supporting the load. 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.

3.3 PAINTING

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

3.4 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.

END OF SECTION

SECTION 22 1100

FACILITY NATURAL-GAS 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. Pipes, tubes, and fittings.
 - 2. Piping specialties.
 - 3. Piping and tubing joining materials.
 - 4. Valves.
 - 5. Pressure regulators.

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

1.4 PERFORMANCE REQUIREMENTS

- A. Minimum Operating-Pressure Ratings:
 - 1. Piping and Valves: 100 psig minimum unless otherwise indicated.
 - 2. Service Regulators: 65 psig minimum unless otherwise indicated.
- B. Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 0.5 psig but not more than 5 psig, and is reduced to secondary pressure of 0.5 psig or less.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Piping specialties.
 - 2. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
 - 3. Pressure regulators. Indicate pressure ratings and capacities.
 - 4. Dielectric fittings.

1.6 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans and details, drawn to scale, on which natural-gas piping is shown and coordinated with other installations, using input from installers of the items involved.
- B. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For motorized gas valves and pressure regulators 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.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.
- B. 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.
- C. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating and protect from direct sunlight.

1.10 PROJECT CONDITIONS

- A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility-locating service for area where Project is located.
- B. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
 - 1. Notify Construction Manager no fewer than two days in advance of proposed interruption of natural-gas service.

2. Do not proceed with interruption of natural-gas service without Construction Manager's written permission.

1.11 COORDINATION

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

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 2. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.

2.2 PIPING SPECIALTIES

- A. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.3 JOINING MATERIALS

- A. Joint Compound and Tape: Suitable for natural gas.

2.4 MANUAL GAS SHUTOFF VALVES

- A. See "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.
- B. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
 1. CWP Rating: 125 psig.
 2. Threaded Ends: Comply with ASME B1.20.1.
 3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
 4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
 6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.
- C. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. BrassCraft Manufacturing Company; a Masco company.
 - b. Conbraco Industries, Inc.; Apollo Div.
 - c. Lyall, R. W. & Company, Inc.

- d. McDonald, A. Y. Mfg. Co.
 - e. Perfection Corporation; a subsidiary of American Meter Company.
 - 2. Body: Bronze, complying with ASTM B 584.
 - 3. Ball: Chrome-plated bronze.
 - 4. Stem: Bronze; blowout proof.
 - 5. Seats: Reinforced TFE; blowout proof.
 - 6. Packing: Threaded-body packnut design with adjustable-stem packing.
 - 7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - 8. CWP Rating: 600 psig.
 - 9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - 10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- D. Bronze Plug Valves: MSS SP-78.
- 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Lee Brass Company.
 - b. McDonald, A. Y. Mfg. Co.
 - 2. Body: Bronze, complying with ASTM B 584.
 - 3. Plug: Bronze.
 - 4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
 - 5. Operator: Square head or lug type with tamperproof feature where indicated.
 - 6. Pressure Class: 125 psig.
 - 7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 - 8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

2.5 PRESSURE REGULATORS

- A. General Requirements:
- 1. Single stage and suitable for natural gas.
 - 2. Steel jacket and corrosion-resistant components.
 - 3. Elevation compensator.
 - 4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.
- B. Service Pressure Regulators: Comply with ANSI Z21.80.
- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Actaris.
 - b. American Meter Company.
 - c. Fisher Control Valves and Regulators; Division of Emerson Process Management.
 - d. Invensys.
 - e. Richards Industries; Jordan Valve Div.
 - 2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
 - 3. Springs: Zinc-plated steel; interchangeable.
 - 4. Diaphragm Plate: Zinc-plated steel.
 - 5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
 - 6. Orifice: Aluminum; interchangeable.
 - 7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.

8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
 9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
 10. Overpressure Protection Device: Factory mounted on pressure regulator.
 11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
 12. Maximum Inlet Pressure: 100 psig.
- C. Appliance Pressure Regulators: Comply with ANSI Z21.18.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Canadian Meter Company Inc.
 - b. Eaton Corporation; Controls Div.
 - c. Harper Wyman Co.
 - d. Maxitrol Company.
 - e. SCP, Inc.
 2. Body and Diaphragm Case: Die-cast aluminum.
 3. Springs: Zinc-plated steel; interchangeable.
 4. Diaphragm Plate: Zinc-plated steel.
 5. Seat Disc: Nitrile rubber.
 6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
 7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
 8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
 9. Maximum Inlet Pressure: 2 psig.

2.6 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Hart Industries International, Inc.
 - d. Jomar International Ltd.
 - e. Matco-Norca, Inc.
 - f. McDonald, A. Y. Mfg. Co.
 - g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - h. Wilkins; a Zurn company.
 2. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 125 psig minimum at 180 deg F.
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Close equipment shutoff valves before turning off natural gas to premises or piping section.
- B. Inspect natural-gas piping according to the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.
- C. Comply with NFPA 54 requirements for prevention of accidental ignition.

3.3 OUTDOOR PIPING INSTALLATION

- A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.
- B. Steel Piping with Protective Coating:
 - 1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
 - 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
 - 3. Replace pipe having damaged PE coating with new pipe.
- C. Install fittings for changes in direction and branch connections.

3.4 INDOOR PIPING INSTALLATION

- A. Comply with the International Fuel Gas Code for installation and purging of natural-gas piping.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. Install piping indicated to be exposed at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- F. Locate valves for easy access.
- G. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Verify final equipment locations for roughing-in.
- K. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- L. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- M. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- N. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- O. Connect branch piping from top or side of horizontal piping.
- P. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- Q. Do not use natural-gas piping as grounding electrode.
- R. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

3.5 VALVE INSTALLATION

- A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.
- B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.6 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints:
 - 1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
 - 2. Cut threads full and clean using sharp dies.
 - 3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.

4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
 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.
- D. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

3.7 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hangers and supports specified in Section 220529 "Hangers and Supports for Plumbing Piping and Equipment."
- B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
 2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
 3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.

3.8 CONNECTIONS

- A. Connect to utility's gas main according to utility's procedures and requirements.
- B. Install natural-gas piping electrically continuous and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.
- C. Install piping adjacent to appliances to allow service and maintenance of appliances.
- D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
- E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.9 PAINTING

- A. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, and piping specialties, except components, with factory-applied paint or protective coating.
1. Alkyd System: MPI EXT 5.1D.
 - a. Prime Coat: Alkyd anticorrosive metal primer.
 - b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
 - c. Topcoat: Exterior alkyd enamel.
 - d. Color: Yellow.
- B. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.10 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Test, inspect, and purge natural gas according to the International Fuel Gas Code and authorities having jurisdiction.
- C. Natural-gas piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.11 OUTDOOR PIPING SCHEDULE

- A. Aboveground natural-gas piping shall be the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.

3.12 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Valves at service meter shall be the following:
 - 1. Bronze plug valve.
- B. Distribution piping valves shall be the following:
 - 1. Bronze plug valve.
- C. Valves in branch piping for single appliance shall be the following:
 - 1. Two-piece, full-port, bronze ball valves with bronze trim.

END OF SECTION

SECTION 230100 – COMMISSIONING OF MECHANICAL SYSTEMS**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. Section includes commissioning process requirements for mechanical (HVAC&R) systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section 016500 – “GENERAL COMMISSIONING REQUIREMENTS” for general commissioning process requirements.
 - 2. Division 22 Section 220100 - “COMMISSIONING OF PLUMBING SYSTEMS”.
 - 3. Division 26 Section 260100 - “COMMISSIONING OF ELECTRICAL SYSTEMS”.

1.3 DEFINITIONS

- A. Commissioning Authority (CxA): Independent agent hired by Owner and not associated with General Contractor or its subcontractors, Architect or its sub-consultants, or Construction Administrator or its staff or consultants. Under Owner’s direction, and not General Contractor’s direction, CA will direct and coordinate day-to-day commissioning activities without assuming oversight responsibilities.
- B. Refer to section 016500- GENERAL COMMISSIONING REQUIREMENTS for additional definitions and assignment of responsibilities.

1.4 REFERENCES

- A. National Environmental Balancing Bureau (NEBB) - Procedural Standards for Building Systems Commissioning
- B. American Air Balance Council (AABC) - Commissioning Guideline
- C. SMCNA - HVAC Systems commissioning Manual

1.5 CONTRACTOR'S RESPONSIBILITIES

- A. Refer to section 016500 - GENERAL COMMISSIONING REQUIREMENTS.
- B. Perform commissioning tests at the direction of the CxA.**
- C. Attend construction phase controls coordination meeting.
- D. Attend testing, adjusting, and balancing review and coordination meeting.
- E. Participate in mechanical systems, assemblies, equipment, and component maintenance orientation and inspection.
- F. Provide information requested by the CxA for final commissioning documentation.
- G. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.
- H. Complete project-specific pre-functional/construction checklists and commissioning process test procedures for actual mechanical systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.
- I. Direct and coordinate commissioning testing among subcontractors, suppliers, and vendors.
- J. Verify testing, adjusting, and balancing of Work are complete.
- K. Provide test data, inspection reports, and certificates in Systems Manual.

1.6 COMMISSIONING DOCUMENTATION

- A. Provide the following information to the CxA for inclusion in the commissioning plan:
 - 1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
 - 2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
 - 3. Process and schedule for completing construction checklists and manufacturer's pre-start and startup checklists for mechanical systems, assemblies, equipment, and components to be verified and tested.
 - 4. Certificate of completion certifying that installation, pre-start checks, and startup procedures have been completed.
 - 5. Certificate of readiness certifying that mechanical systems, subsystems, equipment, and associated controls are ready for testing.
 - 6. Test and inspection reports and certificates.
 - 7. Corrective action documents.
 - 8. Verification of testing, adjusting, and balancing reports.

1.7 SUBMITTALS

- A. Certificates of readiness.
- B. Certificates of completion of installation, pre-start, and startup activities.

PART 2 - PRODUCTS (Not Used)**PART 3 - EXECUTION****3.1 GENERAL**

- A. Refer to section 016500 - GENERAL COMMISSIONING REQUIREMENTS.

3.2 PRE-FUNCTIONAL CHECKLISTS

- A. Contractor shall conduct Pre-functional Testing to document compliance with installation and pre-functional checklists prepared by Commissioning Authority for Division-23 items.
- B. Request verification of Pre-functional checklists by CxA prior to proceeding with system start-up and Functional Testing of systems.
- C. Refer to Section 016500 - GENERAL COMMISSIONING REQUIREMENTS for issues relating to pre-functional checklists and testing, description of process, details on non-conformance issues relating to pre-functional checklists and test.

3.3 SYSTEM START-UP & INSPECTIONS

- A. Contractor is solely responsible for system start-up. CxA may, at his discretion, witness start up procedures, but will not perform any Functional Testing of systems until Contractor has completed start-up and resolved all operating deficiencies.
- B. Contractor is solely responsible for all tests and inspections required by the Authority Having Jurisdiction (AHJ). All test reports and certificates required by the AHJ shall be submitted prior to Functional Testing.
- C. Contractor shall provide no less than 48 hours notice prior to conducting tests specified in other sections of the specifications, including:
 - 1. Duct pressure tests
 - 2. Hydronic piping pressure tests
 - 3. Hydronic piping flushing

CxA shall witness tests at his discretion. Test results shall be documented with respective Pre-functional/construction checklists

3.4 FUNCTIONAL TESTING PREPARATION

- A. Certify that mechanical systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify that mechanical instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Certify that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, corrective work approved, and balance has been verified by CxA (see paragraph below).
- D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, and alarm conditions).
- E. Inspect and verify the position of each device and interlocks identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed.

3.5 TESTING AND BALANCING VERIFICATION

- A. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
- B. Upon completion of testing and balancing work, submit a copy of the report for CxA via Architect. CxA shall review report and issue comments via the Architect.
- C. Verification: The CxA will notify Contractor seven (7) days in advance of the date of field verification. Notice will not include data points to be verified. This verification must take place prior to Functional Testing of systems.
 - 1. Provide technicians, instrumentation, and tools to verify testing and balancing of mechanical systems at the direction of the CxA.
 - 2. The testing and balancing Subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
 - 3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
 - 4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.6 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of mechanical testing shall include entire HVAC installation, from central equipment for heat generation and refrigeration through distribution systems to each space served. Testing shall include measuring capacities and effectiveness of operational and control functions.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. Tests will be performed using design conditions whenever possible.
- E. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the Contracting Officer and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- F. The CxA may direct that set points be altered when simulating conditions is not practical.
- G. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- H. If tests cannot be completed because of a deficiency outside the scope of the mechanical system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
- I. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.7 GENERAL TESTING PROCEDURES FOR HVAC SYSTEMS, SUBSYSTEMS, AND EQUIPMENT

- A. HVAC Instrumentation and Control System Testing: Contractor shall fully test operation of controls system prior to requesting Functional Testing of equipment and systems with CxA. Point-to-point check out sheets and as-built control diagrams shall be provided to CxA so he may develop testing procedures. Refer to Section 230926c BUILDING AUTOMATION SYSTEM COMMISSIONING REQUIREMENTS for commissioning of controls.
- B. Mechanical Subcontractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan for piping systems. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA.
- C. HVAC Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air distribution systems, chilled water systems and hot water systems.

- D. HVAC Equipment Testing: Provide technicians, instrumentation, tools, and equipment to test performance of all HVAC equipment as outlined below.

3.8 FUNCTIONAL TEST PROCEDURES FOR SYSTEMS TO BE COMMISSIONED

A. General

1. The following paragraphs outline the functional test procedures for the various Div. 23 items to be commissioned. Functional testing will take place only after pre-functional checklists have been completed, equipment has been started-up, TAB has been verified, and Contractor has certified that systems are ready for functional testing.
2. All systems controlled via the Building Automation System shall have all control points and sequences tested by Controls Contractor prior to requesting testing by Commissioning Authority. Refer to Section 230926c BUILDING AUTOMATION SYSTEM COMMISSIONING REQUIREMENTS for commissioning of controls.
3. Refer to Section 016500 - GENERAL COMMISSIONING REQUIREMENTS for specific systems to be tested.

B. All Equipment:

1. Verify nameplate information (serial numbers, model numbers, etc.); verify that equipment capacity is in accordance with requirements of construction documents.
2. Verify unit runs smoothly and quietly.
3. Verify operation of safeties.
4. Verify electrical wiring and grounding is correct.
5. Verify maintenance and NEC clearances are maintained.
6. Verify Pre-Functional Checklists have completed.

C. Air Handling Units:

1. Record outside air temperature during test.
2. Record programmed setpoints (occ/unocc heating and cooling temps, coil discharge air temps, static pressure, economizer temp, CO2 setpoint, safeties and alarms)
3. Record programmed schedules
4. Verify fans run smoothly and quietly.
5. Verify voltages and amperages are within tolerance.
6. Verify correct fan rotation (in VFD Auto, Hand, Manual, and Bypass positions).
7. Verify AHU data in TA&B report versus design.
8. Verify chilled water control valve modulation to control supply air temperature.
9. Verify hot water control valve modulation to control discharge air temperature
10. Verify fan modulation to maintain duct static pressure setpoint.
11. Verify damper operation (Return, Outside and relief).
12. Verify Smoke detector operation.
13. Verify all alarms and safeties.
14. Verify all sequences.

D. Dx Single-Zone Units:

1. Record outside air temperature during test.
2. Record space temperature during test.
3. Record programmed setpoints (occ/unocc heating and cooling temps, runtime, safeties and alarms)
4. Record programmed schedules and interlocks
5. Verify fans run smoothly and quietly.
6. Verify voltages and amperages are within tolerance.
7. Verify unit data in TA&B report versus design.
8. Verify compressor cycling to control space temperature.
9. Verify Smoke detector operation.
10. Verify all alarms and safeties.
11. Verify all sequences.

E. Testing Adjusting and Balancing (TAB).

1. Review TAB report for accuracy and completeness.
2. Take random sample of air flow from supply air diffusers and compare to TAB report / design drawings.
3. Take pressure readings at inlets and outlets of hydronic pumps and compare to TAB report and pump curves.

F. Direct Digital Controls (DDC) for HVAC –Refer to Section 230926c BUILDING AUTOMATION SYSTEM COMMISSIONING REQUIREMENTS.**3.9 TRAINING**

- A. Refer to section 016500 - GENERAL COMMISSIONING REQUIREMENTS.

3.10 O&M MANUALS

- A. Refer to section 016500 - GENERAL COMMISSIONING REQUIREMENTS and section 017800 CLOSEOUT SUBMITTALS.

END OF SECTION

SECTION 23 0500

COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. 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 and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
- F. The following are industry abbreviations for plastic materials:
 - 1. CPVC: Chlorinated polyvinyl chloride plastic.
 - 2. PE: Polyethylene plastic.
 - 3. 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.
- 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. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.7 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.
- B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces.

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 23 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

- A. Refer to individual Division 23 piping Sections for special joining materials not listed below.
- B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) 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. 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.

2.4 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.

- C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg. F.
 - 1. Manufacturers:
 - a. 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. Perfection Corp.
 - b. Precision Plumbing Products, Inc.
 - c. Sioux Chief Manufacturing Co., Inc.
 - d. Victaulic Co. of America.

2.5 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - 1. Manufacturers:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

3. Pressure Plates: Plastic Carbon steel. Include two for each sealing element.
4. 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 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.

2.7 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.
- C. One-Piece, Floor-Plate Type: Cast-iron floor plate.
- D. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.8 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 2. Design Mix: 5000-psi, 28-day compressive strength.
 3. Packaging: Premixed and factory packaged.

2.9 PAINTS, ADHESIVES AND SEALANTS

- A. Use paints, adhesive and sealants that comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

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 easy valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - 1. New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Insulated Piping: One-piece, stamped-steel type with spring clips.
 - c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type and set screw.
 - e. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.
 - f. Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.
 - 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 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. 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.
- Q. Verify final equipment locations for roughing-in.
- R. Refer to equipment specifications in other Sections of these Specifications and manufacturers data for roughing-in requirements.

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.

3.3 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
 - 1. 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.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with no 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. 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.
 - 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. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 5. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
 - 6. Use 3000-psi, 28-day compressive-strength concrete and reinforcements.

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
- B. Field Welding: Comply with AWS D1.1.

3.8 GROUTING

- A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

END OF SECTION

SECTION 23 0513

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 COORDINATION

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

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.
- C. Motors shall be manufacturer's premium efficiency design for constant speed motors and manufacturer's high efficiency design for variable speed motors
- D. Service factor 1.15.
- E. Class F insulation or better with a Class B rise at a 1.0 service factor; multi-dipped and baked in Class H varnish.
- F. Stator windings copper. Motor leads stranded copper and are permanently identified and brought out to the terminal box through a neoprene gasket.

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. Motors shall be capable of developing NEMA Design B locked rotor and pull up torque with 90% of rated voltage applied.
- C. Mechanical: stator frame and end brackets are a minimum of grade 25 cast iron construction; terminal box is one size larger than NEMA requirements and rotatable in 90-degree increments; external cooling fans are non-sparking corrosion resistant material; quantity of two drain holes at the lowest points of the motor frame; bearings L-10 life of 40,000hours or 100,000hours for direct-coupled loads; nameplate 304 stainless steel and fastened with four stainless steel ins; all hardware zinc-dichromate plated; balanced dynamically to 0.6 mils peak to peak maximum displacement; capable of all positioning mounting and operation.
- D. Insulation: Class F
- E. 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.
- F. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.
- G. Testing per NEMA MG1-12.

2.3 POLYPHASE MOTORS

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

2.4 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split phase.
 - 3. Capacitor start, inductor run.
 - 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

END OF SECTION

SECTION 23 0529

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Steel pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Metal framing systems.
 - 4. Thermal-hanger shield inserts.
 - 5. Fastener systems.
 - 6. Equipment supports.
- B. See Division 23 Section "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.5 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: 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. Equipment supports.
- C. Welding certificates.

1.6 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: provide products by one of the manufacturers specified.

2.2 STEEL PIPE HANGERS AND SUPPORTS

2.3 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
 - 3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
 - 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel
- B. Manufacturers:
 - 1. B-Line Systems, Inc.; a division of Cooper Industries.
 - 2. Empire Industries, Inc.
 - 3. Globe Pipe Hanger Products, Inc.
 - 4. Grinnell Corp.
 - 5. National Pipe Hanger Corporation.
 - 6. Piping Technology & Products, Inc.

2.4 METAL FRAMING SYSTEMS

- A. MFMA Manufacturer Metal Framing Systems:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cooper B-Line, Inc.
 - b. Thomas & Betts Corporation.
 - c. Unistrut Corporation; Tyco International, Ltd.
 - 2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
 - 3. Standard: MFMA-4.
 - 4. Channels: Continuous slotted steel channel with inturred lips.
 - 5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 - 6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel
 - 7. Metallic Coating: galvanized

2.5 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.

2.6 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: ASTM C 552, Type II cellular glass with vapor barrier.
- D. Insulation-Insert Material for Hot Piping: 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 or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- G. Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.7 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.
 - 1. Manufacturers:
 - a. Hilti, Inc.
 - b. ITW Ramset/Red Head.
 - c. Masterset Fastening Systems, Inc.
 - d. MKT Fastening, LLC.
 - e. Powers Fasteners.
- 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.
 - 1. Manufacturers:
 - a. B-Line Systems, Inc.; a division of Cooper Industries.
 - b. Empire Industries, Inc.
 - c. Hilti, Inc.
 - d. ITW Ramset/Red Head.
 - e. MKT Fastening, LLC.
 - f. Powers Fasteners.

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. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
- B. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- C. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.

- D. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
- E. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- F. Use padded hangers for piping that is subject to scratching galvanic or electrolysis erosion.
- G. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
 - 2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
 - 3. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
- H. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
 - 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.
- I. 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.
- J. 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. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 - 3. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 - 4. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
- K. 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.
- L. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
- M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

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 all insulated piping.
- E. Fastener System Installation:
 - 1. Install powder-actuated fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- 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.
- 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
- 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.

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. VOC emissions from paints and coatings must not exceed the VOC and chemical component limits of Green Seal's Standard GS-11 requirements. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 23 0593

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

- A. This Section includes TAB to produce design objectives for the following:
 - 1. Air Systems:
 - a. Constant-volume air system.
 - 2. Reporting results of activities and procedures specified in this Section.

1.3 DEFINITIONS

- A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.
- B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.
- C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.
- D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.
- E. NC: Noise criteria.
- F. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.
- G. RC: Room criteria.
- H. Report Forms: Test data sheets for recording test data in logical order.
- I. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- J. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.
- K. TAB: Testing, adjusting, and balancing.

- L. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
- M. Test: A procedure to determine quantitative performance of systems or equipment.
- N. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.4 SUBMITTALS

- A. Strategies and Procedures Plan: Within 60 days from Contractor's Notice to Proceed, submit 6 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.
- B. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.
- C. Warranties specified in this Section.

1.5 QUALITY ASSURANCE

- A. Testing, adjusting and balancing (TAB) of the air conditioning systems and related ancillary equipment shall be performed by an impartial technically qualified TAB firm selected and employed by the Owner, separate and apart from the construction contract. TAB Firm Qualifications: Engage a TAB firm certified by, NEBB or TABB.
- B. TAB shall provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems.
 - 1. Where field verification is called for, the CxA will notify Contractor 4 days in advance of the date of field verification. Notice will not include data points to be verified.
 - 2. The testing and balancing Subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
 - 3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
 - 4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.
- C. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
 - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 - 2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.
- D. TAB Report Forms: Use standard forms from NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."
- E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 7.2.2 - "Air Balancing."

- F. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6.7.2.3 - "System Balancing."

1.6 PROJECT CONDITIONS

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

1.7 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.

1.8 WARRANTY

- A. 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. Guarantee shall include the following provisions:
 - 1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
 - 2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
 - 1. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- B. Examine approved submittal data of HVAC systems and equipment.
- C. Examine Project Record Documents described in Division 01 Section "Project Record Documents."

- 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 equipment performance data including fan and pump curves. 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. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.
- F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.
- G. Examine system and equipment test reports.
- H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gages, automatic and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
- J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- K. Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.
- L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- M. Examine equipment for installation and for properly operating safety interlocks and controls.
- N. 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 system readiness reports. Verify the following:
 - 1. Permanent electrical power wiring is complete.
 - 2. Automatic temperature-control systems are operational.
 - 3. Equipment and duct access doors are securely closed.
 - 4. Balance, smoke, and fire dampers are open.
 - 5. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 - 6. 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 NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.
 - 1. Comply with requirements in ASHRAE 62.1-2004, Section 7.2.2 - "Air Balancing."
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.
- C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

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. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
- D. Check airflow patterns from the outside-air louvers and dampers and the return and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
- E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
- F. Verify that motor starters are equipped with properly sized thermal protection.
- G. Check dampers for proper position to achieve desired airflow path.
- H. Check for airflow blockages.
- I. Check condensate drains for proper connections and functioning.
- J. Check for proper sealing of air-handling unit components.
- K. Check for proper sealing of air duct system.

3.5 PROCEDURE FOR DUCT SYSTEM LEAKAGE TESTING

- A. Leakage of the duct system shall not exceed 10% of total design airflow. The testing procedure shall be based on ASTM E1554, Standard Test Methods for Determining External Air Leakage of Air Distribution Systems by Fan Pressurization. Testing shall be performed by the Test and Balance contractor approved by the owner and Engineer. Documentation verifying duct leakage of less than 10% shall be submitted with the Final Testing Report.

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure fan static pressures to determine actual static pressure as follows:
 - a. Measure outlet static pressure as far downstream from the fan as practicable 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 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.
 - 2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and air-treating equipment.
 - a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
 - 3. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
 - 4. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.
 - 5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.
- B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
 - 1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.
 - a. Where sufficient space in submain 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. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
- C. Measure terminal 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 terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.
 - 1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
 - 2. Adjust patterns of adjustable outlets for proper distribution without

3.7 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Electric-Heating Coils: Measure the following data for each coil:
 - 1. Nameplate data.
 - 2. Airflow.
 - 3. Entering- and leaving-air temperature at full load.
 - 4. Voltage and amperage input of each phase at full load and at each incremental stage.
 - 5. Calculated kilowatt at full load.
 - 6. Fuse or circuit-breaker rating for overload protection.
- B. Refrigerant Coils: Measure the following data for each coil:
 - 1. Dry-bulb temperature of entering and leaving air.
 - 2. Wet-bulb temperature of entering and leaving air.
 - 3. Airflow.
 - 4. Air pressure drop.
 - 5. Refrigerant suction pressure and temperature.

3.8 PROCEDURES FOR SPACE PRESSURIZATION MEASUREMENTS AND ADJUSTMENTS

- A. Before testing for space pressurization, observe the space to verify the integrity of the space boundaries. Verify that windows and doors are closed and applicable safing, gaskets, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.
- B. Measure, adjust, and record the pressurization building by adjusting the relief airflows to achieve the indicated conditions.
- C. To achieve indicated pressurization, set the supply airflow to the indicated conditions and adjust the relief airflow to achieve the indicated pressure or airflow difference.
- D. For spaces with pressurization being monitored and controlled automatically, observe and adjust the controls to achieve the desired set point.
 - 1. Compare the values of the measurements taken to the measured values of the control system instruments and report findings.
 - 2. Check the repeatability of the controls by successive tests designed to temporarily alter the ability to achieve space pressurization. Test overpressurization and underpressurization and observe and report on the system's ability to revert to the set point.
- E. In spaces that employ multiple modes of operation, such as normal mode and emergency mode or occupied mode and unoccupied mode, measure, adjust, and record data for each operating mode.
- F. Record indicated conditions and corresponding initial and final measurements. Report deficiencies.

3.9 PROCEDURES FOR TEMPERATURE MEASUREMENTS

- A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.
- B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.
- C. Measure outside-air, wet- and dry-bulb temperatures.

3.10 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.
- 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.

3.11 TOLERANCES

- A. Set HVAC system airflow rates within the following tolerances:
 - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus 5 to plus 10 percent.
 - 2. Air Outlets and Inlets: 0 to minus 10 percent.

3.12 FINAL REPORT

- A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.
- B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
 - 1. Include a list of instruments used for procedures, along with proof of calibration.

- C. Final Report Contents: In addition to certified field report data, include the following:
1. Fan curves.
 2. Manufacturers' test data.
 3. Field test reports prepared by system and equipment installers.
 4. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.
- D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
1. Title page.
 2. Name and address of TAB firm.
 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 firm 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, type size, and fittings.
 14. Notes to explain why certain final data in the body of reports varies from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outside-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Settings for supply-air, static-pressure controller.
 - g. Other system operating conditions that affect performance.
- E. System Diagrams: Include schematic layouts of air distribution system. Present each system with single-line diagram and include the following:
1. Quantities of outside, supply, return, and exhaust airflows. Duct, outlet, and inlet sizes.
 2. Pipe and valve sizes and location
 3. Position of balancing devices.
- F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data: Include the following:
 - 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. Sheave dimensions, center-to-center, and amount of adjustments in inches.

- j. Number of belts, make, and size.
 - k. Number of filters, type, and size.
 - 2. 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.
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Filter static-pressure differential in inches wg.
 - f. Preheat coil static-pressure differential in inches wg.
 - g. Cooling coil static-pressure differential in inches wg.
 - h. Outside airflow in cfm.
 - i. Outside-air damper position.
 - j. Return-air damper position.
 - k. Vortex damper position.
- G. Apparatus-Coil Test Reports:
 - 1. Coil Data:
 - a. System identification.
 - b. Location.
 - c. Coil type.
 - d. Number of rows.
 - e. Fin spacing in fins per inch o.c.
 - f. Make and model number.
 - g. Face area in sq. ft.
 - h. Tube size in NPS.
 - i. Tube and fin materials.
 - j. Circuiting arrangement.
 - 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm.
 - b. Average face velocity in fpm.
 - c. Air pressure drop in inches wg.
 - d. Outside-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. Refrigerant expansion valve and refrigerant types.
 - i. Refrigerant suction pressure in psig.
 - j. Refrigerant suction temperature in deg. F.
- H. Fan Test Reports: For supply, return, and exhaust fans, include the following:
 - 1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches, and bore.
 - h. Sheave dimensions, center-to-center, and amount of adjustments in inches.

2. 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.
 - g. Number of belts, make, and size.
 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.
- I. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
1. Report Data:
 - a. System and air-handling unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg. F.
 - d. Duct static pressure in inches wg.
 - e. Duct size in inches.
 - f. Duct area in sq. ft.
 - g. Indicated airflow rate in cfm.
 - h. Indicated velocity in fpm.
 - i. Actual airflow rate in cfm.
 - j. Actual average velocity in fpm.
 - k. Barometric pressure in psig.

3.13 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. Randomly check the following for each system:
 - a. Measure airflow of at least 10 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. Measure sound levels at two locations.
 - e. Measure space pressure of at least 10 percent of locations.
 - f. Verify that balancing devices are marked with final balance position.
 - g. Note deviations to the Contract Documents in the Final Report.
- B. Final Inspection:
1. After initial inspection is complete and evidence 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 Owner.
 2. TAB firm test and balance engineer shall conduct the inspection in the presence of Owner.

3. Owner shall randomly select measurements documented in the final report to be rechecked. The 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 the 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.
6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.
7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.14 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional testing and balancing 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 testing, inspecting, and adjusting during near-peak summer and winter conditions.

END OF SECTION

SECTION 23 0700

HVAC INSULATION

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Insulation Materials:
 - a. Flexible elastomeric.
 - b. Mineral fiber.
 - 2. Insulating cements.
 - 3. Adhesives.
 - 4. Mastics.
 - 5. Sealants.
 - 6. Factory-applied jackets.
 - 7. Field-applied fabric-reinforcing mesh.
 - 8. Field-applied jackets.
 - 9. Tapes.
 - 10. Securements.
 - 11. Corner angles.

1.2 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
 - 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
 - 2. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 - 3. Detail removable insulation at piping specialties, equipment connections, and access panels.
 - 4. Detail application of field-applied jackets.
 - 5. Detail application at linkages of control devices.
 - 6. Detail field application for each equipment type.

1.3 QUALITY ASSURANCE

- A. 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.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.4 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.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in Part 3 schedule articles 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.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex.
 - c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.
- 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 III 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.; 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 duct and plenum applications, provide insulation with factory-applied FSK jacket. 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. Sizes shown on the drawings are free area dimensions (after installation of duct liner)
- J. Acceptable product for lining rectangular section ducts and plenums: Johns Manville "Permacote Linacoustic R-300" or approved equal.

2.2 INSULATING CEMENTS

- A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.
- B. The VOC content of adhesives and sealants used must be less than the current VOC content limits of South Coast Air Quality Management District (SCAQMD) Rule #1168, and all sealants used as fillers must meet or exceed the requirements of the Bay Area Air Quality Management District Regulation 8, Rule 51.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - 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.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - 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.
 - 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- 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. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
- B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - 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. Marathon Industries, Inc.; 590.
 - e. Mon-Eco Industries, Inc.; 55-40.
 - f. Vimasco Corporation; 749.
 - 2. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 180 deg. F.
 - 4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - 5. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-10.
 - b. Foster Products Corporation, H. B. Fuller Company; 35-00.
 - c. ITW TACC, Division of Illinois Tool Works; CB-05/15.
 - d. Marathon Industries, Inc.; 550.
 - e. Mon-Eco Industries, Inc.; 55-50.
 - f. Vimasco Corporation; WC-1/WC-5.
 - 2. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 200 deg. F.
 - 4. Solids Content: 63 percent by volume and 73 percent by weight.
 - 5. Color: White.

2.5 SEALANTS

- A. Joint Sealants:
 - 1. Joint Sealants for Cellular-Glass Products: Subject to compliance with requirements, provide the following available products that may be incorporated into the Work include, but are not limited to, 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.
- B. FSK and Metal Jacket Flashing Sealants:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-76-8.
 - b. Foster Products Corporation, H. B. Fuller Company; 95-44.
 - c. Marathon Industries, Inc.; 405.

- d. Mon-Eco Industries, Inc.; 44-05.
- e. Vimasco Corporation; 750.
- 2. Materials shall be compatible with insulation materials, jackets, and substrates.
- 3. Fire- and water-resistant, flexible, elastomeric sealant.
- 4. Service Temperature Range: Minus 40 to plus 250 deg. F.
- 5. Color: Aluminum.

2.6 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

2.7 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
- C. Aluminum Jacket: Factory cut and rolled to indicated sizes. Comply with ASTM B 209, 3003 alloy, H-14 temper.
 - 1. Finish and Thickness: Stucco-embossed finish, 0.016 inch thick.
 - 2. Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and kraft paper.
 - 3. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish, and thickness as jacket.

2.8 SECUREMENTS

- A. Aluminum Bands: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing or closed seal.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Products; Bands.
 - b. PABCO Metals Corporation; Bands.
 - c. RPR Products, Inc.; Bands.
- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- C. Wire: 0.062-inch soft-annealed, stainless steel.
 - 1. Manufacturers: Subject to compliance with requirements:
 - a. C & F Wire.
 - b. Childers Products.
 - c. PABCO Metals Corporation.
 - d. RPR Products, Inc.

2.9 CORNER ANGLES

- A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, 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. 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.
 - 5. Provide rigid insulation at all duct and pipe hangers, at all hanger locations.
- 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 duct and pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above ambient services, do not install insulation to the following:
 - 1. Vibration-control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.
 - 5. Handholes.
 - 6. Cleanouts.

3.3 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 - 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Floor Penetrations:
 - 1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
 - 2. Pipe: Install insulation continuously through floor penetrations.
 - 3. Seal penetrations through fire-rated assemblies.

3.4 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
 - 1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
 - 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 - 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
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.
 - 4. 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.

5. 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.
 6. 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.
 7. 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.
 8. 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.

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

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

3.6 MINERAL-FIBER INSULATION INSTALLATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
 - 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 - 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 - 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 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 F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 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.
- B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 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 F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 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.

3.7 FIELD-APPLIED JACKET INSTALLATION

- A. Where FSK jackets are indicated, install as follows:
 - 1. Draw jacket material smooth and tight.
 - 2. Install lap or joint strips with same material as jacket.
 - 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 - 4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch- wide joint strips at end joints.
 - 5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
- B. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.8 FINISHES

- A. Duct, Equipment, and Pipe Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with flat white paint system identified.
 - 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.

3.9 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
 - 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(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
- C. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation:
 - 1. Indoor, exposed outdoor air.
 - 2. Indoor, concealed return air plenums.
 - 3. Outdoor, exposed outdoor air.

3.11 INDOOR DUCT AND PLENUM APPLICATION SCHEDULE

- A. Service: Indoor, exposed rectangular and round, outside-air ducts.
 - 1. Material: Mineral-fiber blanket.
 - 2. Thickness: 2 inches.
 - 3. Density: 1 lb/cu. ft.
 - 4. k value: 0.27 at 75 Degrees F.
 - 5. Number of Layers: One.
 - 6. Vapor Barrier: Provide a vapor barrier on all supply and outside air ductwork
 - 7. Jacket: factory-applied all service jacket (ASJ)

3.12 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Underground piping.
 - 2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.13 PIPING INSULATION SCHEDULE

- A. Refrigerant Suction and Hot-Gas Piping concealed inside the building:
 - 1. All Pipe Sizes: Insulation shall be the following:
 - a. Insulation Material: Flexible elastomeric
 - b. Insulation Thickness: 1 ½" inches
 - c. Minimum K value @ 75 Deg F: 0.20
 - d. Jacket: None
 - e. Vapor Retarder Required: Yes
- B. Refrigerant Suction and Hot-Gas Piping Exposed outside the building:
 - 1. All Pipe Sizes: Insulation shall be the following:
 - a. Insulation Material: Flexible elastomeric
 - b. Insulation Thickness: 1 ½" inches
 - c. Minimum K value @ 75 deg. F: 0.20
 - d. Jacket: Aluminum
 - e. Vapor Retarder Required: Yes

END OF SECTION

**DIRECT DIGITAL CONTROLS FOR
LOCAL BUILDING AUTOMATION SYSTEMS
TRIDIUM-BACNET WEB-BASED –SECTION 230926a**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Division 23
 - 1. General Mechanical Requirements
 - 2. Mechanical equipment
 - 3. Piping
 - 4. Variable Frequency Drives (VFDs)
 - 5. Building Automation System Commissioning Requirements
- C. Division 26
 - 1. General Electrical Requirements
 - 2. Raceways
 - 3. Disconnect Switches
 - 4. Wiring
- D. Division 27
 - 1. Telecommunications cabling
- E. Division 28
 - 1. Fire Alarm Systems.
- F. Mechanical and electrical drawings: Specifications and drawings are complementary to each other and binding. What is called for by one shall be binding as if called for by both. Should there be a conflict between drawings and specifications regarding a material shown of work described or detailed then the material of work having the greater value shall be provided.

1.2 SUMMARY

- A. Provide all hardware, software, materials, labor, and programming for the implementation of a complete standalone Local Building Automation System (BAS) for control of HVAC systems and components.
- B. The system shall consist of a network of microprocessor-based, peer-to-peer, networked, distributed devices utilizing the BACnet communication protocol in an open, interoperable system. The system shall include all wiring and control devices, sensors, actuators, valves, dampers, and hardware required for a complete operational system that will achieve the control sequences specified.
- C. Provide all programming to achieve specified operational sequences, and development of graphical screens, setup of schedules, trends, logs, alarms, network management, and operational connection of the Network Control Unit (NCU) to the local area network.

- D. Access to the Building Automation System for configuration and monitoring shall be performed via a Network Control Unit (NCU) connected to the LAN or WAN.
- E. All components of the system shall be BACnet Testing Laboratories (BTL) Certified.
- F. System design shall follow pertinent and applicable BACnet guidelines. Controllers that require a master computer or controller to perform basic functions are not acceptable. In the event of a network communication failure, or the loss of any other controller on the BACnet network, the control system shall continue to independently operate under control of the resident program stored in nonvolatile memory as detailed herein.
- G. The network infrastructure shall conform to the BACnet published guidelines for network wiring and system architecture. Wire type, distance, termination, and use of routers shall strictly conform to the BACnet wiring standards. The number of nodes per channel shall be no more than 80% of the defined segment (logical or physical) limit in order to provide future system enhancement with minimal infrastructure modifications.
- H. Mechanical equipment controllers shall include all control points and achieve all control sequences specified while operating under stand-alone control, independently of connection to the network manager.
- I. Provide DDC system shop drawings and submittals, participate in submittal review meetings, and obtain final approval of submittal from Owner and Engineer prior to installation of system.
- J. Fully test system prior to requesting installation inspection and pre-functional testing by Owner, Engineer, and Commissioning Authority.
- K. Schedule competent technical personnel to participate in Commissioning activities.
- L. Provide a Schedule of Values for work of this section, that includes the following:
 - 1. Submittals (5%)
 - 2. Materials (35%)
 - 3. Installation (35%)
 - 4. Installation Verification with Owner's CxA (5%)
 - 5. Programming & Graphics (10%)
 - 6. Point check out and Commissioning with Owner's CxA (5%)
 - 7. Final O&Ms and As-Built Documentation (5%)

1.3 SYSTEM PERFORMANCE

- A. Comply with the following performance requirements:
 - 1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
 - 2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
 - 3. Object Command: Reaction time of less than ten seconds between operator command of a binary object and device reaction.
 - 4. Object Scan: Transmit change of state and change of analog values to control units or workstation within eight to ten seconds.
 - 5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
 - 6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.

7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.

1.4 ACCEPTABLE CONTRACTORS

- A. Pending compliance with this specification, the following firms have been deemed acceptable contractors for the products and services herein specified:
 1. Trane US Inc.
 2. Tempset Controls Inc.
 3. Goto Automation
- B. Contractor responsible for work under this Section shall be a local factory certified office of the manufacturer of control systems located within 75-mile radius from the job site. Experience requirements below apply only to the local factory certified office.
- C. Contractor shall have, as a minimum, five (5) years of documented continuous business experience in the installation of controls, instrumentation and Energy Management Systems.
- D. Contractor's local personnel conducting work of this section shall have a minimum of three (3) years of experience in the installation of BACnet systems. Personnel conducting work shall be:
 1. Tridium Niagara N4 Certified
 2. BACnet Certified Professional

Contractor shall provide evidence of certifications upon request.

- E. The installing office shall provide a list of completed and accepted BACnet job references. The references shall include one job from each of the Three (3) years required.
- F. Each reference shall include the following: the job name, the job size, the owner with address, contact name and phone number, the general contractor, the mechanical contractor, and the contracting company's system programmer name(s).
- G. The Contractor's BACnet Certified personnel shall be directly responsible for all work related to:
 1. System design
 2. Submittals
 3. Programming;
 4. Installation Supervision
 5. Calibration
 6. Checkout
 7. Commissioning.

1.5 SUBMITTALS

- A. Refer to Division-1 Submittals and Division-23 General Mechanical Work for additional submittal requirements.
- B. Scope of Work Summary: Include in submittal package a clear written summary of the scope of control work, including but not limited to the following:
 1. Integration with the existing systems (if any) at the facility;
 2. Scope of demolition work (if any)

3. Systems to be controlled as part of this work, clearly stating which systems will receive full DDC systems, and which (if any) will receive only timeclock control.
4. Evidence of coordination with manufacturers of equipment provided under the mechanical and electrical scope of work to verify that all required control points and sequences will be implemented, regardless of whether the DDC controls reside in a controller provided by the equipment manufacturer or the controls contractor.

C. Product Data:

1. DDC System Hardware:
 - a. Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
 - b. Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
2. Network Control Devices and System Software:
 - a. Include technical data for operating system software, service maintenance agreement and device/point count license details.
 - b. Provide legally licensed copies of all software tools, configuration tools, management tools, and utilities used during system installation and commissioning.
3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram. Network Control Devices and System Software:
4. Cabling: Technical data sheets for all cables.

D. Shop Drawings:

1. Include AISD Project Number on Cover Page.
2. Include specification section and revision on Cover Page.
3. Single-line schematic diagram, top-level subsystem, depicting the network architecture. The top-level subsystem shall illustrate the network media, channel transceiver types, subsystems, network interfaces, Human Machine Interfaces (HMI), repeaters, and terminators if utilized.
4. Floor plan diagrams of the building shall indicate unit and unit controller locations, room numbers or area names and space sensor locations and a diagram of how the BACnet Network wiring is routed from the Building Controller to all of the BACnet controllers.
5. System diagrams for each system and subsystem, including power supply through starters and motors; motor starting and interlock wiring; pushbuttons; all control wiring; interior electrical circuits of control instruments with terminal designations; control motors; colors of wires; wire tags and tag numbers, location of router, controllers, instruments and remote elements; horsepower of motors; normal position of valves, dampers, and relays. A detailed description of the operation of the control system, including control device designation, shall accompany the drawings. The drawings shall include a floor plan and riser diagram of the school indicating unit locations, sensor

locations, areas served by each piece of equipment and BACnet Network and Sub-network wiring details with routing of all communication cables.

6. Bill of materials of equipment indicating quantity, manufacturer, and model number.
7. Details of control panel faces, including controls, instruments, and labeling.
8. Schedule of dampers including size, leakage, and flow characteristics.
9. Schedule of valves including flow characteristics.
10. DDC System Hardware:
 - a. Wiring diagrams for control units with termination numbers.
 - b. Schematic diagrams and floor plans for field sensors and control hardware.
 - c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
11. Controlled Systems:
 - a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
 - b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
 - c. Written description of sequence of operation including schematic diagram. In the event the sequences proposed by Engineer are unclear, incomplete, or known to be non-compliant with Owner's requirements, Contractor shall issue a Request For Information (RFI) document prior to preparing submittals.
 - d. Points list: Provide a complete list of all input and output points, alarms, setpoints and schedules that will be transmitted to and from the Web Server. This point list shall include points to be obtained from BACnet Controllers provided by equipment manufacturers.

E. Preliminary Submittal (Shop Drawings and Product Data)

1. Prepare a Preliminary Submittal for review by Owner, Engineer, and Commissioning Authority.
2. Make arrangements with General and Mechanical Contractors to transmit Preliminary Submittal electronically to all recipients simultaneously, with no paper copy to follow.
3. Shop Drawings and Product Data shall be submitted at the same time but as separate files.
4. Request a Preliminary Submittal Review meeting with General Contractor, Mechanical Contractor, Owner, Engineer, and Commissioning Authority no less than six (6) days after transmittal. This time is required for review by all parties.
5. Contractor shall lead the Preliminary Submittal Review Meeting to address at least the following:
 - a. Owner, Engineer, and Commissioning Authority comments;
 - b. Resolution to any pending RFI's related to control work;
 - c. Final coordination of any controls provided by equipment manufacturers (in which case manufacturers should be asked to attend meeting as well)
 - d. Review Submittal Checklist
 - e. Timeline for final submittal.

F. Final Submittal (Shop Drawings and Product Data)

1. Prepare Final Submittal after addressing all issues discussed during Preliminary Submittal Review Meeting.
2. Allow six (6) days for review by Owner, Engineer and Commissioning Authority.
3. Do not proceed with installation prior to receiving notification of submittal approval.

1.6 OPERATION AND MAINTENANCE DATA

- A. At the time of Functional Testing, update submittal data to reflect condition of systems as installed and programmed.
- B. Make any final revisions made during Functional Testing with Owner and Commissioning Authority.
- C. Submit ALL requirements listed under Paragraph 1.6 Submittals, as part of the Operation and Maintenance Manual. Include warranty start date.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Refer to Paragraph 1.5.
- 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. Installation in accordance with all codes and local ordinances. Refer to Part 3 of this specification for additional installation requirements.

1.8 DELIVERY, STORAGE, AND HANDLING

- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.
- B. System Software: Update to latest version of software at Project completion.

1.9 COORDINATION

- A. Prior to preparing submittals, coordinate location of control devices and routing of wiring with plans and room and equipment details. For retrofit applications, conduct a detailed inspection of the site and equipment to receive controls in order to identify optimal locations for devices, mounting of controllers, and routing of wiring.
- B. It is the intent of this specification that the Section 230926 Contractor shall be responsible for all power and control wiring and raceways associated with the turnkey operational installation of the DDC system. Prior to submittals, coordinate with any additional power requirements that require the involvement of the Division 26 Contractor.
- C. Coordinate with other Division 23 Contractors and equipment suppliers for control of mechanical equipment. It is the intent of this specification that the Section 230926 Contractor shall assume responsibility for a turnkey fully operational control system that includes interfacing with controls integral to equipment –whether via conventional electro-mechanical control or BACnet interfaces.
- D. Coordinate equipment with Division 28 Section "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system.
- E. Coordinate equipment with Division 26 Section "Motor-Control Centers" and "Variable Frequency Controllers" to achieve compatibility with motor starters and annunciation devices.

1.10 WARRANTY

- A. The entire BACnet network controls system including wiring, controllers, controlling devices, sensing devices, integral components, service and labor will be warranted for one (1) year from date of system acceptance date unless the manufactures warranty extends beyond the one (1) year warranty. The warranty will then be as indicated by the manufacture of the product.
- B. System acceptance date starts upon successful completion of Functional Testing, as determined by Commissioning Authority.
- C. If corrective software and/or hardware modifications are made during the warranty period, the BAS controls contractor shall update all user documentation, user and manufacturer archived CD ROM and software disks.

1.11 TRAINING

- A. Provide a minimum of **16 hours** of training to AISD personnel. The number of individuals selected for training shall be at the sole discretion of AISD.
- B. Training shall cover all aspects of the specified controls system from system overview and operation to basic trouble-shooting. Training shall include a mix of classroom and actual hands on instruction to include but not limited to training during commissioning of BACnet nodes on site and application specific at the BAS system contractor's local office. Training shall include a minimum of eight (8) hours of classroom and eight (8) hours of field training on the newly installed control system. At AISD's discretion, the training may be mixed to allow for more or less time in the classroom or field training areas.
- C. The BAS System Contractor shall create an agenda for the training class and submit it for approval by AISD Energy Management Department before training classes are scheduled.
- D. Provide all training manuals, materials, and operator and maintenance manuals as required.

1.12 CODES AND STANDARDS

- A. The completed and operational BAS shall be in compliance with and meet the requirements of all governing bodies, Authorities Having Jurisdiction (AHJ), applicable local or national standards and codes, except where more stringent or detailed requirements are indicated by the Contract Documents, including the requirements set forth in this Specification and the following:
 - 1. ASHRAE 135-2016: BACnet -Building and Air Conditioning Engineers (ASHRAE)
 - 2. Underwriters Laboratories UL-916: Energy Management Systems (EMS)
 - 3. NIST IR 6392 Annex B: Profiles of Standard BACnet Devices
 - 4. EIA-485: Standard for Electrical Characteristics of Generator and Receivers for Use in Balanced Digital Multi-Point System.

PART 2 - PRODUCTS**2.1 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURES**

- A. The intent of this specification is to provide a peer-to-peer networked, distributed control system using ANSI/ASHRAE Standard 135-2016, BACnet technology communication protocols, in an open, interoperable system. The direct digital control (DDC) system shall consist of BACnet based microprocessor-based controllers, plus instrumentation, control valves, dampers, operators, control devices, interface equipment, network manager, BACnet communication interfaces, and other apparatus required to operate systems and perform functions specified. The DDC system shall be capable of providing total integration of the facility infrastructure systems with user access to all system data via Human Machine Interface (HMI) using a Web Browser such as Internet Explorer™, Mozilla Firefox™ or Google Chrome™ connected to the system network using the LAN or WAN.

2.2 NETWORKS

- A. The system architecture shall support the following levels.
 - 1. Master Slave/Token Passing (MS/TP)
 - 2. BACnet IP (B/IP)
- B. Local area network minimum physical and media access requirements:
 - 1. Ethernet; IEEE standard 802.3u
 - 2. Cable; 100 Base-T, UTP-8 wire, Category 5e
 - 3. Minimum throughput; 100 Mbps

2.3 GRAPHICAL USER INTERFACE (GUI) SOFTWARE

- A. Graphical User Interface: Provide a software tool that allows for the development and management of the end users' Graphical User Interface (GUI) and as the primary point of access to the BAS for the end user.
- B. The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, log-off button and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.
- C. Real Time Displays: The GUI shall at a minimum support the following features and functions:
 - 1. Graphic screens shall be developed using any drawing package capable of generating or assembling objects from a GIF, JPG, PNG or ICO file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures.
 - 2. Graphic screens shall have the capability to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URL's, and links to other graphic screens.

3. Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.
 4. Schedule and holiday times shall be adjusted using a graphical calendar.
 5. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu.
 6. Adjustments to analog objects, such as set points, shall be done by right-clicking the selected object and using a graphical slider to adjust the value.
- D. System Configuration: At a minimum the GUI shall permit the operator to perform the following tasks with proper password access:
1. Create, delete or modify control strategies
 2. Add/delete objects to the system
 3. Tune control loops through the adjustment of control parameters
 4. Enable or disable control strategies
 5. Override inputs and outputs (permanent and timed)
 6. Generate hard copy records or control strategies on a printer
 7. Select point to be trended over a period of time and initiate the recording of values automatically.
- E. On-Line Help: Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.
- F. Security: Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operators' access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.
- G. System Diagnostics: The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.
- H. Alarm Console:
1. The system will be provided with a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console can be enabled or disabled by the system administrator.
 2. When the Alarm Console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.

2.4 WEB BROWSER CLIENTS

- A. A web browser shall be the primary means of access to the BAS for day to day operation from any PC connected to the LAN and remote via internet without the need for any proprietary software.
- B. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™, Mozilla Firefox™ or Google Chrome™. 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.
- C. The Web browser 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.
- D. The Web browser client shall support at a minimum, the following functions:
 - 1. User log-on identification and password shall be required. If an unauthorized user attempts access, a blank web page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
 - 2. Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.
 - 3. HTML programming shall not be required to display system graphics or data on a Web page.
 - 4. Storage of the graphical screens shall be in the Network Control Unit (NCU), without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
 - 5. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.
 - 6. User shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
 - a. Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
 - b. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
 - c. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
 - d. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
 - e. View logs and charts.
 - f. View and acknowledge alarms.
 - g. The system shall provide the capability to specify a user’s (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
 - h. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.

2.5 NETWORK CONTROL UNITS

- A. The Network Control Unit (NCU) shall provide the interface between the LAN or WAN and the field control devices, and provide global supervisory control functions over the control devices connected to the NCU.
- B. The NCU shall be capable of executing application control programs to provide:
 - 1. Calendar functions
 - 2. Scheduling
 - 3. Trending
 - 4. Alarm monitoring and routing
 - 5. Time synchronization
 - 6. Integration of BACnet controller data
 - 7. Network management functions for all BACnet based devices.
- C. The NCU must provide the following hardware features as a minimum:
 - 1. 1000Mhz Processor
 - 2. 1GB DDR-3 SDRAM
 - 3. 4GB Flash Memory
 - 4. Wi-Fi Connectivity IEEE802.11a/b/g/n
 - 5. Two 10/100MB Ethernet Ports
 - 6. Two Isolated RS-485 Ports
 - 7. One USB Type A Connector
 - 8. Real Time Clock
 - 9. Support of up to Four IO/Communication Expansion Modules
- D. The NCU shall provide multiple user access to the system and support for ODBC or SQL. A database resident on the NCU shall be an ODBC-compliant database or must provide an ODBC data access mechanism to read and write data stored within it.
- E. The Network Control Unit will provide all scheduling, alarming, trending, and network management for the all BACnet devices.
- F. Provide multiple Network Control Units as necessary. The NCU shall support a minimum of 128 BACnet controllers. In order to maintain peak performance of the network, no more than 110 BACnet controllers may be connected to a single NCU and no more than 64 BACnet controllers per NCU Communication Trunk. In any event, no more than 70% of the available resources of the NCU (as indicated by the resource meter of the programming tools for the NCU) shall be committed. In the event that the available resources are less than 30%, the number of nodes connected to the NCU shall be reduced in order to maintain a 30% or greater buffer of resources within the NCU.
- G. The NCU shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 5 simultaneous users.
- H. Event Alarm Notification and actions - The NCU shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers. The NCU shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up, telephone connection, or wide-area network.
 - 1. Alarm generation shall be selectable for annunciation type and acknowledgement; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers. The NCU shall be able to route any

alarm condition to any defined user location whether connected to a local network or remote via dial-up, telephone connection, or wide-area network.

- a. To Alarm
 - b. Return to normal
 - c. To fault
2. Provide for the creation of a minimum of eight of alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc.
 3. Provide timed (schedule) routing of alarms by class, object, group, or node.
 4. Provide alarm generation from binary object “runtime” and /or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control. Control equipment and network failures shall be treated as alarms and annunciated.
 5. Alarms shall be annunciated in any of the following manners as defined by the user, but implemented by this contractor:
 - a. Screen message on screen
 - b. Email of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on:
 - 1) Day of week
 - 2) Time of day
 - 3) Recipient
 - c. Pagers via paging services that initiate a page on receipt of email message.
 - d. Graphic with flashing alarm object(s).
 - e. Printed message, routed directly to a dedicated alarm printer.
 6. The following shall be recorded by the NCU for each alarm (at a minimum):
 - a. Time and date
 - b. Equipment (Air handler #, pump, etc.)
 - c. Acknowledge time, date and user who acknowledged
 - d. Number of occurrences since last acknowledgement
 7. Alarm actions may be initiated by user defined programmable objects created for that purpose.
 8. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user.
 9. A log of all alarms shall be maintained by the NCU and/or a server (if configured in the system) and shall be available for review by the user.
 10. Provide a “query” feature to allow review of specific alarms by user defined parameters.
 11. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.
 12. An Error Log to record invalid property changes or commands shall be provided and available for review by the user.

I. Acceptable Products:

1. JACE-8000:
 - a. Niagara N4 Version 4.4 (Consult with Owner if a newer version is available)
 - b. Open License NiCS (Vendor Neutral, No Vendor Locking)
 - c. Embedded Workbench
 - d. 40% Minimum Spare Capacity (Devices & Points)
 - e. 5-Year SMA (Software Maintenance Agreement)

J. Data Collection and Storage

1. The NCU shall have the ability to collect data for any property of any object and store this data for future use.
2. The data collection shall be performed by log objects, resident in the NCU that shall have, at a minimum, the following configurable properties:
 - a. Designating the log as interval or deviation.
 - b. For interval logs, the object shall be configured for time of day, day of weeks and the sample collection interval.
 - c. For deviation logs, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
 - d. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis.
 - e. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.
3. All log data shall be stored in a relational database in the NCU and the data shall be accessed from a server (if the system is so configured) or a standard Web Browser. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements. All log data shall be available to the user in the following data formats:
 - a. HTML
 - b. XML
 - c. Plain Text
 - d. Comma or tab separated value
4. Systems that do not provide log data in HTML and XML formats at a minimum shall not be acceptable.
5. The NCU shall have the ability to archive its log data either locally (to itself), or remotely to a server or other NCU on the network. Provide the ability to configure the following archiving properties, at a minimum:
 - a. Archive when the log has reached its user-defined capacity of data stores
 - b. Archive on time of day
 - c. Archive on user-defined number of data stores in the log (buffer size)
 - d. Provide ability to clear logs once archived
6. Provide and maintain an Audit Log that tracks all activities performed on the NCU. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the NCU), to another NCU on the network, or to a server. For each log entry, provide the following data:
 - a. Time and date
 - b. User ID
 - c. Change or activity; i.e. change setpoint, add or delete objects, commands, etc.

K. Database Backup and Storage

1. The NCU as provided shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval. Copies of the current database and, at the most recently saved database shall be stored in the NCU. The age of the most recently saved database is dependent on the user-defined database save interval. The NCU database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

2. Provide all tools necessary for the development, maintenance, expansion and use of the BAS described within these specifications. All software tools shall be compatible with the network management tool (workbench) that is provided as part of this project. For the purpose of this specification software tools shall be divided into the following categories and meet these specified requirements.

L. NCU Programming Wizards for LCU/TCU Controllers

1. Provide Wizards or objects that facilitate the programming and configuration of the local Control Unit (LCU) and terminal Control Unit (TCU) Controllers sequence of operation through a menu driven wizard. All software tools (including Wizards) shall be compatible with the network management tool (workbench) that is provided as part of this project. The programming and configuration tools shall perform the following functions:
 - a. LCU Controllers programming shall be accomplished by Graphical programming language (GPL) where objects are used to define different portions of the control sequence. All control sequences programmed into the controller shall be stored in non-volatile memory. Systems that only allow selection of sequences from a library or table are not acceptable. All code must be exportable to a library for future use.
 - b. TCU Controllers – Provide for the programming of the required sequence of operation through an intuitive menu driven selection process. The configuration tools menu shall define items such as I/O configurations, set point, delays, PID loops, optimum start stops, and network variables settings. The configuration tool must indicate the device status and allows system override. Or, provide for the programming of the required sequence of operation through Graphical programming language (GPL) where objects are used to define different portions of the control sequence. All control sequences programmed into the controller shall be stored in non-volatile memory. Systems that only allow selection of sequences from a library or table are not acceptable. All code must be exportable to a library for future use.

M. NCU Network Management Software Tools

1. Provide a complete set of Network Management tools that provides for the development and management of BACnet networks.
2. Network management shall include the following services: device identification, device installation, device configuration, device diagnostics, device maintenance and network variable binding.
3. The network configuration tool shall also provide diagnostics to identify devices on the network, to reset devices, and to view health and status counters within devices.
4. These tools shall provide the ability to “discover” existing BACnet networks, regardless of what network management tool(s) were used to install the existing network, so that existing BACnet devices and newly added devices are part of a single network management database.
5. The network management database shall be resident in the NCU and with proper authorization, shall allow access to the network management database. Systems employing network management databases that are not resident in the NCU, shall not be accepted.
6. System shall allow access to all of the Network Management tool functions including controller programming from a Web Browser.

N. NCU Programming Software

1. Provide programming software for the Network Control Unit that allows for the development of the NCU control logic, point management, global properties such as alarm, trend and scheduling.
2. All library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens. Access to these functions shall be provided through Graphical User Interface software (GUI). Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide “real-time” data updates. Any real-time data value or object property may be connected to display its current value on a user display. Systems requiring separate software tools or processes to create applications and user interface displays shall not be acceptable.
3. Programming Methods – Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user’s application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in color depending on the type of link; i.e., internal, external, hardware, etc.
 - a. Configuration of each object will be done through the object’s property sheet using fill-in the blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.
 - b. The software shall provide the ability to view the logic in an off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.
 - c. All programming shall be done in real-time. Systems requiring the uploading, editing, and downloading of database objects shall not be allowed.
 - d. The system shall support object duplication within a customer’s database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.

O. NCU Object Library

1. A standard library of software objects that represent functions and applications for the development and setup of application logic, user interface displays, system services, and communication networks.
2. The objects in this library shall be capable of being copied and pasted into the user’s database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.
3. In addition to the standard libraries specified here, the supplier of the system shall maintain an on-line accessible (over the Internet) library, available to all registered users to provide new or updated objects and applications as they are developed.

2.6 LOCAL CONTROL UNITS, TERMINAL CONTROL UNITS, INTEGRATED SPACE SENSORS

A. General

1. All controllers provided as part of this system and used for indoor applications shall operate under ambient environmental conditions of 32 degF (0 degC) to 122 degF (50 degC) dry bulb and 5% to 90% relative humidity, non-condensing as a minimum.
2. All controllers provided as part of this system and used for outdoor applications shall operate under ambient environmental conditions of -40 degF (-40 degC) to 158 degF (70 degC) dry bulb and 5% to 90% relative humidity, non-condensing as a minimum.

B. System Design

1. Local Control Units (LCU) shall be utilized for primary mechanical and electrical systems such as Air handling equipment, Make-up Air Unit, Boiler System Control, and Chiller System Control type of applications.
2. Terminal Control Units (TCU) shall be utilized for terminal equipment, such as Variable Air Volume, Fan Coil, Heat Pump, Roof Top applications.
3. Each LCU and TCU controller shall have a minimum of 10% spare capacity of each point type for future points. As a minimum, each controller shall have one spare of each point type available on the controller.
4. The LCU and TCU controller programming or configuration tools shall be fully accessible through the Operator Workstation and Web Browser Client through the use of Wizards. Provide Wizards or objects as specified in NCU paragraph that facilitate the programming and configuration of the LCU and TCU through a menu driven wizard.

C. Controller Local Area Network (BAS sub-LAN)

1. Provide a network of stand-alone, distributed direct digital controller that operate on ANSI/ASHRAE Standard 135-2016 BACnet communication protocol.
2. Provide BAS Controllers that utilize BACnet technology and are BTL certified. Controllers using proprietary protocols are unacceptable.
3. The design of the BAS sub-LAN shall network Local Control Unit (LCU) and Terminal Control Unit (TCU) to a Network Control Unit (NCU).
4. This level of communication shall support a family of application specific controllers and shall communicate bi-directionally with the network through DDC Controllers for transmission of global data.
5. Terminal Control Unit (TCU) shall be arranged on the BAS sub-LAN's in a functional relationship manner with Local Control Unit (LCU). Ensure that a Variable Air Volume (VAV) Terminal Control Unit (TCU) is logically on the same LAN or segment as the Local Control Unit (LCU) that is controlling its corresponding Air Handling Unit (AHU).

D. Programming Software (LCUs and TCUs)

1. Provide programming software that allows for the development of the control logic and point management.
2. Main programming method shall be Object-Oriented-Programming. Conditional programming (If, Then, Else) as the main programming method is not permitted.
3. A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens. Access to these functions shall be provided through Graphical User Interface software (GUI). Applications are to be created by selecting the desired control objects from the library, dragging or pasting

them on the screen, and linking them together using a built-in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide “real-time” data updates. Any real-time data value or object property may be connected to display its current value on a user display. Systems requiring separate software tools or processes to create applications and user interface displays shall not be acceptable.

4. Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user’s application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification.
5. Configuration of each object will be done through the object’s property sheet using fill-in the blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.
6. The software shall provide the ability to view the logic with value being inputted/outputted of the graphical blocks (debug mode).
7. The software shall allow for controllers to be programmed and debugged remotely without the need for direct-connecting to the controller needing reprogramming or debugging.
8. The system shall support object duplication within a customer’s database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.

E. TCU Configuration Software

1. Configuration of the TCU controller shall be done through the configuration tool using fill-in the blank fields, list boxes, and selection buttons.
2. The configuration tool menu shall define items such as I/O configurations, set point, delays, PID loops, optimum start stops, and network variables/object settings. The configuration tool shall indicate the device status and allows system override.
3. The Configurable Controller shall allow the use of its spare I/O as dumb I/O to be shared over the network to other Controllers such as Programmable Controllers, where a sequence of operation can be applied to the I/O. Such applications shall include but not be limited to exhaust fan control, heaters, lighting control, etc.

F. Local Control Units (LCU)

1. The Local Control Units (LCU) shall be 32-bits microprocessor-based. They shall also be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the project point list.
2. Each LCU shall have sufficient memory, to support its own operating system and databases, including:
 - a. Control processes
 - b. Energy management applications
 - c. Alarm management applications

- d. Historical/trend data for points specified
 - e. Maintenance support applications
 - f. Custom processes
 - g. Manual override monitoring
3. Each LCU shall support:
- a. Analog inputs of 4-20 mA, 0-10 Vdc, 10,000 ohm thermistor or 1000 ohm RTD.
 - b. Digital inputs from dry contact closure, pulse accumulators, voltage sensing.
 - c. Each LCU shall be capable of providing the following control outputs without the addition of equipment outside the DDC controller cabinet:
 - 1) Digital outputs (contact closure for motor starters up to size 4)
 - 2) Analog outputs of 4-20 mA or 0-10 VDC
 - d. The LCU analog or universal input shall use a 16-bit A/D converter.
 - e. The LCU analog or universal output shall use a 10-bit D/A converter.
 - f. Each output shall have supervised manual override switch and a potentiometer or integrated LCD operator interface (preferred).
 - g. Each LCU shall have a minimum of 10% spare capacity for each point type for future point connection. Provide all processors, power supplies and communication controllers complete so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring. As a minimum, provide one of each type of point available on the controller.
 - h. Provide sufficient internal memory for the specified control sequences and have at least 25% of the memory available for future use.
 - i. Each controller shall perform its primary control function independent of other NCU controller LAN communication, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real-time data from the NCU controller time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional, integral, and derivative (PID) gains for all applications. All programmed PID gains and biases shall be available for adjustment via the NCU field-adjustable by the user via terminals as specified herein.
 - j. The LCU shall provide local status indication for each output for constant, up-to-date verification of all point conditions via dedicated LEDs or built-in LCD operator interface without the need for an operator handheld device.
 - k. The LCU shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.
 - l. Should the LCU memory be lost for any reason, the user shall have the capability of reloading the controller software via the NCU Controller. Direct connection to LCU controller for reloading controller software is not acceptable.
 - m. Multiplexer boards that convert an analog input into several digital inputs such as the DUIC-5P board are not permitted and shall not be used without explicit authorization from the AISD Energy Management Department.

G. Terminal Control Units (TCU)

1. Provide Terminal Control Units (TCU) for control of each piece of terminal equipment.
2. The Terminal Control Units (TCU) shall be 32-bit microprocessor-based. They shall also be multi-tasking, real-time digital control processors consisting of modular hardware with plug-in enclosed processors, communication controllers, power supplies and input/output point modules. Controller size shall be sufficient to fully meet the requirements of this specification and the project point list.
3. Each TCU shall have sufficient memory, to support its own operating system and databases, including:
 - a. Control processes
 - b. Maintenance support applications
 - c. Custom processes
 - d. Manual override monitoring
4. Each TCU shall support:
 - a. Analog inputs of 4-20 mA, 0-10 Vdc, 10,000 ohm thermistor or 1000 ohm RTD
 - b. Digital inputs from dry contact closure, pulse accumulators, voltage sensing.
 - c. Each TCU shall be capable of providing the following control outputs without the addition of equipment:
 - 1) Digital outputs (contact closure for motor starters up to size 4)
 - 2) Analog outputs of 4-20 mA or 0-10 VDC
5. The TCU analog or universal input shall use a 16-bit A/D converter.
6. The TCU analog or universal output shall use a 10-bit D/A converter.
7. Controllers shall include all point inputs and outputs necessary to perform the specific control sequences. As a minimum, 25% of the point outputs shall be of the universal type; that is, the outputs may be utilized either as modulating or two-state, allowing for additional system flexibility. Analog outputs shall be industry standard signals such as 24V floating control, allowing for interface to a variety of modulating actuators.
8. Each TCU controller performing space temperature control shall be provided with a matching room temperature sensor.
9. Each controller shall perform its primary control function independent of other NCU controller LAN communication, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real-time data from the NCU controller time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional, integral, and derivative (PID) gains for all applications. All programmed PID gains and biases shall be available for adjustment via the NCU field-adjustable by the user via terminals as specified herein.
10. Provide each TCU with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Operating programs shall be field selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.
11. VAV Terminal Control Units:
 - a. The VAV box TCU controllers shall be powered from a 24 VAC source and shall function normally under an operating range of 20 to 28 VAC ($\pm 15\%$), allowing for power source fluctuations and voltage drops. The BAS contractor

- shall provide a dedicated power source and separate isolation transformer for each controller unable to function normally under the specified operating range. The controllers shall also function normally under ambient conditions of 32 degF to 122 degF (0 degC to 50 degC) and 5% to 90% RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.
- b. The Variable Air Volume (VAV) Terminal Control Unit (TCU) shall include a built-in differential pressure transducer that shall connect to the VAV terminal unit manufacturer's standard differential pressure sensor to measure the average and amplify differential pressure in the duct. The controller shall convert this value to actual air flow. Single point differential pressure sensing device is not acceptable. The VAV TCU differential pressure transducer shall have a measurement range of 0 to 1 in. W.C. (0 to 250 Pa) and measurement accuracy of "5% at 0.1 to 1 in. W.C. (25 to 250 Pa) and a minimum resolution of 0.0001 in. W.C. (0.025 Pa), insuring primary air flow conditions shall be controlled and maintained to within 5% of setpoint at the specified minimum and maximum air flow parameters. The VAV TCU differential pressure transducer shall have a zero value air flow measurement repeatability of 0.001 in. W.C. (0.25 Pa), VAV TCU differential pressure transducer requiring periodic zero value air flow calibration is not acceptable. The BAS contractor shall verify the type of differential pressure sensors used in the existing boxes, and ensure compatibility with the VAV TCU controllers.
 - c. The Variable Air Volume (VAV) Terminal Control Unit (TCU) shall include provision for air flow balancing using a local air flow balancing interface. A portable air flow balancing interface or an Intelligent Space Sensor (ISS) capable of balancing air flow is acceptable. The portable air flow balancing interface shall connect to the VAV TCU or the matching room temperature sensor.
 - d. The Variable Air Volume (VAV) Terminal Control Unit (TCU) shall also provide a web browser based air flow balancing tool. This tool shall allow the air balancer to manually control the action of the actuator including the following function: open VAV damper, close VAV damper, open all VAV dampers, close all VAV dampers.
 - e. The VAV box controller shall interface to a matching room temperature sensor as previously specified. The controller shall function to maintain space temperature to within "1.5 degF (0.9 degC) of setpoint at the room sensor location. Each controller shall also incorporate an algorithm that allows for resetting of the associated air handling unit discharge temperature if required to satisfy space requirements. This algorithm shall function to signal the respective DDC controller to perform the required discharge temperature reset in order to maintain space temperature setpoint.
 - f. It shall be possible to view and reset the space temperature, temperature setpoint, maximum airflow setting, minimum airflow setting, and actual airflow, through the BAS LAN.
12. TCU Thermostat
- a. Provide Terminal Control Unit (TCU) Thermostat controllers designed with unique functions and features particular to a specific type of mechanical equipment or applications that may be less common and or standardized in its use and application.

- b. TCU Thermostat – A self-contained controller with a built-in user interface that is intended for installation in the occupied space of the building. The TCU Thermostat shall have the following features:
 - 1) The FCU Thermostat shall be a microprocessor-based fully-programmable controller with all of its control logic, inputs and outputs, network communication and user interface provided within the manufacturer provided enclosure specific to the application. The enclosure shall be aesthetically appealing with a modern design that will fit in with the architecture of the building. A sample of the TCU Thermostat shall be provided as part of the submittal process.
 - 2) The TCU Thermostat shall be programmed through the user interface contained within the controller and through a software based configuration tool.
 - 3) The user interface display shall be provided with 3 levels of password protection: Level 1 – Lockout with view only and time adjustment; Level 2 - schedule override and mode settings; Level 3 – full access to all parameters. Where required in the sequence of operation provide for within Level 2 access the ability to change the units of measure displayed for temperature from Fahrenheit to Celsius. The display shall be back lighted for easy viewing.
 - 4) If required within the sequence of operation, provide for a control schedule and time clock within the TCU Thermostat. The control schedule shall provide for a separate schedule for each day of the week with 4 events per day. The real time clock will have a six-hour power reserve time.
 - 5) The TCU Thermostat shall utilize a PI (proportional and integral) control algorithm. Upon power failure, all programmed schedules and parameters must be retained in non-volatile flash memory.
 - 6) Each TCU Thermostat shall be capable of providing the following control inputs and outputs without the addition of equipment:
 - a) One (1) on-board thermistor
 - b) Four (4) universal inputs (0-10VDC, thermistor, dry-contact)
 - c) Five (5) universal outputs (0-10VDC or dry-contact N.O.)
- 13. Multiplexer boards that convert an analog input into several digital inputs such as the DUIC-5P board are not permitted and shall not be used without explicit authorization from the AISD Energy Management Department.

H. Acceptable Manufacturers/Products

- 1. Distech
- 2. Trane

2.7 ELECTRONIC INPUT/OUTPUT DEVICES

A. Sensors and Transmitters

- 1. Provide sensors and transmitters required as outlined in the input/output summary and sequence of operation, as required to achieve the specified accuracy as specified herein.
- 2. Temperature transmitters shall be equipped with individual zero and span adjustments. The zero and span adjustments shall be non-interactive to permit

- calibration without iterative operations. Provide a loop test signal to aid in sensor calibration.
3. Temperature transmitters shall be sized and constructed to be compatible with the medium to be monitored. Transmitters shall be equipped with a linearization circuit to compensate for non-linearity of the sensor and bridge and provide a true linear output signal.
 4. Temperature sensors shall be of the resistance type and shall be either three-wire 100 ohm platinum RTD, or two-wire 1000 ohm platinum RTD.
 5. Thermistors are acceptable provided the mathematical relationship of a thermistor with respect to resistance and temperature with the thermistor fitting constraints is contained with the Control Unit (CU) operating software and the listed accuracy's can be obtained. Submit proof of the software mathematical equation and thermistor manufacturer fitting constants used in the thermistor mathematical expressions. Thermistors shall be of the negative thermistor coefficient (NTC) type with a minimum of 100-Ohm/°F resistance change versus temperature to insure good resolution and accuracy. BAPI or approved equal. AISD prefers 10K Type II Thermistors.
 6. Combination Sensors or "Combo Sensors" such as Temperature and Humidity are only permitted with prior authorization from AISD Energy Management Department.
 7. The following point type accuracies are required and include errors associated with the sensor, lead wire and A to D conversion.

Sensor Type	Range	Min. Accuracy
Duct/AHU Temperature	40 – 130°F	± 0.5 Degree F
Room Temperature	50 – 85°F	± 0.5 Degree F
Outside Air Temperature	-20 – 120°F	± 0.5 Degree F
Chilled Water Temperature	32 – 80°F	± 0.5 Degree F
Hot Water Temperature	80 – 220°F	± 0.5 Degree F
Humidity	0 – 100%	± 3% RH
Duct Static Pressure	0 – 3" w.c.	± 1% full scale per 50°F
Space Static Pressure	- 0.25" – 0.25" w.c.	± 1% full scale per 50°F
Current Sensor	Sized for application	± 1% full scale
Power (kWh)	Sized for application	± 2% full scale (at 1.0 PF)
Air Flow	700 – 4,000fpm	± 2% full scale
Water Flow	Sized for application	± 4% full scale
CO ₂ Sensors	0 – 2,000 PPM	± 3% full scale

8. Sensors shall not drift more than 1% of full scale per year.
9. Sensors used in British Thermal Unit (BTU) or process calculations shall be accurate to ±0.10°F over the process temperature range. Submit a manufacturer's calibration report indicating that the calibration certification is traceable to the National Institute of Standards and Technology (NIST).
10. Thermowells
 - a. When thermowells are required, the sensor and well shall be supplied as a complete assembly.
 - b. Thermowells shall be pressure rated and constructed in accordance with the system working pressure.
 - c. Thermowells and sensors shall be mounted in a threadlet or ½" NPT saddle and allow easy access to the sensor for repair or replacement.
 - d. Thermowells shall be constructed of the following materials:

- 1) Chilled and Hot Water; 316 stainless steel
 - 2) Condenser Water and Steam; 316 stainless steel
 - 3) Brine (salt solutions); marine grade stainless steel
 - 4) Heat transfer grease shall be used on all thermowell applications.
11. Space Temperature Sensors
 - a. Each room sensor shall include the following options:
 - 1) Style: Delta style (E.g. BAPI BA/-R)
 - 2) Setpoint Adjustment: The setpoint adjustment slider shall allow for modification of the temperature by the occupant. Each Setpoint Slider shall be adjustable for allowable range from the Graphic User Interface. Default [+/-3F].
 - 3) Setpoint Adjustment Slider Graduation: “COOL/WARM”
 - 4) Setpoint Adjust Slider Acting: Direct Acting
 - 5) Temperature Indicator: Do Not Provide.
 - 6) Override Switch: Required. In parallel with sensor.
 - 7) Foam-backing: Provide for sensors mounted on exterior walls, CMU walls, structure beams or if sensor is subjected to air draft from wall.
12. Outside air Temperature, Humidity and CO2 Sensors
 - a. Sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall be provided with a solar shield.
 - b. Transmitters shall be of NEMA-3R construction and rated for ambient temperatures.
13. Duct Type Sensors
 - a. Duct mount sensors shall mount using a handy box through a hole in the duct and be position do as to be easily accessible for repair or replacement. A neoprene grommet (seal-tight fitting and mounting plate) shall be used on the sensor assembly to prevent air leaks.
 - b. Duct sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate. Sensor probes shall be constructed using 304-rated stainless steel.
 - c. Duct sensor shall be of the appropriate length and mounted in a location on the duct to obtain the best representation of the actual air temperature.
 - d. For outdoor air duct applications, use a weatherproof box with weatherproof cover and gasket.
 - e. Sensor handy box shall not be used as a pull-box. Installation shall allow the replacement of sensor without the need for disconnecting/removing additional wiring or conduit.
14. Averaging Duct Type Sensors
 - a. Provide capillary supports at the sides of the duct to support the sensing string. Support the middle of the span to prevent flopping of the capillary tube as required. No metal-to-metal contact shall be allowed.
 - b. Where the capillary enters the equipment, it shall be protected from sharp edges using a poly tube sleeve.
15. Relative Humidity Sensors/Transmitters
 - a. The sensor shall be a solid state, capacitive polymer type.
 - b. Humidity transmitter shall be equipped with a 2-wire 4-20mA or 3-wire 0-10VDC linear proportional output.

- c. The humidity transmitter shall meet the following overall accuracy including lead loss and A to D conversion:
 - 1) Accuracy: $\pm 2\%$ RH from 10-90%
 - 2) Drift: 0.5% per year
 - 3) Response time: < 5 seconds in moving air
 - 4) Linearity: Negligible
 - 5) Hysteresis: < 1%
 - 6) Calibration: Factory calibrated.
 - d. Duct type sensing probes shall be constructed of 304 stainless steel and be equipped with a neoprene grommet, bushings and a mounting bracket.
16. Differential Pressure Transmitters and Accessories
- a. Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage and to hold calibrated accuracy when subject to a momentary 40% over-range input.
 - b. Pressure transmitters shall provide the option to transmit a 0-5 VDC, 0-10 VDC, or 4-20 mA output signals.
 - c. Pressure transmitters shall be equipped with a LED display indicating the transmitter output signal.
 - d. Differential pressure transmitters used for pressure or flow measurement shall be supplied with shutoff and bleed valves in the high and low sensing pick-up lines (5 valve manifold).
 - e. Provide, at a minimum, a NEMA-1 housing for the transmitter. Locate transmitters in accessible local control panels wherever possible.
 - f. Duct sensing pressure applications shall utilize a static pressure traverse probes.
17. Low Air Pressure Applications
- a. The pressure transmitter shall be capable of transmitting a linear electronic signal proportional to the differential of the room and reference static pressure input signals with the following minimum performance specifications.
 - 1) Span: No greater than two times the design space differential pressure
 - 2) Accuracy: $\pm 0.5\%$ of full scale
 - 3) Dead Band: Less than 0.3% of output
 - 4) Repeatability: Within 0.2% of output
 - 5) Linearity: $\pm 0.2\%$ of span
 - 6) Response: Less than one second for full span input
 - 7) Temperature Stability: Less than 0.01% output shift per degree change
 - b. The transmitter shall utilize variable capacitance sensor technology and be immune to shock and vibration.
 - c. Measuring of outside air pressure shall be accomplished by using a pressure pickup probe suitable for outdoor pressure sampling that stabilizes and reduces fluctuations from wind gusts.
 - d. Measuring of indoor space pressure shall be accomplished by using a static pressure pickup probe either wall or ceiling mounted.
18. Medium to High Air Pressure Applications
- a. The pressure transmitter shall be similar to the low air pressure transmitter. Provide differential pressure transmitters, which meet the following performance requirements:
 - 1) Zero & Span: (% full scale/degree): 0.041% including linearity, hysteresis and repeatability

- 2) Accuracy: 1% full scale (best straight line)
 - 3) Static Pressure Effect: 0.5% full scale
 - 4) Thermal Effects: $\leq \pm 0.03\%$ full scale/degree
19. Wet-Media Differential Pressure Applications
 - a. The differential pressure transmitter shall be of industrial grade and transmit a linear output signal in response to variation of differential pressure or water pressure sensing points.
 - b. The differential pressure transmitter shall meet the following performance specifications:
 - 1) Die-cast NEMA-4 Enclosure with readout LCD display
 - 2) Suitable input differential pressure range
 - 3) Dual sensor design
 - 4) Microprocessor profiled with built-in noise rejection
 - 5) 0-10VDC, 0-5VDC or 4-20mA output
 - 6) Maintain accuracy up to 20 to 1 ratio turndown
 - 7) Reference Accuracy: $\pm 0.2\%$ of full span
 - 8) Push-button auto-zero
 - 9) Provide with bypass/test manifold
 - c. Differential pressure transmitters with wired remote sensors are not to be used without the prior approval from AISD Energy Management Department.
- B. Valve and Damper Actuators
 1. Electronic Valve and Damper Actuators
 - a. Electronic actuators shall be direct-coupled type capable of being mounted over the shaft of the damper or valve. They shall be approved by a suitable safety or regulatory agency. Power consumption shall not exceed 8 watts or 15 VA of transformer sizing capacity per high torque actuator nor 2 watts or 4 VA for VAV actuators. Sound level shall not exceed 45 dB for high torque or 35 dB for VAV actuators.
 - b. Electronic overload protection shall protect actuator motor from damage. If damper jams actuator shall not burnout. Internal end switch type actuators are not acceptable. Actuators may be mechanically and electrically paralleled on the same shaft to multiply the available torque. A reversing switch shall be provided to change action from direct to reverse in relation to control signal as operation requires.
 - c. All 120 VAC powered actuators shall be installed with a locking switch (key operated switch, Leviton 1221-2L) as a disconnecting means for servicing within reach of the actuator, but not on the actuator. Verify location with Architect, Engineer, and/or Owner prior to install.
 2. Control Damper Actuators
 - a. Outside air, return air, and exhaust air actuators shall be spring return type. Individual battery backup or capacitor return is not acceptable.
 - b. The control circuit shall be fully modulating using 0-10VDC, 2-10VDC, 4-20 mA, or Pulse Width Modulation signals. A 0-10VDC, 2-10VDC, or 4-20 mA signal shall be produced by the actuator which is directly proportional to the shaft clamp position which can be used to control actuators paralleled off a master motor or to provide a feedback signal to the automation system indicating damper position. Accuracy shall be within $\pm 2.5\%$.

- c. Zone and Face and bypass dampers and other control dampers shall be modulating using the same control circuit detailed above but shall not be spring return.
 - d. Actuators serving Outside/Exhaust/Relief dampers shall provide position feedback to the control system.
 - e. Provide auxiliary switches on damper shaft or blade switch to prove damper has opened on all 100% outside air handling equipment.
3. Miscellaneous Damper Actuators
- a. Outside air combusting and ventilation air intake and exhaust damper actuators shall be 2 position (open/close) spring return, and close if any water piping, coils or other equipment in the space which the damper serves needs to be protected from freezing.
4. Air Terminals
- a. Air terminal actuators shall be fully modulating floating (drive open, drive closed) 3 wire control or use control circuit as detailed in control dampers depending on the controller's requirements.
5. Inlet Vanes Actuators
- a. Inlet vanes and actuators shall not be used for this job. Speed control of the fan motor shall use a variable frequency drive (VFD).
6. Combination Smoke and Fire Damper Actuators
- a. Actuators shall be factory mounted and connected to the damper section and conform to suitable safety or regulatory agency approved specifications.
7. Valve Actuators
- a. Actuators shall have a gear release button on all non-spring return models to allow manual setting. The actuator shall have either an insulating air gap between it and the linkage or a non-conducting thermoplastic linkage. Care shall be taken to maintain the actuator's operating temperatures and humidity within its specifications. Pipes shall be fully insulated and heat shields shall be installed if necessary. Mount actuators so condensation shall not form on actuators and be prevented by a combination of insulation, air gap, or other thermal break.
 - b. The control circuit shall be fully modulating using 0-10VDC, 2-10VDC, 4-20 mA, or Pulse Width Modulation signals. A 0-10VDC, 2-10VDC, or 4-20 mA signal shall be produced by the actuator which is directly proportional to the shaft clamp position which can be used to control actuators paralleled off a master motor or to provide a feedback signal to the automation system indicating valve position.
 - c. Valve body and actuators shall be equipped fully assembled and tested at the valve factory.
 - d. Valve actuators serving bypass valves shall provide position feedback to the control system.
 - e. All actuators shall be provided with means to accept a 1/2" conduit fitting.
8. Control Valve Actuators (4 inch and larger)
- a. The Valve actuator shall consist of a permanent split capacitor, reversible type electric motor that drives a compound epicycle gear. The electric actuator shall have visual mechanical position indication, readable from a distance, and show output shaft and valve position. Unit shall be mounted directly to the valves

- without brackets and adapters, or readily adapted to suit all other types of quarter-turn valves.
- b. The actuator shall have an integral terminal strip, which, through conduit entries, will ensure simple wiring to power supplies. Cable entries should be approved by a suitable safety or regulatory agency. Use recommended gland stops within the NPT hole to prevent glands from being screwed in too far and damaging cable.
 - c. The actuator shall be constructed to withstand high shock and vibrations without operations failure. The actuator cover shall have captive bolts to eliminate loss of bolts when removing the cover from the base. One copy of the wiring diagram shall be provided with the actuator.
 - d. The actuator shall have a self-locking gear train that is permanently lubricated at the factory. The gearing shall be run on ball and needle bearings. Actuators with high output torque shall have two adjustable factory calibrated mechanical torque limit single-pole double-throw switch type. The motor shall be fitted with thermal overload protection. The motor rotor shaft shall run in ball bearings at each end of motor.
 - e. The actuator housing shall be hard anodized aluminum for full environmental protection.
 - f. The actuator shall be provided with means for manual override.
 - g. The environmental temperature range of the actuator shall be from -30°C to $+60^{\circ}\text{C}$ (-20°F to $+140^{\circ}\text{F}$).
 - h. For intermittent on/off service, the actuator shall be rated at a 20% duty cycle (i.e., 12 minutes extended duty in every hour, or alternatively; one complete cycle every 2 minutes). For more frequent cycling and modulating service, an actuator shall be rated for continuous duty. The actuator rated for continuous duty shall be capable of operating 100% of the time at an ambient temperature of 40°C .
 - i. The actuator shall have an integral self-locking gear train. Motor brakes shall not be required to maintain desired valve position. Levers or latches shall not be required to engage or disengage the manual override. Mechanical travel stops, adjustable to 15° in each direction of 90° rotation shall be standard, as well as two adjustable travel limit switches with electrically isolated contacts. Additional adjustable switches shall be available as an option.
 - j. Single Phase Motor: The motor shall have Class B insulation capable of withstanding locked-rotor for 25 seconds without overheating. Wiring shall also be Class B insulation. An auto-reset thermal cutout protector shall be embedded in the motor windings to limit heat rise to 80°C in a 40°C ambient. All motors shall be capable of being replaced by simply disconnecting the wires and then removing mounting bolts. Disassembly of gears shall not be required to remove the motor.
 - k. Materials of Construction: The electric actuator shall have a pressure die-cast, hard-anodized aluminum base and cover. The compound gear shall be made of die-cast, hard-anodized aluminum or steel. An alloy steel worm gear shall be provided for manual override and torque limiting. Bearings for gears shall be of the ball and needle type; bronze bearings shall be used on the shafting parts.
 - l. Accessories: Potentiometer for providing continuous feedback of actuator position at the CU (for valves specified position feedback).
9. Variable Frequency Drives (VFD)

- a. Refer to division 23 and 26 for approved list of VFDs and other requirements.
- b. The VFD shall communicate utilizing the BACnet protocol via manufacturer card to communicate and receive data through the DDC system. All VFDs shall have separate conduits for hi-voltage input circuits, hi-voltage output circuits and control circuits. In addition to the BACnet communications, each drive shall have two hard-wired points from the BAS system. The three points are as follows:
 - 1) VFD Start/Stop
 - 2) VFD Speed Reference
 - 3) VFD Run Status (acquired via VFD terminals).
- c. Remote mounted VFDs with service disconnects between the VFD and the load, shall be wired to the service disconnect early-break auxiliary switch for proper VFD shutdown upon disconnect operation.

C. OTHER ACCESSORIES

- 1. Electric Low Limit Thermostat (Freeze-Stat)
 - a. Heavy-duty, duct type, fixed differential, vapor-charged sensing element, manual reset, with test/reset button.
 - b. Sensing element shall be a capillary tube responding to the lowest temperature sensed along any segment of bulb length. Switch shall be rated for 10 amps at full load DPDT (double-pole double-throw).
 - c. The capillary tube shall be protected from damage at the location that it enters the AHU. Any exposed areas of the capillary tube shall be protected by covering with poly- tubing. Refer to Averaging sensors section above. Provide one 20-foot long bulb thermostat for every 20-sq.ft of coil area.
 - d. Adjustable Range: 15 to 55 degree F.
 - e. AISD prefers Johnson Controls A70 Series Low Limit Thermostats.
- 2. Water Flow Switches
 - a. Suitable safety or regulatory agency approved device, suitable for all service application conditions. Body minimum working pressure rating shall equal or exceed service pressure. Unit shall have two single-pole double-throw switches. Actuating flow rated shall be field adjustable for the specified and indicated service. Switch location shall preclude exposure to turbulent or pulsating flow conditions. Flow switch shall not cause pressure drop at maximum system flow rate.
- 3. Strap-On Aqua stat
 - a. Strap-on aqua stats are not to be used without the prior approval from AISD Energy Management Department.

D. FLOW, PRESSURE AND ELECTRICAL MEASURING APPARATUS

- 1. Traverse Probe Air Flow Measuring Stations
 - a. Traverse probes shall be a dual manifold, cylindrical, type constructed of 3003 extruded aluminum with an anodized finish to eliminate surface pitting and unnecessary air friction. The multiple total pressure manifold shall have sensors located along the stagnation plane of the approaching airflow and without the physical presence of forward projecting sensors into the air stream. The static pressure manifold shall incorporate dual offset static tips on opposing sides of the averaging manifold so as to be insensitive to flow-angle variations of as much as $\pm 20^\circ$ in the approaching air stream.
 - b. The airflow traverse probe shall not induce a measurable pressure drop, nor shall the sound level within the duct be amplified by its singular or multiple

- presences in the airstreams. Each airflow-measuring probe shall contain multiple total and static pressure sensors placed at equal distances along the probe length. The number of sensors on each probe and the quantity of probes utilized at each installation shall comply with the ASHRAE Standards for duct traversing.
- c. Traverse probes shall be accurate to $\pm 2.5\%$ of the measured airflow range and be installed in a duct section that meets manufacturer's installation specifications sheet. Allow adequate distance from elbows, junctions or other disturbances.
- 2. Thermal Dispersion Air Flow Measuring Stations
 - a. Thermal dispersion air flow measuring stations are only permitted with prior approval from AISD Energy Management Department.
 - 3. Shielded Static Pressure Sensor
 - a. Provide for each zone where required a shielded static pressure sensor suitable for ceiling surface mounting, complete with multiple sensing ports, pressure impulse suppression chamber, airflow shielding, compression takeoff fittings, all contained in a welded stainless steel casing, with polish finish on the exposed surfaces.
 - b. These probes shall be capable of sensing the static pressure in the proximity of the sensor to within 1% of the actual pressure value while being subjected to a maximum airflow from a radial source.
 - c. The shielded static sensing devices shall be used for both reference and space pressure sensing.
 - d. Pressure sensors used for outside air pressure reference purposes shall be equipped with a conduit seal for pneumatic tubing and bushings for a weather tight installation.
 - e. All sensors shall be installed according to the manufacturer's installation specifications sheet and in a location that is not subject to frequent air disturbance.
 - 4. Static Pressure Traverse Probe
 - a. Provide multipoint traverse probes in the duct at each point where static pressure sensing is required.
 - b. Each duct static traverse probe shall contain multiple static pressure sensors located along the exterior surface of the cylindrical probe. Pressure sensing points shall not protrude beyond the surface of the probe.
 - c. The duct static traverse probe shall be of 304 stainless steel construction and be complete with threaded end support rod, sealing washer and nut, and mounting plate with gasket and static pressure signal fitting. The static traverse probe shall be capable of producing a steady, non-pulsating signal of standard static pressure levels without the need for correction factors, and an instrument accuracy of 5% full range.
 - d. The probe shall be installed according to the manufacturer's installation specifications sheet and in a location that is not subject to frequent air disturbance.
 - 5. Liquid Flow Meters
 - a. Electronic Type Flow Meters: (ONICON F-Series Manufacturer or approved equal)

- 1) Accuracy of flow meter shall be $\pm 0.5\%$ of reading at calibrated velocity with a pressure drop of less than 1 PSI at 20 ft/s in 1.5" pipe, decreasing in larger pipes and lower velocities.
 - 2) Electronic sensing method shall be electromagnetic.
 - 3) Insertion-type for renovation projects.
 - 4) Inline-type for projects involving new hydronic piping or piping reconfiguration.
 - 5) The standard temperature range shall be 180° F continuous, 200° F peak. High temperature range shall be 280° F continuous, 300° F peak with an operating pressure of 400 PSI maximum.
 - 6) The flow meter shall be wet-calibrated at the manufacturer's laboratory against primary volumetric standards directly traceable to NIST. Provide certification of calibration with each meter.
 - 7) Input signal from flow meter to be 0-10VDC or 4-20mA.
 - 8) Insertion-type meters shall be installed to allow removal of meter removal during system operation.
 - b. Venturi Type Flow Meters:
 - 1) Pressure drop on venturi type flow meters shall not exceed 0.25" WC. Each venturi low and high-pressure taps shall be equipped with nipples, valves, and quick disconnects.
 - 2) Equip each venturi with a metal identification tag indicating the size, location, flow (gpm), and meter reading for the flow specified.
 - 3) Provide (1) dial differential pressure meter of the proper range to determine piping system flow rate. The meter shall become the property of AISD.
 - 4) Venturi meters shall utilize flanged or screwed connections for removal purposes and shall be rated for the system operating pressures.
 - 5) The venturi flow meter shall be factory calibrated to provide a minimum of flow accuracy between actual and factory flow calibration data.
6. Current Transformers
- a. The current transformers shall be designed to be installed or removed without dismantling the primary bus or cables. The transformer shall be of a split core design. Solid core current transformers shall not be used without the prior approval from the AISD Energy Management Department.
 - b. The core and windings shall be completely encased in a suitable safety or regulatory agency approved thermoplastic rated 94VA. No metal parts shall be exposed other than the terminals.
 - c. The current transformers shall meet the following specifications:
 - 1) Frequency Limits: 20 to 100 Hz
 - 2) Insulation: 0.6 KV Class, 10 KV BIL
 - 3) Accuracy: $\pm 1\%$ at 5.0 to 25.0 VA accuracy class with U.P.F burden
7. Current Sensing Switches
- a. The split core current sensing switch shall be self-powered with solid-state circuitry. Current sensing switches shall consist of a solid state current sensing circuit, adjustable trip point, solid state switch, single-pole double-throw or double-pole double-throw relay, as required and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device and looped if required to attain the correct sensing value. The current sensing switch shall accept over current up to twice its trip into range.
 - b. It shall be reverse voltage protected and have high over current capability.

- c. Frequency Limits: 20 to 100 Hz.
 - d. Accuracy: $\pm 0.5\%$ of full scale.
 - e. Response Time: 300 milliseconds to 90% of step change.
8. Power Monitoring
- a. Wattnode BACnet or approved equal.
 - b. Current transformers rated and as required for proper interfacing to electrical gear scheduled to be monitored.
 - c. Provide voltage disconnect switch and CT shorting block equal to ELKOR i-BLOCK or approved equal.
 - d. Install in dedicated control panel.

2.8 CONTROL VALVES AND DAMPERS

A. General Control Valve Requirements

- 1. All automatic control valves shall be linear, fully proportioning, with modulating ball, plug or V-port inner guidelines unless otherwise specified. The valves shall be quiet in operation and fail safe in either normally open, normally closed position or fail in last commanded state in the event of loss of electronic output signal. See drawings and sequence of operation for system requirements.
- 2. All valves shall be capable of operating per sequence when required by the sequence of operation. All control valves shall be sized by the BAS system contractor and/or the valve manufacturer, and shall be guaranteed to meet the heating and cooling loads as specified. All control valves shall be suitable for the pressure conditions, and shall close against the differential pressures involved. Valve body pressure rating and connection type (screwed or flanged) shall conform to ANSI pressure classifications appropriate for the system working pressures.
- 3. All valves shall be programmed to be 0% on HMI = 0% signal on DDC controller = Valve Closed to Coil. Likewise, 100% on HMI = 100% Signal (10VDC, 20mA, etc.) on DDC controller = Valve Open to Coil. Same holds true for Dampers (Multizone dampers shall be 0% = Full Hot Deck, 100% = Full Cold Deck). Any deviation from this strategy shall require permission from Owner during the 90% Submittal review.

B. Steam Control Valves: AISD has phased out all steam generating equipment.

C. Hot and Cold Water Control Valves

- 1. Hot and cold water globe type control valves shall be single-seated type, with equal percentage flow characteristics. The valve discs shall be composition type and shall be sized using ISA methods.
- 2. Pressure drop through the valves shall not exceed 5 PSI when the valve is fully open and under design flow unless otherwise indicated
- 3. Ball valves shall be equipped with 316 stainless steel trim, Teflon seals and adjustable packing gland nuts. Provide a handle for manual operation during start-up and maintenance.

D. Air Terminal Reheat Valves

- 1. Reheat valves shall be modulating logarithmic equal percentage type globe or ball valves as detailed in paragraph C above. 2-position control is not acceptable.

E. Two Position Control Valves

1. For open/closed and/or three-way diverting applications, butterfly valves are acceptable and shall be heavy-duty pattern with a body rating comparable to the pipe rating.
2. Provide each butterfly valve with a replaceable lining suitable for temperature and service requirements.
3. Equip each with a butterfly valve with disc and stainless steel stem.
4. Valves used for shut-off or isolation purposes shall be bubble-tight.

F. Automatic Control Dampers

1. Automatic dampers shall give a feedback of position only when noted in contract documents.
2. Automatic dampers shall have multiple blades and sized for the application by the BAS Contractor and/or as indicated on the design drawings.
3. Submit a schedule of damper sizes to the Prime Contractor, with a copy to the Architect/Engineer and AISD within 15 days after being awarded the contract.
4. Dampers used for throttling airflow shall be opposed blade type arranged for normally open or normally closed operation as required. The damper is to be sized so that when wide open the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear. Multi-section dampers must be provided with sufficient interconnecting hardware or jackshaft for unison operation of all blades in the entire assembly.
5. Damper frames and blades shall be constructed of either minimum 16 gauge galvanized steel or 14 gauge aluminum and arranged to facilitate field assembly of several individual sections into a larger damper area and allow secure fastening of damper frame to the surrounding ductwork, collar or fan housing. Maximum blade length in any section shall not be longer than 48 inches. Additional stiffening or bracing shall be provided for any section exceeding 48 inches in height.
6. Damper blades shall not exceed eight (8) inches in width. All blades except for fume hood exhaust systems shall be galvanized sheet steel. Blades shall be suitable for high velocity performance.
7. All damper bearings to be made of nylon. Bushings that turn in the bearing are to be oil impregnated sintered metal. Dampers shall be tight closing, low leakage type with synthetic elastomer seals on the blade edges and on the top, bottom and sides of the frame. Dampers shall not leak in excess of 8 cubic feet per minute per square foot when closing against 4 inches water gauge static pressure.
8. Leakage and flow characteristic charts shall be submitted to the Architect/Engineer for review.

PART 3 - EXECUTION**3.1 GENERAL**

- A. Do not proceed with work without approved submittals. Any alterations and/or changes to the control sequences shall be submitted to the Engineer for approval for such changes prior to design of the control system and submittal of control shop drawings. AISD Energy Management Department to review and comment on shop drawings before work begins. All work performed prior to submittal approval shall be at contractor's own risk.
- B. Provide all hardware, software, programming, materials, labor, licenses, permits and incidentals necessary to provide completely operational digital controls systems. Perform start up and commissioning on each control product, system, and subsystem to provide fully operable systems in accordance with the specified functional performance.
- C. Comply with applicable codes and ordinances. If any conflict arises between these specifications and drawings or codes and ordinances, immediately notify the Architect/Engineer and AISD. Do not deviate from the drawings and specifications nor install any work which may be in conflict with codes and ordinances until the conflict is resolved and the solution accepted by the Architect/Engineer and AISD.
- D. The BAS System Contractor is responsible for providing a complete and operational system as described in the description of operation, in the points lists summary, and/or the mechanical/electrical drawings for this project. Any item referenced in one part of the system documentation but not listed elsewhere shall be covered under contractors pricing (i.e. damper called out in sequence but not indicated on drawings).
- E. The mechanical, electrical, and building automation system drawings show the general arrangement of the respective systems. Follow these drawings, as closely as actual building construction and the work of other trades permit. Provide devices, fittings, and accessories, which may be required but not shown on the drawings or specified herein. Investigate conditions affecting the work and arrange the work accordingly. Provide modifications and accessories as required to meet such conditions.

3.2 COORDINATION OF WORK

- A. Examine and compare the BAS specifications and drawings with the specifications and drawings of the other trades and report any discrepancies between them to the Architect/Engineer and AISD. Obtain the Architect/Engineer's written instructions for changes necessary to the BAS work.
- B. Install and coordinate the BAS work in cooperation with the other trades installing interrelated work including mechanical, testing adjusting and balancing, and electrical (including fire alarm) during bidding and submittal process. All changes required in the work of the contractor, caused by inadequate coordination and noncompliance with specifications, shall be made at contractor's expense.
- C. Where control system will interface with controls provided by equipment manufacturers, ensure that coordination takes place such that all sequences and required control and monitoring points are made available. Documentation stating "work by others" is not acceptable. All work must be clearly coordinated.

- D. Carefully check space requirements with other trades to ensure that all material can be installed in the allotted spaces, including above finished suspended ceilings, between coils sections, etc.
- E. Install the BAS work to permit removal (without damage to other parts) of parts requiring periodic replacement or maintenance.
- F. Renovations/Additions: The BAS contractor shall examine the existing controls system and shall become familiar with all pertinent components and functions of the existing system, including any energy management systems. The contractor shall be responsible for including all work necessary for the following:
 - 1. Existing controls that are to remain in operation after this project shall remain in place and be modified only as required to incorporate new controls.
 - 2. The new controls shall be fully compatible with the existing system.
 - 3. The new controls shall be fully interconnected with the existing system.
 - 4. It shall be the responsibility of the Prime contractor to insure the coordination of proper decommissioning and disconnection/removal of old control system components that will not be reused. Old database and sequences of operation shall be cleaned up, old conduit and wiring removed, old devices and controllers salvaged and returned to the AISD Energy Management Department in a timely manner. Any controllers and/or field devices damaged during the removal process shall be repaired and/or replaced at no cost to AISD.

3.3 WIRING INSTALLATION

A. GENERAL

- 1. BAS contractor shall be responsible for all control and power wiring associated with the control system including any related 120V electrical work that may require interlocks, circuit breakers, and/or connections at the panel boards spares or spaces.
- 2. All electrical work shall be performed in accordance with the requirements of Division 26.
- 3. All wiring shall be run parallel and perpendicular to building lines (no angles) and concealed where possible. All wiring shall be installed in a professional manner and in accordance with the National Electrical Code and local ordinances. Electrical or mechanical inspection sign off does not remove AISD's right to refuse acceptance of the electrical installation for incorrect or noncompliance with NEC and project specifications. Installation must comply with all local control system electrical code requirements.
- 4. The control contractor shall use a licensed, qualified and bonded electrical contractor for all wiring above 24Volts.
- 5. Units already having 120 VAC power run by Division 26 for fans, VAV's, electric heat, etc. shall be provided with required 24 VAC power via a step-down transformer and protected with a circuit breaker, whether provided by the BAS system contractor or unit manufacturer.
- 6. Provide electrical disconnecting means for servicing, for each control panel, digital controller, transformer, power supply, and other devices that are served by 120VAC or higher voltage.
- 7. Raceways:
 - a. Wiring shall be run in EMT conduit in exposed areas and in vertical risers between floors with sleeves and including any new walls or existing walls that

- have additional work being performed. EMT conduit fittings shall be steel compression type. All firewall penetrations shall be caulked with approved fire caulking material.
- b. Low voltage plenum rated wire may be used without conduit in concealed but accessible areas (i.e. above lay-in ceilings) and shall be installed in a professional and workmanship like manner and secured up as high as possible. All wall penetrations by plenum cable shall use sleeves with bushings to avoid sharp edges.
 - c. All conduits on roofs, in areas exposed to weather conditions, in mechanical spaces, and located within six (6) feet above floor level shall be of rigid type conduit with watertight fittings. Use of non-threaded fittings on rigid conduit shall be limited and used only when necessary.
 - d. Underground conduit shall be of the appropriate schedule PVC or coated ridged and back filled per code.
 - e. Where flexible metal conduit is used, the maximum allowable length shall be 36 inches, and the minimum shall be 18 inches. All flex conduit fittings shall be of the compression type. Where conduit is attached to vibrating or rotating equipment, flexible metal conduit with a minimum length of 18 inches and maximum length of 36 inches shall be installed and anchored in such a manner that vibration and equipment noise will not be transmitted to the rigidly mounted conduit. Where exposed to the elements or in damp or wet locations, (such as Mechanical rooms) waterproof flexible metal conduit shall be installed at and below 6 feet above floor level. Installation shall be as specified for flexible metal conduit.
 - f. When in crawl spaces, EMT conduit may be used when kept up high to the structure; otherwise rigid type conduit shall be used. Waterproof flexible metal conduit shall be used in crawl spaces with the above length requirements.
 - g. Provide a pull string in all conduits for pulling spare wire.
 - h. No conduit shall be filled to more than 80% of available space.
- 8. Coordinate with the Mechanical and Electrical Installation Contractors to ensure controls shall be accessible for repair and maintenance.
 - 9. Provide supervised field-wiring for all alarm panel monitoring points, asset protection points (safeties, sump pumps, maintenance alarms) and all points identified to include supervised wiring on the points schedule.
 - 10. Separate Ground: Where recommended by controls manufacturer for the system/application involved, DDC system/components shall employ and maintain a separate, “clean earth” grounding protection. “Mixing” of grounding systems shall be prohibited. (Isolate DDC controls conduits/metal boxes from other raceway systems using isolation bushings and other measures as necessary.)
 - 11. There shall be no power wiring of 120 volts or higher in the same conduit or raceways with communications or low voltage control wiring
 - 12. There shall be no power wiring of 120 volts or higher in the same conduit or raceways with communications or low voltage control wiring.
 - 13. Control wiring shall follow the following jacket coloring conventions:
 - a. Pink Jacket: BACnet IP wiring
 - b. Orange Jacket: BACnet MS/TP wiring
 - c. Yellow Jacket: Thermostat wiring (wall mounted sensors)
 - d. White Jacket: All other field wiring
 - 14. Hardwired Safety Circuit:
 - a. Hardwired safety alarm monitoring and shutdown shall be accomplished through the use of a Fan Safety Relay Board Model: RIBMNLB-6/-4/-2

manufactured by Functional Devices, Inc. or approved equal. The number of circuits/size of board (6, 4 or 2) shall be selected accordingly to accommodate all the specified safety devices plus one spare relay/circuit. Each safety device shall be manual-reset and shall be homerun to the safety relay board via dedicated wiring. Daisy-chaining of devices shall only be permitted when more than one device of the same kind is required to accomplish the specified scope of work (i.e. two freeze-stats to cover the entire area of the cooling coil). Safety relay board shall be installed in the associated controls cabinet. Enclosed version of this safety relay board shall not be used. Each relay on the board shall be clearly labeled identifying the function of the circuit (i.e. Freeze-Stat, High-Static, Smoke-Detector, etc). The first dry-contact of the master relay shall be used to shut down the fan(s) of the associated unit via the Starter or VFD. The second dry-contact shall be used to report the general status of the safety circuit back to the BMS. Individual status monitoring of safeties shall be provided if specified in the scope of work.

- b. Units scheduled to receive only one safety device (i.e. float switch), are permitted to be installed without a Fan Safety Relay Board if safety device is not scheduled to be monitored by the BMS for status reporting.
- c. Freeze-stat normally-closed contact shall be homerun to control panel to energize a DPDT (Double-Pole, Double-Throw) relay. First contact shall be wired to Fan Safety Relay Board for Fan Shutdown. Second contact shall be wired to cut power to all spring-return actuators.

B. Wiring less than 30 volts:

- 1. In ceilings of areas where return air plenum is used, plenum rated cable will be allowed unless noted otherwise. Where plenum cable is used, it shall be run parallel with building lines, banded together in bundles, supported without sags or “clothes line” appearance at 5 foot centers or less. Cabling that is not run in a neat fashion shall be removed and reinstalled. Determination of neatness shall be at the discretion of the Owner and Engineer. All plenum rated cabling shall be clearly marked on the outside jacket to indicate “Plenum” service.
- 2. Exposed, unfinished locations, such as mechanical rooms and below accessible raised flooring: Conductors and cable plenum rated (where local code or officials allow). All plenum rated cables shall be in conduit in unfinished area and mechanical rooms starting 6 feet above finished floor.
- 3. Concealed, unfinished locations, such as ceiling plenums, ceiling spaces, shafts, crawl spaces, tunnels: Conductors enclosed in raceway and cable enclosed in raceway or plenum-rated cable (where local code or officials allow).

C. Twisted-Pair Communication Media

- 1. Only use the transceiver manufacturers recommended cable types.
- 2. Install the network communications segments for device channels using bus topology format. Install the network communications segments for all backbone channels using bus topology format.
- 3. Provide all network communication cables, terminations to network control devices and network infrastructure components in accordance with the current requirements of the BACnet Wiring Guide.

D. Control Power Wiring

- 1. BAS system contractor to provide list/location of all control panels requiring 120 VAC power so they may be coordinated with Electrical.

2. The BAS system contractor shall provide final low voltage power supplies and termination of power wiring to network devices and infrastructure components where required.
3. Provide interlock wiring between supply and return fans, electrical wiring for relays (including power feed) for temperature and pressure indication. Provide interlock wiring between refrigeration machines, pumps and condensing equipment as required for the specified sequence of operation and the refrigeration system integral controller(s). Do not provide interlock wiring if a dedicated digital output has been specified for the equipment or the sequence of operation requires independent start/stop.
4. Provide power wiring, conduit and connections for low temperature thermostats, high temperature thermostats, alarms, flow switches, actuating devices for temperature, humidity, pressure and flow indication, point resets and user disconnect switches for electric heating, appliances controlled by this division.

E. Input/Output Control Wiring

1. RTD wiring shall be three-wire or four-wire twisted, shielded, and at a minimum of 18 gauge conductors.
2. Other analog inputs shall use, twisted, shielded, and at a minimum of 18 gauge conductors.
3. Binary control function wiring shall use at a minimum of 18 gauge conductors.
4. Analog output control functions shall be twisted, shielded, and use at a minimum of 18 gauge conductors.
5. Binary input wiring shall be a minimum of 18 gauge conductors.
6. Thermistors shall be equipped with the manufacturers calibrated lead wiring.
7. 120 VAC control wiring shall be minimum of #14 gauge wire, THHN type, in ½" conduit.

F. Conduit and Fittings

1. Conduit for Control Wiring, Control Cable and Transmission Cable: Electrical metallic tubing (EMT) with steel compression fittings, cold rolled steel, zinc coated or zinc-coated rigid steel with threaded connections. Rigid steel (RGS) with threaded fittings (connections to junction/outlet boxes and cabinets shall be made with threaded HUBS or double lock-nuts). Provide insulated bushings at all RGS conduit terminations where double lock-nuts are used. The use of Hubs are preferred. The use of threadless RGS fittings shall be kept to a minimum and used only when threading of the GRS is impossible.
2. Outlet Boxes (Dry Location): Sheradized or galvanized drawn steel suited to each application, in general, four inches square or octagon with suitable raised cover.
3. Outlet Boxes (Exposed to Weather): Threaded hub cast aluminum or iron boxes with gasket device plate.
4. Pull and Junction Boxes: Size according to number, size, and position of entering raceway as required by National Electrical Codes. Enclosure type shall be suited to location.

G. Relays

1. Relays other than those associated with digital output cards shall be general-purpose, enclosed plug-in type protected by a heat and shock resistant duct cover. Number of contacts and operational function shall be as required. All relays shall be equipped with an LED pilot light. AISD prefers IDEC relays.

2. Solid State Relays (SSR): Solid state relays are not permitted and shall not be used without prior authorization from AISD Energy Management Department.
3. Contactors: Contactors shall be of the single coil, electrically operated, mechanically held type. Positive locking shall be obtained without the use of hooks, latches, or semi-permanent magnets. Contractor shall be double-break silver-to-silver type protecting arcing contacts. The number of contacts and rating shall be selected for the application. Operating and release times shall be 100 milliseconds or less. Contactors shall be equipped with coil transient suppression devices.

3.4 CONTROL PANELS

- A. Enclosed cabinet type with hinged door for mounting controllers, relays, power supplies and miscellaneous control and communication devices.
- B. Control panels shall be fabricated to match the approved shop drawings submitted by the controls contractor. Fabrication shall be in a neat and workmanlike manner and shall facilitate repair, maintenance, and adjustment of the equipment contained therein.
- C. Locate all panels in mechanical or electrical rooms. Submit proposed locations for approval prior to preparing control drawings.
- D. Control panels shall be fabricated and laid out to incorporate the following features:
 1. Lockable doors. All control panels shall be provided with lockable doors using a cylinder AH2 lock kit.
 2. Hinged door shall swing left.
 3. Identification of all internally and cover mounted devices. Cover mounted labels shall be engraved labels as specified in this section.
 4. Provide one duplex outlet mounted inside the control panel. This receptacle may be served from the control panel 120 VAC power source. Label receptacle with source circuit information.
 5. Each control panel shall be provided with a control power disconnect switch located and wired so as to disconnect all control power in the panel. Provide one control power disconnect switch per system served (i.e. two disconnect switches for control panel serving two units).
 6. All control panels containing electrical equipment shall be NEMA rated for the location in which they are installed. Cover mounted components, tubing penetration, and conduit penetrations shall be made in a manner consistent with the NEMA rating.
 7. All conduits entering the control panel shall be fitted with a plastic insulating bushing to prevent cable damage.
 8. Wires and tubes that pass from the panel interior to cover mounted devices shall be provided with a flex loop that is anchored on both sides of the hinge.
 9. All internal wiring and tubing shall run inside plastic open-slot wire ducts. Wire duct shall be sized to hold the required number of wires and tubes without crimping the wires or tubing and with sufficient space to allow wiring and tubing to be traced during troubleshooting operation.
 10. All control panels shall be provided with removable backplane to allow the panel enclosures to be installed at the job site during rough-in while the panels are fabricated off-site for later installation.
 11. Labels serving all input/output wiring shall be installed between the open-slot wire duct and the controller so that labels are visible without removing the covers from the wire ducts. Labels shall be as specified in this section.

12. All wiring inside the panel shall be separated by classification; i.e., Class 1 circuits shall not be run with Class 2 circuits, etc. Segregation shall be maintained inside the panel to the fullest extent possible. Where low voltage wires carrying low level ac and dc signals cross wires containing power and high level ac signals, the wires shall cross at a 90° angle.
 13. 120 VAC power wiring shall enter the panel separately as close to the point of connection as possible
 14. Provide a wireway above or below the control panel whenever more than six conduits enter the panel. Wireway shall be the width of the panel with a minimum of six inches in height and six inches in depth.
- E. Panel Location:
1. Each control panel is to be located for convenient servicing. Top of panel shall be at six foot above finish floor.
 2. Mount panels adjacent to associated equipment.
- F. Network Control Unit (NCU) Panel:
1. Mount in IDF/MDF room or pre-approved location.
 2. Provide one duplex outlet mounted inside the control panel.
 3. Locate NCU power adapter inside the control panel.

3.5 TEMPERATURE AND PRESSURE SENSOR INSTALLATION

- A. Temperature and pressure sensors shall require no field calibrations, initial calibration and range set at factory. BAS contractor to calibrate the DDC system with the field sensors. Thermistors are not field calibratable, but still must be field calibrated with the DDC system.
- B. Temperature and pressure sensor assemblies shall be readily accessible and adaptable to each type of application in such manner as to allow for quick, easy replacement and servicing without special tools or skills.
- C. Differential pressure transmitters provided with a LCD readout display shall be mounted on wall at 5-feet AFF and nearby from sampling ports in accessible location.
- D. Differential pressure transmitters intended for control of building chilled water or hot water distribution pumps, shall be hardwired to the Local Control Unit (LCU) in direct control of the associated Variable Frequency Drives.
- E. Sensors installed on units shall be provided with their own dedicated handy box and under no circumstances a sensor shall be “tucked in” or hidden in a junction-box. Installation shall allow the replacement of a sensor without dismantling other sensors, wiring or conduit.
- F. Outdoor installation shall be; of weatherproof construction or in appropriate NEMA enclosures. These installations shall be protected from solar radiation and wind effects. Protective shield shall be stainless steel.
- G. Sensors shall be provided with protective enclosure where located on plans in common areas (hallways, library, cafeteria, gymnasium). Enclosure shall be clear plastic and keyed alike. Key type is C254A as in a Honeywell Versa Guard TG510A 1001. All Gymnasium areas shall use a wire basket type of enclosure.
- H. Sensors in duct shall be mounted in locations to sense the correct temperature of the air only and shall not be located in dead air spaces or positions obstructed by ducts, equipment, and

so forth. Locations where installed shall be within the vibration and velocity limit of the sensing element. Ducts shall be securely sealed where elements or connections penetrate ducts to avoid measuring false conditions.

- I. All sensors measuring temperatures in pipes larger than 2 inches in diameter or in pressure vessels shall be supplied with wells properly fabricated for the service. Wells shall be non-corrosive to the medium being measured and shall have sufficient physical strength to withstand pressures and velocities to which they are subjected. Wells shall be installed in the piping at elbows where piping is smaller than the length of the well to affect proper flow across the entire area of the well.

3.6 INSTALLATION OF ACTUATORS

- A. Where damper motors operate outdoor relief, exhaust and fresh air dampers, pretension damper drive linkage to ensure tight closure.
- B. Do not install damper motors on ductwork of less than 0.76 mm thick without first reinforcing it.
- C. Where a damper motor is installed on an insulated surface of a duct plenum, mount it on a standoff bracket so as not to interfere with the continuity of the insulation.
- D. Locate damper and valve actuators so that they are easily accessible for testing and servicing.
- E. Damper motors shall be selected for the torque requirements of the damper. Damper operators that are undersized for the application shall be replaced with larger operators, at no extra cost. On retrofit applications, when existing dampers are suspected to be dragging, the next larger torque actuator shall be used.
- F. Provide one damper motor and linkage for every 2-m² damper section area, or as required to meet the torque requirements of the damper under design airflow conditions (or minimum of one damper motor per damper section). Do not use two motors linked together on one shaft, or by jackshaft.
- G. Actuators shall be installed in such manner to avoid damage to actuator due to condensation.

3.7 NETWORK INFRASTRUCTURE INSTALLATION

- A. All network infrastructure components and wiring shall be installed prior to control device installation. For twisted pair networks - install, test, and document test results and physical locations of cabling, conduit, and junction boxes on as-built drawings.
- B. Install and commission all routers, physical layer repeaters, and terminators prior to control device installations. Test routers, etc. with the approved network management tool, document results, and identify physical locations of all routers, repeaters, and terminators on as-built drawings.
- C. Install necessary power supplies for infrastructure components and devices prior to device installation. Document the following: power source location indicating panel number and breaker id on the set of as-built drawings, at the source panel, and at each device or infrastructure component.

3.8 CONTROL DEVICE INSTALLATION

- A. Coordinate with mechanical and electrical contractors and identify each physical network device location. For retrofit applications physically inspect the site. Document locations on shop drawings and include with submittals provided to architect/engineer and AISD Energy Management department representative.
- B. Provide all isolation, interfacing, and wiring to complete the installation of equipment items that have integral control systems such as packaged air conditioners, heating units and boiler firing systems. Coordinate with manufacturers prior to submitting proposals and again prior to preparing submittals. Provide all components and circuits and interdisciplinary coordination required to interface the controls system for all required status monitoring, operational features, and fire management functions. Completely test and adjust all systems.
- C. Prior to device installation confirm that wiring for all network media, power supply, and I/O has been completed and is available at each location. Notify architect/engineer and/or owners representative immediately of any discrepancies or missing items
- D. Install each network device as physically close as possible to controlled equipment with respect to environmental and electrical noise conditions.

3.9 NETWORK DEVICE PROGRAMMING, GRAPHICAL DISPLAYS, STANDARD SETPOINTS, POINT NAMING STANDARDS, ALARMING AND TREND LOGGING.

- A. All network device programming used to implement control sequences shall be provided to AISD. It shall not be necessary for AISD to further program the system. However, provisions shall be made to allow future modification of the installed control programs.
- B. Provide licensed copies of all software tools, programming aids, and connecting cables, used to install, develop and troubleshoot the controls system to AISD.
- C. Implement the control sequences for the equipment on this project as prescribed in the construction documents and drawing sequence of operation descriptions.
- D. Provide the following Graphic User Interfaces (GUI) as the minimum acceptable but not limited to:
 - 1. Home Page
 - 2. Time Schedule Page
 - 3. Alarm Console Page
 - 4. Trend Logs Page
 - 5. Summary Page(s)
 - 6. Floor Plan(s)
 - a. Provide each floor plan with key plans and dynamically highlight which part of the key plan is in current view.
 - b. Mark location of space sensors to match final installation.
 - c. Provide calibrated space readings (i.e. space temp, CO2, RH, etc.)
 - d. Provide quick links (buttons) to associated HVAC equipment graphic pages.
 - 7. Dedicated GUI per each equipment being monitored/controlled by the BAS
 - a. Provide dedicated override points for all outputs.
 - b. Group points as follows:
 - 1) Setpoints: Bottom left-hand side
 - 2) Status Points: Bottom center (i.e. space temp, effective setpoints, etc.)

- 3) Overrides: Bottom right-hand side
 - 4) Actual Occupancy: Top right
 - 5) All Other Points: Overlaid around HVAC schematic
8. All graphics shall adhere to the Owner's graphic standards. Contact CxA for access to templates prior to graphics development.
- E. Point naming shall adhere to the Owner's point name conventions. Contractor shall reach out to the CxA prior to the commencement of programming for a copy of the latest version of the Point Naming Standards.
- F. Provide the following minimum cooling and heating setpoints for equipment scheduled to control to maintain space temperature:
 1. Occupied Cooling Setpoint (OCS) [Default: 74°F]
 2. Occupied Heating Setpoint (OHS) [Default: 70°F]
 3. Unoccupied Cooling Setpoint (UCS) [Default: 85°F]
 4. Unoccupied Heating Setpoint (UHS) [Default: 55°F]
 5. Unoccupied Dead-band [Default: 5°F]
 6. Slider Adjust Range [Default: $\pm 3^{\circ}\text{F}$]
 7. Effective Cooling Setpoint
 8. Effective Heating Setpoint
 9. Effective Cooling Setpoint (Occupied) = OCS + Slider Adjust Value
 10. Effective Cooling Setpoint (Unoccupied) = UCS
 11. Effective Heating Setpoint (Occupied) = OHS + Slider Adjust Value
 12. Effective Heating Setpoint (Unoccupied) = UHS
- G. Provide Alarm Extensions to the following points:
 1. Freeze-Stat (Change of State Alarm)
 2. Condensate Float Switch (Change of State Alarm)
 3. Low/High Static Pressure Alarm (Change of State Alarm)
 4. Fan Command vs Fan Status (Command Failure Alarm)
 5. Compressor Command vs Compressor Status (Command Failure Alarm)
- H. Provide Trend Logs to the following points:
 1. All temperature sensors (Change of Value; Tolerance 1.0F)
 2. All outputs
 3. All status points

3.10 LABELS AND IDENTIFICATION

- A. All devices relating to the work or systems included herein, including controllers, valves, relays, etc., shall be identified with a unique identification number or name on the submitted control drawings. This identification number or name, along with the service of the device (discharge air temperature, freeze-stat, etc.), shall be permanently affixed to the respective device.
- B. All field devices shall be supplied with a label indicating its function and point name. Labels shall be "DYMO"-type electronically printed approximately 2-1/2" x 3/4". Surface shall be cleaned before installing labels. No handwritten labels shall be accepted.
- C. Damper and valve actuators shall be labeled indicating which direction is towards open/bypass position (i.e. CW=BYPASS; CCW=OPEN).

- D. Label ceiling grid where sensors installed above ceiling when applicable.
- E. BAS Panels shall be supplied with a nameplate indicating the equipment being served (i.e. AHU-1 Cafeteria, CO2 Monitoring, etc.). Nameplates shall be engraved on rigid plastic labels approximately 3" x 1". "DYMO" tape will not be accepted. Only black phenolic with white lettering will be accepted.
- F. All 120 VAC power shall be labeled with source panel and circuit number.
- G. All BAS Junction Boxes covers shall be spray-painted green with "BAS" stenciled over.
- H. All controls wiring, tubing and cabling both inside and outside of control panels shall be labeled at both ends using BRADY PermaSleeve Black on White Wire Marker Sleeves (do not shrink). The wire designations shall match those on the shop and installation drawings. All markings shall be mechanically produced. No handwritten labels shall be accepted.
- I. Communication wiring shall be labeled to specify where it is coming from (previous device) and where it is going next (next device) at each communication drop (e.g. each controller inside a control panel, each VFD provided with a communication card).

3.11 EQUIPMENT PROTECTION AND CLEANING

- A. The BAS system contractor shall provide adequate means for and shall fully protect all finish parts of the materials and equipment against damage during the progress of the work until final acceptance.
- B. Equipment and accessories shall be thoroughly cleaned of cement, plaster, and other materials; grease and oil spots shall be removed with cleaning solvent and surfaces carefully wiped.

3.12 AIR BALANCING

- A. The BAS system contractor shall assign an individual full time to assist the air balance technician during the air-balancing process to assure full balance compliance.
- B. The air balance plug-in shall have the ability to globally override local set point values and command all VAV air terminal devices to fully closed, fully open, minimum, and maximum damper positions.
- C. All air balance settings and values shall be documented on the as-built control drawings for future reference.

3.13 SUBSTANTIAL PERFORMANCE TEST PROCEDURES

- A. General
 - 1. The work under this section shall undergo a formal Functional Testing Commissioning process as documented in Section 230926c. Contractor shall set aside adequate time for the Commissioning process, including point checkout, sequence verification, and graphics checkout. Contractor shall include adequate time to respond to deficiencies without delaying project completion.
 - 2. Prior to requesting Functional Testing, this Contractor shall have every control point checked end to end to ensure accuracy and integrity of the system.

3. Upon completion of control point end-to-end checkout, Contractor shall submit check-out documentation and DDC O&M Manuals to AISD and Commissioning Authority for review. Refer to Part 1 of this specification for O&M documentation requirements.
4. Upon review and approval of DDC O&M documentation, AISD and Commissioning Authority shall schedule the date for commencement of Functional Testing.
5. Controls Contractor shall make available for the Commissioning process a competent technician who is familiar with the installation and programming of the system. Contractor's technician shall accompany AISD and Commissioning Authority during Functional Testing.
6. Refer to Section 230926c for detailed description and requirements of the Commissioning process.

B. Documentation

1. Upon successful completion of the Commissioning process, and once all deficiencies identified during Commissioning have been corrected, Contractor shall submit a final As-Built DDC O&M Manual with all programming, control points, network variables, setpoints, and graphics as actually implemented.
2. Provide as-built wiring diagrams showing all device locations, infrastructure component locations, control panels, sensors, actuators, ladder diagrams, for associated hardware interlocks, and sequence of operation descriptions for each subsystem within the network design. Show all interfaces with existing and equipment controls.
3. Provide control panel layout sheets complete with point names, point addresses and wire identification numbers. Attach one copy to each respective panel door.
4. All As-Built (O&M Manuals, etc.) documentation, shop drawings, points verification sheets, coordination meeting minutes, etc. shall be included in the O&M manuals as well as on a Compact Disc (CD) accompanying the final As-Built.

C. Software Backups & Platform Access

1. Upon successful completion of the Commissioning process, the Contractor shall provide a Platform & Station Backup of the Network Control Unit along with the Credentials to access the NCU Platform.

3.14 PROJECT ACCEPTANCE

- A. Upon receipt and approval of final DDC O&M Controls work shall be considered substantially complete, as recommended by the Commissioning Authority and approved by Owner and Engineer For additional acceptance requirements see Div 230926c.

3.15 POINT LISTS AND SEQUENCES OF OPERATIONS

- A. Refer to drawings.

END OF SECTION 230926a

SECTION 230926c**COMMISSIONING OF BUILDING AUTOMATION SYSTEM (TRIDIUM-BACNET)****PART 1 - GENERAL****1.0 SCOPE**

This specification is Austin Independent School District's Division 230926c Rev. 7/30/2018 and supplements the Commissioning Requirements in Division-1 with specific requirements from Direct Digital Controls (DDC) specified under Division 23. This specification shall be used in its entirety and shall only be modified by, or with permission from AISD-Energy Management Department.

1.1 RELATED DOCUMENTS

- A. Division-1, Section 019113 -Commissioning Requirements, addresses responsibilities and procedures for the commissioning process. All requirements of Division-1 specifications apply to this section.
- B. Division-23, Section 230926a -Direct Digital Controls for Local Building Automation Systems (TRIDIUM-BACNET) addresses requirements for design, installation and testing of DDC system using the BACnet protocol for local control of building HVAC systems. All requirements of Section 230926a apply to this section.

1.2 RESPONSIBILITIES

- A. Commissioning is the joint responsibility of the Contractor (including subcontractors and vendors) and the Commissioning Authority hired directly by the Owner, the Owner, and the Design Engineer. General assignment of responsibilities during the Commissioning process is specified in Section 019113. All the requirements of Section 019113 apply to this section.
- B. (General) Contractor retains responsibility for coordinating participation of Local Building Automation System subcontractors (Section 230926) throughout the commissioning process, and for ensuring participation by other subcontractors and equipment suppliers, vendors and manufacturers as required to conduct activities specified herein.
- C. Building Automation Systems subcontractor (Division 23) is responsible for assigning representatives with expertise and authority to act on behalf of the subcontractor to conduct commissioning activities specified. Building Automation Systems subcontractors are also responsible for providing tools, software and equipment required to conduct commissioning activities.
- D. Commissioning Authority is responsible for organizing, witnessing and documenting commissioning activities specified.
- E. Owner is responsible for assigning personnel with expertise and authority to act on behalf of the Owner as relates to commissioning of Building Automation Systems, and to provide access to facilities, equipment, and servers as required to conduct commissioning tasks.

- F. Design Engineer is responsible for developing a design that is in compliance with the Owner's Project Requirements and Design Guidelines and for responding to Commissioning Authority's comments.

Design Engineer is also ultimately responsible for the proper operation of the system as designed, regardless of whether or not he chooses to participate in testing and demonstrations.

1.3 SUMMARY OF WORK

A. DESIGN PHASE (Information Only)

1. Conceptual Design Meeting: Early during Conceptual Design and prior to making firm decisions on the type of HVAC systems and controls to be provided, Design Team shall request a meeting with AISD Service Center personnel and Owner's Commissioning Authority. The main objective of the meeting is to review the Owner's Standard Specifications and Guidelines and ensure design will proceed in accordance.
2. Preliminary Design Submittal: Design Engineer provides complete DDC points list and sequence of operations for all systems at DD design submittal and again at 95% CD design submittal. Sequences and points lists shall be in accordance with Owner's guidelines and standard points lists. Electronic Submittals shall be provided to AISD Service Center personnel and Owner's Commissioning Authority.
3. Design Review Comments: Owner and Commissioning Authority provide comments upon review of DD and 95% CD design submittals. Comments issued in electronic form.
4. Design Review Meeting: A final design review meeting is held upon review of 95% CD's, to verify inclusion of review comments in design. Meeting is attended (at least) by Design Engineer, Owner, and Commissioning Authority. Commissioning Authority provides written documentation of decisions made during meeting.
5. Design Review Follow-up: Commissioning Authority conducts a follow up review of Construction Documents issued for permitting/bids and forwards comments to Owner and Engineer on any outstanding items.

B. SUBMITTAL PHASE

1. Preliminary Submittal: Controls subcontractor (Div-23) provides preliminary DDC submittal in accordance with specifications, with digital copies transmitted to AISD Service Center and Owner's Commissioning Authority (ACR). This submittal shall occur shortly after contract award and prior to approval of equipment submittals so that systems may be properly coordinated. In addition to requirements of Section 230926, Building Automation System submittal shall include at least the following:
 - a. Detailed written sequences as they will actually be programmed and using the program variable names;
 - b. Complete point lists including all controlled devices, monitored values, status points, set-points and all variables obtained from BACnet devices including those from equipment provided with BACnet communication cards;

2. Preliminary Submittal Review: Owner and Commissioning Authority issue joint review comments on Preliminary Submittal to Engineer for inclusion with Design Team's review comments to Contractor.
3. Preliminary Submittal Review Meeting: Upon acknowledgement of receipt of Preliminary Submittal review comments, Local Controls subcontractor will request through the Contractor and AISD Project Manager, a review meeting with Owner, Engineer, and Commissioning Authority. Commissioning Authority documents action items resulting from meeting for inclusion in Final Submittal.
4. Final Submittal: Upon addressing comments, Local Controls subcontractor issues Final Submittal for review by Engineer, Owner, and Commissioning Authority.
5. Final Submittal Review Comments: Owner, and Commissioning Authority issue joint comments to Engineer for inclusion with Design Team's final submittal review comments to Contractor.
6. No hardware installation should take place prior to receiving submittals that have been approved by Owner, Engineer and Commissioning Authority.

C. PRE-FUNCTIONAL INSPECTION -Local Building Automation Systems Controls

1. Controls Contractor Request for Pre-Functional Inspection: Upon completion of installation and programming of ALL systems, Controls subcontractor shall issue a written request for Pre-Functional Inspection by Engineer, Owner and Commissioning Authority, certifying that the following work is complete and ready for inspection:
 - a. Manufacturer start-up has been conducted for all equipment requiring it - coordinate with Mechanical Contractor;
 - b. Piping has been flushed and (preliminary) test and balance completed - coordinate with Mechanical Contractor;
 - c. All control and monitoring devices installed, wired and tested;
 - d. Point-to-point check to verify correspondence of control points to control devices verified (provide report);
 - e. All operational sequences tested;
 - f. Control Panel layout sheets complete with point name, point address, and wire identification number (indicating DDC device), with one copy attached to each respective panel door;
 - g. All points and devices permanently tagged with point name, address, and panel number;
 - h. As-Built Controls Diagrams and Sequence Documentation reflecting systems as programmed and installed, to be used during inspection.

2. Pre-Functional Inspection: Contractor shall set aside a minimum of two days to conduct a joint Pre-Functional Inspection of Local Controls Building Automation System work with Engineer, Owner and Commissioning Authority. Work will include the following:
 - a. Physical inspection of installation for compliance with specifications;
 - b. Sample testing of sensors and devices for verification of calibration;
 - c. Sample point-to-point checkout to verify correspondence of commanded points to controlled devices;
 - d. Testing of central plant cooling sequences including plant enable/disable sequences and call for unoccupied operation;
 - e. Testing of central plant heating sequences including plant enable/disable and call for unoccupied operation;
 - f. Testing of air handler units operating sequences (sampling) including occupied/unoccupied sequences and call for unoccupied operation;
 - g. Testing of zone controls (fan-coil, dx-split, vav-boxes) operating sequences (sampling) including occupied/unoccupied sequences and call for unoccupied operation;
3. Pre-Functional Inspection Report: Commissioning Authority prepares a report detailing deficiencies identified during Pre-Functional Inspection and submits to Engineer so he may evaluate and forward to Contractor.
4. Pre-Functional Re-Inspection(s) Request: Upon completion of items on Pre-Functional Inspection Report, Local Controls subcontractor issues a request for Pre-Functional Re-Inspection and the process is repeated.
5. Pre-Functional Acceptance: Upon completion of all items identified during Pre-Functional Inspection, Commissioning Authority issues an official notification of Pre-Functional Acceptance to Engineer so he may forward to Contractor.
6. When deem advantageous to the project, and depending on system configuration, Pre-Functional Inspection and Functional Testing may be combined into a single activity, at CxA's discretion.

D. FUNCTIONAL TESTING

1. Point Check-out Request: Upon completion of controls installation, the Controls Contractor shall submit documentation and issue written notification to Owner, Engineer, and Commissioning Authority stating that the entire system is ready for Point Check-out, including all graphics.
2. Point Check-out & Report: Commissioning Authority shall inspect system via the Web-based Graphic User Interface (GUI) to verify that all specified points are present, that they are reading properly and that they are accessible, commandable and

overridable as specified. Commissioning Authority will issue a point check-out report listing deficiencies to be corrected.

3. Point Check-out Corrections: Controls contractor shall correct deficiencies listed in the Point Check-out Report and issue written notification when system is ready for Functional Testing.
4. Functional Testing: Upon notification by controls contractor that deficiencies in the Point Check-out Report have been corrected, Engineer, Owner, and Commissioning Authority will meet controls contractor at the project site to conduct Functional Testing as described in Part-4 of this specification.
5. Functional Test Report: Upon completion of Functional Testing, Commissioning Authority shall issue a report listing deficiencies to be corrected.
6. Functional Testing Deficiencies Resolution: Controls contractor shall resolve deficiencies in Functional Test Report. Corrections shall be accomplished within a period of no more than 2 weeks. Upon correction of deficiencies, Contractor shall notify Owner and Commissioning Authority when system is ready for Final Functional Testing.
7. Final Functional Test & Report: Upon receiving notification from Contractor, Owner and Commissioning Authority will verify corrections to controls systems. Commissioning Authority will complete a Final Functional Test Report documenting that systems work as per design intent, and/or outlining any recommendations for future improvement.

E. O&M MANUALS AND AS-BUILT DOCUMENTS

1. Requirements for O&M Manuals and As-Built Documentations are included in Section 230926a.
2. Commissioning Authority shall conduct review of O&M's and As-Built's concurrently with Engineer and track documentation.

F. TRAINING

1. Requirements for training of Owner's personnel are included in Section 230926a.
2. Commissioning Authority shall review training material and attend selected training sessions as deemed useful in order to document adequacy.

PART 2 - PRODUCTS -NOT APPLICABLE

PART 3 - EXECUTION -NOT APPLICABLE

PART 4 - FUNCTIONAL TESTING PROCEDURES

4.0 GENERAL

- A. Seven (7) Day Performance Test: Contractor shall schedule a seven (7) day period to conduct Functional Testing specified herein. Any upset of system operational functionality greater than (2) hours during the seven (7) day test period shall cause the test to be restarted.
- B. Prerequisites for Functional Testing: The following must be complete prior to proceeding with Functional Testing
 - 1. Pre-Functional Testing and Acceptance Notice by Commissioning Authority.
 - 2. End to End Point Checkout by Contractor.
 - 3. Point Checkout Report by Commissioning Authority.
 - 4. Time schedules built and in control of time-controlled equipment.
 - 5. Graphics displays installed and fully operational for each unit, system, and subsystem.
- C. Trending: Implement the following trends prior to initiating testing.
 - 1. Each space sensors shall be placed on a five (5) minute trend for 24 hours to document accurate temperature control of room or zone. Trends shall be recorded electronically for inclusion in Commissioning Report.
 - 2. Each control loop measured variable, controlled variable and setpoint if calculated shall be place on a one (1) minute continuous trend for at least twenty-four (24) hours to document stability of loop. Trends shall be recorded electronically for inclusion in Commissioning Report.
 - 3. Runtime totalizer shall be set on selected digital outputs.
 - 4. Additional variables will be trended at the request of Owner/Commissioning Authority.

4.1 FUNCTIONAL TESTING

- A. Local Network Testing (BACnet)
 - 1. The fire alarm system shall be enabled at the time of testing to ensure correct action of all fire and smoke sequences that interface with controls.
 - 2. Network traffic for each device channel shall be measured for 24 hours utilizing a protocol analyzer tool. Channel analysis shall include bandwidth utilization, and error

statistics. Reconfigure nodes and/or install additional routers as necessary to maintain traffic at a no more than 60% of channel bandwidth capacity. Backbone channels that contain permanent HMI's shall consume no more than 30% of total bandwidth capacity.

3. Each network control device, intelligent router, and network interface shall be tested and health verified using the protocol analyzer diagnostics application. Test results shall include neuron error log statistics, self-test results and device state information.
4. A power failure for the building shall be simulated and system recovery monitored. A protocol analyzer log shall record the network traffic for each channel for a 60-minute period following building power restoration.
5. Disable all sending (upstream) devices and simulate connection failures for receiving devices (downstream) that implement fail-safe configuration settings. Verify that downstream devices play failsafe values in the event that network variable updates are not detected by downstream devices within the minimum receive update intervals.
6. Test results shall be printed, recorded electronically and submitted to Owner, Engineer and Commissioning Authority.

B. Functional Testing of Sequences and Controls

1. Functional Checklists: Functional Testing forms shall be developed by Commissioning Authority for each specific system or subsystem to be tested, identifying all control and monitoring points that must be active.
2. End-to-End Verification: Proper operation/response of controlled points shall be verified from the Web-based Graphic User Interface (GUI) front-end to the actual physical devices in the field, as follows:
 - a. Controlled devices shall be commanded to a value at the GUI and its reaction observed in the field.
 - b. Status points shall be changed and observed both in the field and at the GUI.
 - c. Selected sensors shall be tested for accuracy and proper placement to ensure that sensors are properly assigned to the area served.
 - d. Selected points shall be disabled in the field and the proper alarm/response verified at the GUI.
3. Sequence Verifications: Proper operation of programmed sequences shall be verified for each major system type and sampled for multiple identical systems. Sequence verification will include the following as directed by the CxA:
 - a. Response to time schedule commands.
 - b. Response to changes in setpoints.

- c. Responses to changes in field conditions.
- d. Response to loss and restoration of power.
- e. Response to loss and restoration of communication.

END OF SECTION 230926c

SECTION 23 2300
REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes refrigerant piping used for air-conditioning applications.

1.2 SUBMITTALS

- A. Product Data: For refrigerant piping and each type of valve and refrigerant piping specialty indicated.
- B. Operation and maintenance data.

1.3 QUALITY ASSURANCE

- A. ASHRAE Standard: Comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
- B. ASME Standard: Comply with ASME B31.5, "Refrigeration Piping."
- C. UL Standard: Provide products complying with UL 207, "Refrigerant-Containing Components and Accessories, Nonelectrical"; or UL 429, "Electrically Operated Valves."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Refrigerants:
 - a. Allied Signal, Inc./Fluorine Products; Genetron Refrigerants.
 - b. DuPont Company; Fluorochemicals Div.
 - c. Elf Atochem North America, Inc.; Fluorocarbon Div.
 - d. ICI Americas Inc./ICI KLEA; Fluorochemicals Bus.
 - 2. Refrigerant Valves and Specialties:
 - a. Climate & Industrial Controls Group; Parker-Hannifin Corp.; Refrigeration & Air Conditioning Division.
 - b. Danfoss Electronics, Inc.
 - c. Emerson Electric Company; Alco Controls Div.
 - d. Henry Valve Company.
 - e. Sporlan Valve Company.

2.2 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tube: ASTM B 280, Type ACR.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Bronze Filler Metals: AWS A5.8, Classification [BAg-1 (silver)] [BAg-2 (silver)]

2.3 VALVES

- A. Service Valves: 500-psig pressure rating; forged-brass body with copper stubs, brass caps, removable valve core, integral ball check valve, and with solder-end connections.

2.4 REFRIGERANT PIPING SPECIALITIES

- A. Moisture/Liquid Indicators: 500-psig maximum working pressure and 200 deg F operating temperature; all-brass body with replaceable, polished, optical viewing window with color-coded moisture indicator; with solder-end connections.
- B. Permanent Filter-Dryer: 350-psig maximum operating pressure and 225 deg F maximum operating temperature; steel shell and wrought-copper fittings for solder-end connections; molded-felt core surrounded by desiccant. Filter-dryer to be installed so it is replaceable.
- C. Hot gas muffler.
- D. Pressure relief device.

2.5 REFRIGERANTS

- A. ASHRAE 34, R-410A.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Aboveground, within Building: Type ACR drawn-copper tubing.

3.2 SPECIALTY APPLICATIONS

- A. Install liquid indicators in liquid line leaving condenser, in liquid line leaving receiver, and on leaving side of liquid solenoid valves.
- B. Install permanent filter-dryers in low-temperature systems, in systems using hermetic compressors, and before each solenoid valve.

3.3 PIPING INSTALLATION

- A. Install refrigerant piping according to ASHRAE 15.
- B. Basic piping installation requirements are specified in Division 23 Section "Common Work Results for HVAC."
- C. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- D. Arrange piping to allow inspection and service of compressor and other equipment. Install valves and specialties in accessible locations to allow for service and inspection.
- E. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation. Use sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.
- F. 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. Liquid lines may be installed level.
- G. When brazing, 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.
- H. Hanger, support, and anchor products are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- I. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
- J. Install hangers 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.
- K. Support vertical runs at each floor.

3.4 PIPE JOINT CONSTRUCTION

- A. Braze joints according to Division 23 Section "Common Work Results for HVAC."
- B. Fill pipe and fittings with an inert gas (nitrogen) during brazing to prevent scale formation.

3.5 SYSTEM CHARGING

- A. Charge system using the following procedures:
 - 1. Evacuate entire refrigerant system with a vacuum pump to a vacuum of 500 micrometers.
 - 2. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
 - 3. Charge system with a new filter-dryer core in charging line. Provide full-operating charge.

END OF SECTION

SECTION 23 3113

METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Rectangular ducts and fittings.
 - 2. Round ducts and fittings.
 - 3. Double wall duct and fittings
 - 4. Sheet metal materials.
 - 5. Sealants and gaskets.
 - 6. Hangers and supports.
- B. Related Sections:
 - 1. Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
 - 2. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

- A. Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Structural Performance: Duct hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
 - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
 - 2. Factory- and shop-fabricated ducts and fittings.
 - 3. Duct layout indicating sizes, configuration, and static-pressure classes.
 - 4. Dimensions of main duct runs from building grid lines.
 - 5. Fittings.
 - 6. Sheet metal thicknesses.
 - 7. Reinforcement and spacing.
 - 8. Seam and joint construction.
 - 9. Penetrations through fire, smoke, sound and other partitions.
 - 10. Equipment installation based on equipment being used on Project.
 - 11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
 - 12. Hangers and supports, including methods for duct and building attachment and vibration isolation.
 - 13. Materials, fabrication, assembly, and spacing of hangers and supports.
- C. Welding certificates.

1.5 QUALITY ASSURANCE

- A. Welding Qualifications: Qualify procedures and personnel according to the following:
 - 1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
 - 2. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

1.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Tests:
 - 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - 2. Test the following systems:
 - a. Supply Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections, selected by Architect from sections installed, totaling no less than 25 percent of total installed duct area for each designated pressure class.
 - 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 - 4. Test for leaks before applying external insulation.
 - 5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
 - 6. Give seven days' advance notice for testing.
 - 7. Schedule one test near the beginning of the ductwork installation to confirm duct sealing methods are acceptable.
- C. Duct system will be considered defective if it does not pass tests and inspections.

- D. Prepare test and inspection reports and deliver to the Architect within two days of each test.

PART 2 - PRODUCTS

2.1 RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 ROUND DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
 - 1. Manufacturers: Subject to compliance with requirements:
 - a. Lindab Inc.
 - b. McGill AirFlow LLC.
 - c. SEMCO Incorporated.
 - d. Sheet Metal Connectors, Inc.
 - e. Spiral Manufacturing Co., Inc.
- B. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 DOUBLE-WALL DUCT AND FITTING FABRICATION

- A. Manufacturers:
 - 1. Lindab Inc.
 - 2. McGill AirFlow Corporation.
 - 3. SEMCO Incorporated.
 - 4. Spiral Pipe of Texas.
- B. Ducts: Fabricate double-wall (insulated) ducts with a spiral lockseam outer shell and an inner duct. Dimensions indicated are for inner ducts.
- C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
 - 1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - a. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
 - 3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Inner Duct: Minimum 0.028-inch solid sheet steel.
- E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - 1. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
 - 2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
 - 3. Coat insulation with antimicrobial coating.
 - 4. Cover insulation with polyester film complying with UL 181, Class 1.

2.4 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90.
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.
- D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
- E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. 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.

2.5 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Water-Based Joint and Seam Sealant:
 - 1. Application Method: Brush on.
 - 2. Solids Content: Minimum 65 percent.
 - 3. Shore A Hardness: Minimum 20.
 - 4. Water resistant.
 - 5. Mold and mildew resistant.
 - 6. VOC: Maximum 70 g/L (less water).
 - 7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 - 8. Service: Indoor or outdoor.
 - 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- C. Flanged Joint Sealant: Comply with ASTM C 920.
 - 1. General: Single-component, acid-curing, silicone, elastomeric.
 - 2. Type: S.
 - 3. Grade: NS.
 - 4. Class: 25.
 - 5. Use: O.
- D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

- E. Round Duct Joint O-Ring Seals:
 - 1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
 - 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
 - 3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 HANGERS AND SUPPORTS

- A. Hanger Rods: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
- B. All metal components of ductwork system such as angle stiff shall be galvanized
- C. Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Rods for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- F. Duct Attachment for exposed double wall ducts shall be a single point connection concealed at the top of the duct to minimize visibility. Duct to be supported by stainless steel aircraft cable. Provide 45 degree lateral supports as required to stabilize each run.
- G. Trapeze and Riser Supports:
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install ducts with fewest possible joints.
- D. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- E. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

- F. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- G. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- H. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- I. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- J. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.
- K. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Reference all general and keyed notes on drawings for specifics of exposed duct products, construction, and installation.
- B. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- C. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- D. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter.
- E. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- F. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
 - 1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
 - 2. Outdoor, Supply-Air Ducts: Seal Class A.
 - 3. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class A.
 - 4. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.

5. Unconditioned Space, Exhaust Ducts: Seal Class C.
 6. Unconditioned Space, Return-Air Ducts: Seal Class B.
 7. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
 8. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
 9. Conditioned Space, Exhaust Ducts: Seal Class B.
 10. Conditioned Space, Return-Air Ducts: Seal Class C.
- C. Seal Ductwork exposed to view with materials that match the ductwork finish or provide matching ductwork material to conceal the exposed seals and provide a continuous finish look on the system.

3.4 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
1. Where practical, install concrete inserts before placing concrete.
 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: stainless steel air craft cable.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at maximum intervals of 16 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with 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 DUCT CLEANING

- A. Clean new duct system(s) before testing, adjusting, and balancing.
- B. Use service openings for entry and inspection.
 - 1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 23 Section "Air Duct Accessories" for access panels and doors.
 - 2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
 - 3. Remove and reinstall ceiling to gain access during the cleaning process.
- C. Clean the following components by removing surface contaminants and deposits:
 - 1. Air outlets and inlets (registers, grilles, and diffusers).
 - 2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
 - 3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, condensate drain pans, filters and filter sections, and condensate collectors and drains.
 - 4. Coils and related components.
 - 5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
 - 6. Supply-air ducts, dampers, actuators, and turning vanes.
 - 7. Dedicated exhaust and ventilation components and makeup air systems.

3.7 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer.

3.8 DUCT SCHEDULE

- A. Fabricate ducts as follows:
 - 1. Concealed Supply Ducts
 - a. Paint Grip Galvanized Steel
 - b. Positive 4-inch wg.
 - 2. Exposed Supply Ducts
 - a. Paint Grip Galvanized Steel
 - b. Positive 4-inch wg.
 - 3. Concealed Return Ducts
 - a. Paint Grip Galvanized Steel
 - b. Positive or negative 2-inch wg.
 - 4. Exposed Return Ducts
 - a. Paint Grip Galvanized Steel
 - b. Positive or negative 2-inch wg.
 - 5. Exhaust Ducts
 - a. Paint Grip Galvanized Steel
 - b. Negative wg 2-inch wg.
 - 6. Lab Exhaust Ducts
 - a. Stainless Steel
 - b. Negative wg 2-inch wg.

7. Outdoor-Air Ducts
 - a. Galvanized Steel
 - b. Positive or negative 3-inch wg.
- B. Elbow Configuration:
 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Radius-to Diameter Ratio: 1.5.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam or Welded.
- C. Branch Configuration:
 1. Rectangular Duct: All branch connections shall be 45-degree entry. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 2. Round: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees."
 - a. Conical tap.

END OF SECTION

SECTION 23 7433

DEDICATED OUTDOOR AIR UNIT

PART 1 - GENERAL

1.1 SUMMARY

- A. This Section includes heating and cooling packaged, outdoor, air conditioning units capable of supplying 100% of the total supply air volumes as outdoor air in cooling and heating operation.

1.2 ACTION SUBMITTALS

- A. Product Data: Include manufacturer's technical data for each model indicated, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, computer generated fan curves with specified operating point indicated, manufacturer's installation instructions and accessories
- 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. Wiring Diagrams: Power, signal, and control wiring.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualifications
 - 1. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience, who issues complete catalog data on total product.
 - 2. Startup must be done by manufacturer's technical representative who will provide written certification that installation meets manufacturer's requirements.
 - 3. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters and remote controls are in place, bearings lubricated, and manufacturers' installation instructions have been followed
- B. Field quality-control test reports.
- C. Warranty: Special warranty specified in this Section

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data for rooftop air conditioning units.
- B. Startup service reports.

1.5 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of roof top air handling units and are based on the specific system indicated as basis of design. Contractor is responsible for all costs associated with providing equipment other than that listed as the basis of design. Refer to Division 1 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.
- C. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
- D. Energy-Efficiency Ratio: Equal to or greater than prescribed by the latest adopted version of ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- E. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
- F. Comply with NFPA 54 for gas-fired furnace section.
- G. ARI Compliance for Units with Capacities Less Than 135,000 Btuh: Rate rooftop air-conditioning unit capacity according to ARI 210/240, "Unitary Air-Conditioning and Air-Source Heat Pump Equipment."
 - 1. Sound Power Level Ratings: Comply with ARI 270, "Sound Rating of Outdoor Unitary Equipment."

1.6 COORDINATION

- A. Coordinate size, location, and installation of air-conditioning unit manufacturer's equipment supports with structural components.

1.7 WARRANTY

- A. Special Warranty: Manufacturer agrees to replace components and provide labor required to replace air conditioning components that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Compressors: Not less than five years from date of Substantial Completion.
 - 2. Warranty Period for Heat Exchangers: Not less than five years from date of Substantial Completion.
 - 3. Warranty Period for Solid-State Ignition Modules: Not less than five years from date of Substantial Completion.
 - 4. Warranty Period for Control Boards: Not less than five years from date of Substantial Completion.
 - 5. Warranty Period for Electronic Thermostats: Manufacturer's standard, but not less than three years from date of Substantial Completion.

1.8 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-drive fan.
 - 2. Filters: One set of filters for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Manufacturers:
 - 1. Trane
 - 2. Annexair
 - 3. Valent
- C. DESCRIPTION: Factory assembled and tested; designed for exterior installation; consisting of compressor, refrigerant coils, supply fan and condenser fans, refrigeration controls, gas heating, economizer controls, temperature controls, humidity controls, filters, and dampers.
- D. CABINET, CASING, AND FRAME
 - 1. Panel construction shall be double-wall construction for all doors, side panels and ceiling panels. All floor panels shall have a solid galvanized steel inner liner on the air stream side of the unit to protect insulation during service and maintenance. Insulation shall be a minimum of 1" thick. Exterior surfaces shall be constructed of pre-painted galvanized steel for aesthetics and long term durability. Paint finish to include a base primer with a high quality, polyester resin topcoat of a neutral beige color. Finished panel surfaces to withstand a minimum 750-hour salt spray test without blistering or peeling in accordance with ASTM B117 standard for salt spray resistance when the sample is scribed with an X and sample edges are not protected.
 - 2. Service doors shall be provided on both sides of the mixing box, filter and DX coil sections. An access door shall also be provided to the fan section, heat section and control box in order to provide user access to unit components. All service access doors shall be mounted on multiple, stainless steel hinges and shall be secured by a latch system. Removable service panels secured by multiple mechanical fasteners are not acceptable.
- E. SUPPLY FAN
 - 1. Supply fan shall be a non-overloading, single width, single inlet (SWSI) airfoil centrifugal fan. The fan blade design shall be a double blade with the airfoil geometry, a backward inclined blade fan wheel design will not be acceptable. The fan wheel shall be Class II construction with aluminum fan blades welded to the back plate and end rim. The supply fan shall be mounted using solid-steel shafts and wheel hubs with mating keyways
 - 2. The fan assembly shall have fixed pitched drives with a minimum of two belts. The drives shall be selected with a minimum diameter of 4 inches and a 1.2 service factor. The belts shall be of the grip-notch design.

3. All fan assemblies shall be statically and dynamically balanced at the factory, including a final trim balance, prior to shipment. All fan assemblies shall employ solid steel fan shafts. Heavy-duty pillow block type, self-aligning, grease lubricated ball bearings shall be used. Bearings shall be sized to provide a L-50 life at 250,000 hours. Fan motors shall be heavy-duty 1800 rpm open drip-proof (ODP) type with grease lubricated ball bearings. Motors shall be premium efficiency. Motors shall be mounted on an adjustable base that provides for proper alignment and belt tension adjustment. Motors shall be suitable for use with a variable frequency drive. Fan motors shall be mounted within air handler casing on vibration isolators.
4. The supply fan shall be capable of airflow modulation from 30% to 100% of the scheduled designed airflow. The fan shall not operate in a state of surge at any point within the modulation range.

F. ELECTRICAL

1. Unit wiring shall comply with NEC requirements and with all applicable UL standards. All electrical components shall be UL recognized where applicable. All wiring and electrical components provided with the unit shall be number and color-coded and labeled according to the electrical diagram provided for easy identification. The unit shall be provided with a factory wired weatherproof control panel. Unit shall have a single point power terminal block for main power connection. A terminal board shall be provided for low voltage control wiring. Branch short circuit protection, 115-volt control circuit transformer and fuse, system switches, and a high temperature sensor shall also be provided with the unit. Each compressor and condenser fan motor shall be furnished with contactors and inherent thermal overload protection. Supply fan motors shall have contactors and external overload protection. Knockouts shall be provided in the bottom of the main control panels for field wiring entrance. A GFI receptacle shall be unit mounted. The receptacle shall require a field power connection independent from the unit's main power block and / or disconnect.
2. A single non-fused disconnect switch shall be provided for disconnecting electrical power at the unit. Disconnect switches shall be mounted internally to the control panel and operated by an externally mounted handle.
3. The unit's short circuit resistance rating [SCCR] shall be 10,000 amps.

G. HEATING AND COOLING SECTIONS

1. The direct expansion (DX) coil section shall be installed in a draw through configuration, upstream of the supply air fan. The coil section shall be complete with a factory piped cooling coil and an ASHRAE 62.1 compliant double sloped stainless steel drain pan with a minimum depth of 2.3" on the connection side.
2. Direct expansion (DX) cooling coils shall be fabricated of seamless high efficiency copper tubing that is mechanically expanded into high efficiency aluminum plate fins. Coils shall be a multi-row, staggered tube design with a minimum of 6 rows for maximum dehumidification effect. All units shall have two independent refrigerant circuits and shall use an interlaced coil circuiting that keeps the full coil face active at all load conditions. All coils shall be factory leak tested with high pressure air under water.
3. A positively sloped drain pan shall be provided with the cooling coil. The slope of the drain pan shall be in two directions and comply with ASHRAE Standard 62.1. The drain pan shall have a minimum slope of 1/8" per foot to provide positive draining. The drain pan shall extend beyond the leaving side of the coil. The drain pan construction shall be a stainless steel design. The drain pan shall be connected to a threaded drain connection extending through the unit base. Drain pan shall be removable from the side of the unit without the removal of the cooling coil.

4. The rooftop unit shall include a natural gas heating section. The gas furnace design shall have a natural gas fired heating module factory installed downstream of the supply air fan in the heat section. The module shall be complete with furnace controller and control valve capable of modulating operation from 100% down to 28% of full fire capacity. The heating module shall be a tubular design with in-shot gas burners. The heat exchanger tubes shall be constructed of stainless steel. The module shall have an induced draft fan that will maintain a negative pressure in the heat exchanger tubes for the removal of the flue gases.
5. Each burner module shall have two flame roll-out safety protection switches and a high temperature limit switch that will shut the gas valve off upon detection of improper burner manifold operation. The induced draft fan shall have an airflow safety switch that will prevent the heating module from turning on in the event of no airflow in the flue chamber.
6. The factory-installed DDC unit control system shall control the gas heat module. Field installed heating modules shall require a field ETL certification. The manufacturer's rooftop unit ETL certification shall cover the complete unit including the gas heating modules.

H. HOT GAS REHEAT

1. Unit shall be equipped with a fully modulating hot gas reheat coil with hot gas coming from the unit condenser.
2. Hot gas coil shall be an all aluminum design. The aluminum tube shall be a micro channel 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.
3. Hot gas coil shall be sized to allow for full condensing across the operation range of the unit. High temperature liquid shall be piped downstream of the unit's condenser coils into the liquid line.
4. The reheat coil volume shall be small enough to not require receivers or any device that reduces sub-cooling. Controls and control valves will automatically cycle operation between normal cooling, dehumidification or reheat modes in response to the field wired, space humidity or dew point sensor without refrigeration safety trips.
5. The hot gas reheat option shall have a fully modulated control to allow for unit leaving air temperature control to +/- 2°.
6. The modulating hot gas reheat systems shall allow for independent control of the DX cooling coil leaving air temperature and the reheat coil leaving air temperature. The cooling and reheat leaving air temperature setpoints shall be adjustable through the unit MT III controller.

I. FILTERS

1. Unit shall be provided with a draw-through filter section. The filter rack shall be designed to accept a 2" prefilter and a 4" final filter. The unit design shall have a hinged access door for the filter section. The manufacturer shall ship the rooftop unit with 2" MERV 8 construction filters. The contractor shall furnish and install, at building occupancy, the final set of filters per the contract documents.

J. OUTDOOR AIR SECTION

1. Damper blades shall be gasketed with side seals to provide an air leakage rate of no more than 1.5 cfm / square foot of damper area at 1" differential pressure. Leakage rate to be tested in accordance with AMCA Standard 500. Damper blades shall be operated from multiple sets of linkages mounted on the leaving face of the dampers.
2. Unit shall be equipped with a low leak OA isolation damper. OA shall enter the unit through the end of the unit and shall have hoods sized to prevent water carry over during inclement weather. Damper shall be controlled with a modulating, direct coupled actuator to allow for field adjustment of unit airflow. Damper blades shall be gasketed with side seals to provide an air leakage rate of no more than 4 cfm / square foot of damper area at 1" differential pressure per ASHRAE 90.1 Energy Standard. Leakage rate to be tested in accordance with AMCA Standard 500. Damper blades shall be operated from multiple sets of linkages mounted on the leaving face of the dampers.

K. CONDENSING SECTION

1. Condenser coils shall be an all aluminum design, and mounted on polymer brackets, to minimize di-electric corrosion. The aluminum tube shall be a micro channel 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 fins by a coil guard. Coil guard shall be constructed of cross wire welded steel with PVC coating
2. Condenser fans shall be direct drive, axial type designed for low tip speed and vertical air discharge. Condenser fan rpm shall be 1140 rpm maximum. Fan blades shall be constructed of steel and riveted to a steel center hub. Condenser fan motors shall be heavy-duty, inherently protected, three-phase, non-reversing type with permanently lubricated ball bearing and integral rain shield.
3. Each circuit shall have fan cycling of at least one condenser fan to maintain positive head pressure. An ambient thermostat shall prevent the refrigeration system from operating below 0° F.
4. Condenser coils shall be recessed and protected from hail damage as an integral part of the unit design. Hail guards shall be provided on all units with vertical mounted condenser coils.
5. Each unit shall have multiple, heavy-duty scroll compressors. Each compressor shall be complete with gauge ports, crankcase heater, sight-glass, anti-slug protection, motor overload protection and a time delay to prevent short cycling and simultaneous starting of compressors following a power failure. Compressors shall be isolated with resilient rubber isolators to decrease noise transmission
 - a. At least one compressor to be inverter scroll type for capacity modulation.
6. Each unit shall have two independent refrigeration circuits for redundancy. Each circuit shall be complete with a low pressure control, filter-drier, liquid moisture indicator/sight-glass, thermal expansion valve, and a manual reset high pressure safety switch. The thermal expansion valve shall be capable of modulation from 100% to 25% of its rated capacity. Sight-glasses shall be accessible for viewing without disrupting unit operation. Each circuit shall be dehydrated and factory charged with Refrigerant 410A and oil.
7. Each unit shall have at least 4 compressor stages of cooling capacity control for better part load control as required by ASHRAE 90.1-2013.

L. Unit Controls:

Provide all controls for proper operation as manufactured by the manufacturer, to meet the requirements stated on the plans and/or listed in the specifications.

1. The stand-alone DDC controllers shall not be dependent on communications with any on-site or remote PC or master control panel for proper unit operation. The microprocessor shall maintain existing set points and operate stand alone if the unit loses either direct connect or network communications. The microprocessor memory shall be protected from voltage fluctuations as well as any extended power failures. All factory and user set schedules and control points shall be maintained in nonvolatile memory. No settings shall be lost, even during extended power shutdowns.
2. The DDC control system shall permit starting and stopping of the unit locally or remotely. The control system shall provide a remote alarming function. The unit DDC control system shall provide for proper operation of all sequences and communicating of all Input /Output information to the BAS from the a unit BACnet MS/TP module using BACnet MS/TP protocol.
3. All digital inputs and outputs shall be protected against damage from transients or incorrect voltages. All field wiring shall be terminated at a separate, clearly marked terminal strip
4. The DDC controller shall accept time scheduling from the BAS system using BACnet MS/TP protocol.
5. The unit manufacturer shall provide all work to perform the unit side of the integration of all Input /Output information out to and in from the BAS.

M. Accessories:

1. Service Outlets: Two, powered 115-V, ground-fault, circuit-interrupter type.
2. Hail guards of steel painted to match casing.

N. Roof mounting Application: Provide unit with all supplemental steel and base rails as required to accommodate a roof mounting application. Coordinate roof curb height with existing condensate drain locations to accommodate proper slope to the drain location.

O. Supply Duct configuration: Provide unit with side or bottom discharge air opening coordinated with the plan documents. DOAU-300 to have side discharge. DOAU-400 to have bottom discharge. Transition roof curb adaptors are not acceptable in this application.

3.2 MOTORS

- A. Motor Sizes: Minimum size as indicated; if not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- B. Motor Performance and selection: Comply with ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings" CFM / HP requirements.
- C. Controllers, electrical devices, and wiring are specified in Division 16 Sections.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install units level and plumb, maintaining manufacturer's recommended maintenance clearances. Install units with clearances required to easily remove and replace equipment and components.
- B. Support: Install support structure, level and secure. Install and secure rooftop air conditioning units on curbs.
- C. Provide complete installation and commissioning of the DDC controls including conduit and wiring for all air handling equipment, communication wiring, HMI, DDC power wiring, and other portions as required for a proper operational DDC system. Conduit shall be EMT with insulated compression fittings indoors and IMC outdoors. All wiring including wall drops and above lay in ceiling shall be installed in EMT.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
 - 1. Gas Piping: Comply with applicable requirements in Division 23 Section "Fuel Gas Piping." Connect gas piping to burner, full size of gas train inlet, and connect with union and shutoff valve with sufficient clearance for burner removal and service.
- C. Duct installation requirements are specified in other Division 2323 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
 - 1. Install ducts to termination in roof curb.
 - 2. Connect supply ducts to rooftop unit with flexible duct connectors specified in Division 23 Section "Duct Accessories."
 - 3. Install normal-weight, 3000 psi, compressive strength (28-day) concrete mix inside roof curb, 4 inches thick. Concrete, formwork, and reinforcement are specified in Division 3.
- D. Electrical System Connections: Comply with applicable requirements in Division 16 Sections for power wiring, switches, and motor controls.
- E. Ground equipment according to Division 16 Section "Grounding and Bonding."
- F. 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. Report results in writing.
- B. Perform the following field quality-control tests and inspections and prepare test reports:
 - 1. After installing rooftop air conditioning units and after electrical circuitry has been energized, test units for compliance with requirements.
 - 2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove malfunctioning units, replace with new units, and retest as specified above.

3.4 STARTUP SERVICE

- A. Engage a manufacturer's technical representative to perform startup service. Provide written certification that installation meets manufacturer's requirements.
- B. 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, air-cooled outside coil, and fans.
 - 4. Inspect internal insulation.
 - 5. Verify that labels are clearly visible.
 - 6. Verify that clearances have been provided for servicing.
 - 7. Verify that controls are connected and operable.
 - 8. Verify that filters are installed.
 - 9. Clean outside coil and inspect for construction debris.
 - 10. Clean furnace flue and inspect for construction debris.
 - 11. Connect and purge gas line.
 - 12. Adjust vibration isolators.
 - 13. Inspect operation of barometric dampers.
 - 14. Lubricate bearings on fan.
 - 15. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - 16. Adjust fan belts to proper alignment and tension.
 - 17. Start unit according to manufacturer's written instructions.
 - a. Start refrigeration system in summer only.
 - b. Complete startup sheets and attach copy with Contractor's startup report.
 - 18. Inspect and record performance of interlocks and protective devices; verify sequences.
 - 19. Operate unit for an initial period as recommended or required by manufacturer.
 - 20. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency. Adjust pilot to stable flame.
 - a. Measure gas pressure on manifold.
 - b. Measure combustion-air temperature at inlet to combustion chamber.
 - c. Measure flue-gas temperature at furnace discharge.
 - d. Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
 - e. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

21. Calibrate sensors and controllers.
22. Adjust and inspect high-temperature limits.
23. Inspect outside-air dampers for proper stroke and interlock with return-air dampers.
24. Start refrigeration system and measure and record the following:
 - a. Coil leaving-air, dry- and wet-bulb temperatures.
 - b. Coil entering-air, dry- and wet-bulb temperatures.
 - c. Outside-air, dry-bulb temperature.
 - d. Outside-air-coil, discharge-air, dry-bulb temperature.
25. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
26. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.
 - a. Supply-air volume.
 - b. Return-air volume.
 - c. Relief-air volume.
 - d. Outside-air intake volume.
27. Simulate maximum cooling demand and inspect the following:
 - a. Compressor refrigerant suction and hot-gas pressures.
 - b. Short circuiting of air through outside coil or from outside coil to outside-air intake.
28. After startup and performance testing, change filters, vacuum heat exchanger and cooling and outside coils, lubricate bearings, adjust belt tension, and inspect operation of power vents.

3.5 ADJUSTING

- A. Adjust initial temperature and humidity set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose, without additional cost.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain rooftop air conditioners. Refer to Division 1 Section "Closeout Procedures."

END OF SECTION

SECTION 23 8127

SPLIT SYSTEM AIR CONDITIONERS

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. Reference AISD's standards section 011913 for project commissioning Requirements.

1.2 SUMMARY

- A. This Section includes split-system air-conditioning units consisting of separate evaporator-fan and compressor-condenser components.

1.3 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Samples for Initial Selection: For units with factory-applied color finishes.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.
- F. Warranty: Special warranty specified in this Section.

1.4 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of split-system units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- B. Startup: Startup must be done by manufacturer's technical representative who will provide written certification that installation meets manufacturer's 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. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

- E. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.14, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.5 COORDINATION

- A. Coordinate size and location of concrete bases for units. Cast anchor-bolt inserts into bases.
- B. Coordinate size, location, and connection details with equipment supports, and wall penetrations.

1.6 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components and provide required labor services of split-system air-conditioning units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Five years from date of Substantial Completion.

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: One set of filters for each unit.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carrier Air Conditioning; Div. of Carrier Corporation.
 - 2. Trane.
 - 3. Lennox.

2.2 EVAPORATOR-FAN COMPONENTS

- A. Cabinet: Enameled steel with removable panels on front and ends in manufacture standard color.
 - 1. Discharge Grille: Welded steel bars forming a linear grille and welded into supporting panel.
 - 2. Insulation: Faced, glass-fiber, duct liner.
 - 3. Drain Pans: Galvanized steel, with connection for drain; insulated and complying with ASHRAE 62.1.
 - 4. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- B. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.

- C. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.
- D. Fan: Direct drive, centrifugal.
- E. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 1. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication or EC Motor.
 - 2. Fan motors to be mounted within cabinet on vibration isolators.
- F. Filters: ASHRAE 52.2 MERV rating of 13 unless Owner approves less.

2.3 AIR-COOLED, COMPRESSOR-CONDENSER COMPONENTS

- A. 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.
- B. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
 - 1. Compressor Type: Scroll.
 - 2. Refrigerant: Non HCFC.
- C. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.
- D. Fan: Aluminum-propeller type, directly connected to motor.
- E. Motor: Permanently lubricated, with integral thermal-overload protection.
- F. Low Ambient Kit: Permits operation down to 45 deg. F.
- G. Mounting Base: Structural Steel.
- H. Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1-2004, "Energy Standard for Buildings except Low-Rise Residential Buildings."

2.4 ACCESSORIES

- A. Equipment operating sequences are specified on the drawings and in division 23 specification.
- B. Controls : Include the following features:
 - 1. Low Ambient Lockout Control to prevent cooling-cycle operation below 40 deg. F. outdoor air temperature.
 - 2. Conventional thermostat interface.
- C. Automatic-reset timer to prevent rapid cycling of compressor.

- D. 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.
 - 1. Minimum Insulation Thickness: 1 inch thick.

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-mounting, compressor-condenser components on 4-inch- thick, reinforced concrete base; 4 inches larger on each side than unit. Coordinate anchor installation with concrete base.
- D. Install ground-mounting, compressor-condenser components on polyethylene mounting base.
- E. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of 1 inch.
- F. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to unit to allow service and maintenance.
- C. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts." Drawings indicate the general arrangement of ducts. Connect supply ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories."
- D. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- E. Electrical Connections: Comply with requirements in Division 26 Sections for power wiring, switches, and motor controls.

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, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.

3.4 STARTUP SERVICE

- A. Engage a manufacturer's technical representative to perform startup service. Provide written certification that installation meets manufacturer's requirements.
 - 1. Complete installation and startup checks according to manufacturer's written instructions. Provide written certification that installation meets manufacturer's requirements.

3.5 DEMONSTRATION

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

END OF SECTION

SECTION 26 0000.01

ELECTRICAL DEMOLITION

PART 1 - GENERAL

1.1 WORK INCLUDED

- A. Electrical demolition for remodeling.
- B. Electrical/control portion of HVAC work covered by Division 23 pertaining electrical demolition shall follow the requirement set forth by this specification.

1.2 RELATED WORK

- A. This Section shall be used in conjunction with the following other specifications and related Contract Documents to establish the total requirements for minor electrical demolition for remodeling.
 - 1. Section 26 00 00 - Basic Electrical Requirements.
- B. In the event of conflict regarding minor electrical demolition requirements between this Section and any other Section, the provisions of this Section shall govern.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

- A. Materials and equipment for patching and extending work: as specified in individual Sections.
- B. Provide all materials necessary for work.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. All demolitions or modifications to existing systems shall be coordinated through Owner's Representative. Demolition drawings are based on casual field observation and existing record documentations. Therefore the accuracy or exactness of the drawings is not guaranteed. The Contractor shall verify that field measurements and circuiting arrangements are as shown on Drawings and abandoned wiring and equipment serve only abandoned facilities. The Contractor shall be responsible for reporting discrepancies to Engineer before disturbing existing installation.
- B. Beginning of demolition means Contractor accepts existing conditions.

3.2 PREPARATION

- A. Disconnect electrical systems in walls, floors, and ceilings scheduled for removal. Provide temporary wiring and connections to maintain remaining systems in service during demolition and/or modification. Owner reserve the right up to 24 hours prior to any scheduled event to delay or suspend shutdowns or outages to more convenient times at no additional cost.
- B. Existing Electrical Service: Maintain existing system in service until new system is complete and ready for service. No work shall begin without proper permits and authorizations. Disable system only to make switchovers and connections. Obtain permission from Owner at least (2) weeks before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.
- C. Existing Fire Alarm System: Maintain existing system in service until new system is accepted. Disable system only to make switchovers and connections. Notify Owner at least (2) weeks before partially or completely disabling system. Minimize outage duration. Provisions for manual fire watch shall be provided in areas where services are interrupted. Make temporary connections to maintain service in areas adjacent to work area.
- D. 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. Notify Owner at least (2) weeks before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

3.3 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

- A. Remove, relocate, and extend existing installations to accommodate new plan drawings.
- B. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes full length from source to device. Cut embedded or concealed conduit flush with walls and floors, and patch surfaces.
- C. 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.
- D. Disconnect and remove abandoned panelboards and distribution equipment.
- E. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
- F. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.
- G. Repair adjacent construction and finishes damaged during demolition and extension work.
- H. Maintain access to existing electrical installations that remain active. Modify installation or provide access panel as appropriate.
- I. Extend existing installations using materials and methods compatible with existing electrical installation or as specified.

- J. The level of completion shall be demonstrated to Owner's Representative.
- K. Where equipment is indicated to be demolished and returned to Owner, the Contractor shall include the delivery of this equipment to the Owner's site storage area. Remove with care all equipment to be relocated. Repair or replace of newly damaged equipment is the responsibility of the Contractor.

3.4 CLEANING AND REPAIR

- A. The Contractor shall follow Owner's clean work policy and shall include the removal of trash and demolished material from the building or work area at the end of the each day and removal from the site once a week.
- B. The Contractor shall be responsible for repairing adjacent construction and finishes damaged during demolition and/or modification. The Contractor shall be responsible for the removal of ceiling tiles required in the demolition work. The Contractor shall be responsible for the replacement of damaged tiles and reinstallation of the ceiling prior to final acceptance.
- 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.

3.5 DISPOSITION OF MATERIAL AND EQUIPMENT

- A. Review with the Owner materials that have been removed and are no longer required, to determine any which the Owner may desire to keep. Deliver those materials that the Owner desires to the Owner's specified location.
- B. For those materials not required by the Owner, dispose of them in accordance with applicable regulations.

END OF SECTION

SECTION 260100 – COMMISSIONING OF ELECTRICAL SYSTEMS**PART 1 - GENERAL****1.1 RELATED DOCUMENTS**

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

1.2 SUMMARY

- A. Section includes commissioning process requirements for electrical systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Division 01 Section 016500 – “GENERAL COMMISSIONING REQUIREMENTS” for general commissioning process requirements.
 - 2. Division 22 Section 220100 – “COMMISSIONING OF PLUMBING SYSTEMS”.
 - 3. Division 23 Section 230100 - “COMMISSIONING OF MECHANICAL SYSTEMS”.

1.3 DEFINITIONS

- A. Commissioning Authority (CxA): Independent agent hired by Owner and not associated with General Contractor or its subcontractors, Architect or its sub-consultants, or Construction Administrator or its staff or consultants. Under Owner’s direction, and not General Contractor’s direction, CA will direct and coordinate day-to-day commissioning activities without assuming oversight responsibilities.
- B. Refer to section 016500 - GENERAL COMMISSIONING REQUIREMENTS.

1.4 CONTRACTOR’S RESPONSIBILITIES

- A. Refer to section 016500 - GENERAL COMMISSIONING REQUIREMENTS.
- B. **Perform commissioning tests at the direction of the CxA.**
- C. Attend construction phase controls coordination meeting.
- D. Participate in electrical systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

- E. Provide information requested by the CxA for final commissioning documentation.
- F. Complete project-specific construction checklists and commissioning process test procedures for actual electrical systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.
- G. Direct and coordinate commissioning testing among subcontractors, suppliers, and vendors.
- H. Provide test data, inspection reports, and certificates for Systems Manual.

1.5 COMMISSIONING DOCUMENTATION

- A. Provide the following information to the CxA for inclusion in the commissioning plan:
 - 1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
 - 2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
 - 3. Process and schedule for completing construction checklists and manufacturer's pre-start and startup checklists for electrical systems, assemblies, equipment, and components to be verified and tested.
 - 4. Certificate of completion certifying that installation, pre-start checks, and startup procedures have been completed.
 - 5. Certificate of readiness certifying that electrical systems, subsystems, equipment, and associated controls are ready for testing.
 - 6. Test and inspection reports and certificates.
 - 7. Corrective action documents.

1.6 SUBMITTALS

- A. Certificates of readiness.
- B. Certificates of completion of installation, pre-start, and startup activities.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 GENERAL

- A. Refer to section 016500 - GENERAL COMMISSIONING REQUIREMENTS.

3.2 PRE-FUNCTIONAL CHECKLISTS

- A. Contractor shall conduct Pre-functional Testing to document compliance with installation and start-up checklists prepared by Commissioning Authority for the Division-26 items.
- B. Request verification of Pre-functional checklists by CxA prior to proceeding with system start-up and Functional Testing of systems.
- C. Contractor shall participate in Pre-Functional testing activities to document electrical work associated with mechanical and plumbing systems.
- D. Refer to Section 016500 - GENERAL COMMISSIONING REQUIREMENTS for issues relating to pre-functional checklists and testing, including list of systems to be commissioned, description of process, details on non-conformance issues relating to pre-functional checklists and test.

3.3 SYSTEM START-UP, TESTS & INSPECTIONS

- A. Contractor is solely responsible for system start-up. CxA may, at his discretion, witness start up procedures, but will not perform any Functional Testing of systems until General Contractor has completed start-up and resolved all operating deficiencies.
- B. Contractor is solely responsible for all tests and inspections required by the Authority Having Jurisdiction (AHJ). All test reports and certificates required by the AHJ shall be submitted prior to Functional Testing.
- C. Contractor shall provide no less than 48 hours notice prior to conducting tests specified in other sections of the specifications, including:
 - 1. Grounding tests

3.4 FUNCTIONAL TESTING PREPARATION

- A. Certify that electrical systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify that instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- D. Inspect and verify the position of each device and interlock identified on checklists.
- E. Check all notification and initiation devices and interlocks with associated systems during each mode of operation.

- F. Testing Instrumentation: Provide instrumentation and personnel as required to conduct tests.

3.5 FUNCTIONAL TESTING PROCEDURES OF SYSTEMS TO BE COMMISSIONED

A. All Electrical and Electrically Powered Equipment

1. Inspect electrical wiring and grounding for proper connections, color coding, and quality of installation.
2. Verify supply voltage, all hot legs.
3. Verify amperage is within allowable limits.
4. Inspect for physical damage, proper installation, anchorage.
5. Verify equipment runs smoothly and quietly.
6. Verify operation of safeties.
7. Verify all required means of disconnect are in place.
8. Verify maintenance and NEC clearances are maintained.

B. Service Grounding Test:

1. CxA will witness ground tests to be conducted by Contractor in accordance with specifications. Contractor will provide CxA a minimum 48 hours advance notice of test so that CxA may be witness, or he shall re-test in CxA's presence. Ground resistance testing is to include lightning protection system as well as electrical power systems.
2. Provide ground test report for review by CxA.

C. Electrical Distribution System

D. Lighting Systems:

1. Light Fixtures: Verify all lamps work without flicker.
2. Verify light levels
3. Light Switches: Verify switches control lights per design
4. Lighting Controls:
 - a. Verify sensors pick up motion and turn on lights immediately.
 - b. Verify that lights turn off after specified time.
 - c. Verify sensor coverage includes entire room area being sensed.
 - d. Verify sensor does not pick up occupancy outside the area sensed.
 - e. For ceiling mounted occupancy switches, verify light switches still function in circuit.
5. Emergency Egress: Verify operation of emergency egress lighting and associated light levels.

3.6 TRAINING

- A. Refer to sections 016500 - GENERAL COMMISSIONING REQUIREMENTS.

3.7 O&M MANUALS

- A. Refer to sections 016500 - GENERAL COMMISSIONING REQUIREMENTS and section 017800 CLOSEOUT SUBMITTALS.

END OF SECTION

SECTION 26 0519

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Reference AISD's standards section 011913 for project commissioning Requirements.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.
- B. Related Sections include the following:
 - 1. Division 26 Section "Medium-Voltage Cables" for single-conductor and multiconductor cables, cable splices, and terminations for electrical distribution systems with 2001 to 35,000 V.
 - 2. Division 27 Section "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.4 ACTION SUBMITTALS

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

1.5 QUALITY ASSURANCE

- A. 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.
- 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 NFPA 70.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

- 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. Alcan Products Corporation; Alcan Cable Division.
 - 2. American Insulated Wire Corp.; a Leviton Company.
 - 3. General Cable Corporation.
 - 4. Senator Wire & Cable Company.
 - 5. Southwire Company.
- B. Copper Conductors: Comply with NEMA WC 70.
- C. Aluminum Conductors: Distribution feeder conductors in sizes 4/0 to 1000 kcmil may be aluminum alloy. Aluminum alloy conductors shall be compact stranded conductors of STABILOY® (AA-8030) as manufactured by Alcan Cable or of a recognized 8000 Series aluminum alloy conductor material by the Aluminum Association.
- D. Conductor Insulation: Copper, Comply with NEMA WC 70 for Types THW THHN-THWN XHHW XHHW-2 and SO.
- E. Conductor Insulation: Aluminum, for use in raceways: Sizes #4/0 to 1000 kcmil, Type XHHW-2, temperature rating 90° C and marked "SUN RES". For use in Cable Trays: Sizes # 4/0 AWG and larger Type XHHW-2, temperature rating 90° C and marked: "SUN RES", "VW-1", "GASOLINE AND OIL-RESISTANT II", and "FOR CT USE".
- F. Multiconductor Cable: The use of spiral wound insulated conductors, commonly known as BX, MC or AC cable, will not be allowed without specific approval from AISD.

2.2 CONNECTORS AND SPLICES

- 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. AFC Cable Systems, Inc.
 - 2. Hubbell Power Systems, Inc.
 - 3. O-Z/Gedney; EGS Electrical Group LLC.
 - 4. 3M; Electrical Products Division.
 - 5. Tyco Electronics Corp.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.
- C. Aluminum Requirements:
 - 1. Using Mechanical Screw Type Connectors:
 - a. Connectors shall be dual rated (AL7CU or AL9CU) and Listed by UL for use with aluminum and copper conductors and sized to accept aluminum conductors of the ampacity specified.
 - b. Using a suitable stripping tool, to avoid damage to the conductor, remove insulation from the required length of the conductor.

- c. Clean the conductor surface using a wire brush and apply a Listed joint compound.
 - d. Tighten the connection per the connector manufacturer's recommendation.
 - e. Wipe off any excess joint compound.
- 2. Using Mechanical Compression Type Connectors:
 - a. Connectors shall be dual rated (AL7CU or AL9CU) and Listed by UL for use with aluminum and copper conductors and sized to accept aluminum conductors of the ampacity specified.
 - b. The lugs shall be marked with wire size, die index, number and location of crimps and shall be suitably color coded. Lug barrel shall be factory prefilled with a joint compound Listed by UL.
 - c. Using a suitable stripping tool, to avoid damage to the conductor, remove insulation from the required length of the conductor.
 - d. Clean conductor surface using a wire brush.
 - e. Crimp the connection per the connector manufacturer's recommendation.
 - f. Wipe off any excess joint compound.
- 3. Termination of Aluminum Conductor to Aluminum Bus:
 - a. Prepare a mechanical connection conforming to 1 or 2.
 - b. Hardware:
 - 1. Bolts: Anodized aluminum alloy 2024-T4 and conforming to ANSI B18.2.1 and to ASTM B211 or B221 chemical and mechanical property limits.
 - 2. Nuts: Aluminum alloys 6061-T6 or 6262-T9 and conforming to ANSI B18.2.2.
 - 3. Washers: Flat aluminum alloy 2024-T4, Type "A" plain, standard wide series conforming to ANSI B27.2.
 - 4. Lubricate and tighten the hardware as per the manufacturer's recommendations.
- 4. Termination of Aluminum Conductor to Copper Bus:
 - a. Prepare a mechanical connection conforming to 1 or 2.
 - b. Hardware:
 - 1. Bolts: Plated or galvanized medium carbon steel; heat treated, quenched and tempered equal to ASTM A-325 or SAE grade 5.
 - 2. Nuts: Heavy semi-finished hexagon, conforming to ANSI B18.2.2, threads to be unified coarse series (UNC), class 2B.
 - 3. Washers: Should be of steel; Type A plain standard wide series conforming to ANSI B27.2.
 - 4. Belleville conical spring washers: Shall be of hardened steel, cadmium plated or silicone bronze.
 - 5. Lubricate and tighten the hardware as per the manufacturer's recommendations.
- 5. Termination of Aluminum Conductor to Equipment Not Equipped for Termination of Aluminum Conductor.
 - a. Prepare compression connection using an adapter Listed by UL for the purpose or by pigtailling a short length of suitable size of copper conductor to the aluminum conductor with a compression connector Listed by UL.
 - b. Provide an insulating cover over adapter body or the compression connector.
 - c. Terminate the adapter or the pigtail on to the equipment per manufacturer's recommendation.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper. Stranded for all gauges. Do not use wire smaller than No. 12 AWG, except for signal or control circuits.
- B. Branch Circuits: Copper. Solid conductors for #10 and smaller. Do not use wire smaller than No. 12 AWG, except for signal or control circuits.
- C. Conductors larger than 2/0 may be 8000 Series aluminum alloy.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type XHHW, single conductors in raceway.
- B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway.
- C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
- D. Feeders in Cable Tray: Type THHN-THWN, single conductors in raceway.
- E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.
- F. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
- G. Branch Circuits in Cable Tray: Type THHN-THWN, single conductors in raceway.
- H. Parking Lot Lights: Type XHHW-2, with durable insulation resistant to moisture, insects, and physical damage, single conductors in raceway.
- I. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- J. Class 2 Control Circuits: Type THHN-THWN, in raceway.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

- D. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."
- E. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
 - 1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping."

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services for compliance with requirements.
 - 2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
 - a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.
 - b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - c. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

- C. Test Reports: Prepare a written report to record the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION

SECTION 26 0526

GROUNDING AND BONDING 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. Reference AISD's standards section 011913 for project commissioning Requirements.

1.2 SUMMARY

- A. Section includes grounding systems and equipment, plus the following special applications:
 - 1. Underground distribution grounding.

1.3 ACTION SUBMITTALS

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

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.1 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 4. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
 - 5. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, 1/4 by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

2.2 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, pressure type with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.

2.3 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet in diameter.

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare tinned-copper conductor, No. 2/0 AWG minimum.
 - 1. Bury at least 24 inches below grade.
- C. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, and down to specified height above floor; connect to horizontal bus.
- D. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Structural Steel: Welded connectors.

3.2 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with IEEE C2 grounding requirements.
- B. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches from the foundation.

3.3 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. Signal and Communication Equipment: In addition to grounding and bonding required by NFPA 70, provide a separate grounding system complying with requirements in TIA/ATIS J-STD-607-A.
 - 1. For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
 - 2. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-4-by-12-inch grounding bus.
 - 3. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
- C. 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.

3.4 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
- B. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
 - 2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

- D. Grounding and Bonding for Piping:
 - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
 - 2. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- E. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.
- F. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet apart.
- G. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG.
 - 1. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
 - 2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

3.5 LABELING

- A. Comply with requirements in Division 26 Section "Identification for Electrical Systems" Article for instruction signs. The label or its text shall be green.
- B. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.
 - 1. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to 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. Provide proposed methodology for each specified for approval prior to conducting actual tests. Proceed with tests upon approval of methodology by Engineer and City of Austin.
 2. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 3. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 4. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells, and at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 5. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- E. Grounding system will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports with copy to the Owner.
- G. Report measured ground resistances that exceed the following values:
1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 2. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohm(s).
- H. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 26 0529

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Reference AISD's standards section 011913 for project commissioning Requirements.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.
- B. Related Sections include the following:
 - 1. Division 26 Section "Vibration and Seismic Controls for Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.

1.4 ACTION SUBMITTALS

- A. Product Data: For the following:
 - 1. Steel slotted support systems.

1.5 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

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 installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. 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:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut; Tyco International, Ltd.
 - g. Wesanco, Inc.
 - 2. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 3. Channel Dimensions: Selected for applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
 - 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - 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) Hilti Inc.
 - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
 - 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - 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) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.

- 3) Hilti Inc.
- 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
- 5) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 1. Secure raceways and cables to these supports with two-bolt conduit clamps.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb.
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 1. To Wood: Fasten with lag screws or through bolts.
 2. To New Concrete: Bolt to concrete inserts.
 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 4. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts.

- 5. To Light Steel: Sheet metal screws.
 - 6. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.
 - F. Hangers cannot be supported from other piping, ducts, or joist bridging. Verify with structural whether or not hangers can be supported from metal deck.

3.3 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- C. Anchor equipment to concrete base.
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.4 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 26 0533

RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Reference AISD's standards section 011913 for project commissioning Requirements.

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal conduits, tubing, and fittings.
 - 2. Metal wireways and auxiliary gutters.
 - 3. Boxes, enclosures, and cabinets.
 - 4. Handholes and boxes for exterior underground cabling.
- B. Related Requirements:
 - 1. Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.
 - 2. Division 27 Section "Pathways for Communications Systems" for conduits, wireways, surface pathways, innerduct, boxes, faceplate adapters, enclosures, cabinets, and handholes serving communications systems.
 - 3. Division 28 Section "Pathways for Electronic Safety and Security" for conduits, surface pathways, innerduct, boxes, and faceplate adapters serving electronic safety and security.

1.3 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid steel conduit.
- C. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Allied Tube & Conduit; a Tyco International Ltd. Co.
 - 3. Anamet Electrical, Inc.
 - 4. Electri-Flex Company.
 - 5. O-Z/Gedney; a brand of EGS Electrical Group.
 - 6. Picoma Industries, a subsidiary of Mueller Water Products, Inc.
 - 7. Republic Conduit.
 - 8. Robroy Industries.
 - 9. Southwire Company.
 - 10. Thomas & Betts Corporation.
 - 11. Western Tube and Conduit Corporation.
 - 12. Wheatland Tube Company; a division of John Maneely Company.
- B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. IMC: Comply with ANSI C80.6 and UL 1242.
- D. EMT: Comply with ANSI C80.3 and UL 797.
- E. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
 - 2. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Setscrew or compression.
 - 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
- F. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Cooper B-Line, Inc.
 - 2. Hoffman; a Pentair company.
 - 3. Mono-Systems, Inc.
 - 4. Square D; a brand of Schneider Electric.
- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 Type 3R Type 4 unless otherwise indicated, and sized according to NFPA 70.
 - 1. Metal wireways installed outdoors shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

- C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type Screw-cover type Flanged-and-gasketed type unless otherwise indicated.
- E. Finish: Manufacturer's standard enamel finish.

2.3 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - 1. Adalet.
 - 2. Cooper Technologies Company; Cooper Crouse-Hinds.
 - 3. EGS/Appleton Electric.
 - 4. Erickson Electrical Equipment Company.
 - 5. FSR Inc.
 - 6. Hoffman; a Pentair company.
 - 7. Hubbell Incorporated; Killark Division.
 - 8. Kraloy.
 - 9. Milbank Manufacturing Co.
 - 10. Mono-Systems, Inc.
 - 11. O-Z/Gedney; a brand of EGS Electrical Group.
 - 12. RACO; a Hubbell Company.
 - 13. Robroy Industries.
 - 14. Spring City Electrical Manufacturing Company.
 - 15. Stahlin Non-Metallic Enclosures; a division of Robroy Industries.
 - 16. Thomas & Betts Corporation.
 - 17. Wiremold / Legrand.
- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Metal Floor Boxes:
 - 1. Material: Cast metal or sheet metal.
 - 2. Type: Fully adjustable.
 - 3. Shape: Rectangular.
 - 4. Listing and Labeling: Metal floor boxes shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 lb. Outlet boxes designed for attachment of luminaires weighing more than 50 lb shall be listed and marked for the maximum allowable weight.
- F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- G. Box extensions used to accommodate new building finishes shall be of same material as recessed box.
- H. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

- I. Gangable boxes are allowed.
- J. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 Type 3R Type 4 Type 12 with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- K. Cabinets:
 - 1. NEMA 250, Type 1 Type 3R Type 12 galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.
 - 6. Nonmetallic cabinets shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.4 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

- A. General Requirements for Handholes and Boxes:
 - 1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
 - 2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. CDR Systems Corporation; Hubbell Power Systems.
 - d. NewBasis.
 - e. Oldcastle Precast, Inc.; Christy Concrete Products.
 - f. Synertech Moulded Products; a division of Oldcastle Precast, Inc.
 - 2. Standard: Comply with SCTE 77.
 - 3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
 - 4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
 - 5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - 6. Cover Legend: Molded lettering, "ELECTRIC".
 - 7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
 - 8. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.
- C. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with frame and covers of polymer concrete fiberglass.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. CDR Systems Corporation; Hubbell Power Systems.
 - d. NewBasis.

- e. Nordic Fiberglass, Inc.
- f. Oldcastle Precast, Inc.; Christy Concrete Products.
- g. Synertech Moulded Products; a division of Oldcastle Precast, Inc.
- 2. Standard: Comply with SCTE 77.
- 3. Color of Frame and Cover: Green.
- 4. Configuration: Designed for flush burial with open bottom unless otherwise indicated.
- 5. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
- 6. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- 7. Cover Legend: Molded lettering, "ELECTRIC."
- 8. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
- 9. Handholes 12 Inches Wide by 24 Inches Long and Larger: Have inserts for cable racks and pulling-in irons installed before concrete is poured.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Outdoors: Apply raceway products as specified below unless otherwise indicated:
 - 1. Underground Conduit: RNC, Type EPC-40-PVC, concrete encased.
 - 2. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment).
 - 3. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.
- B. Indoors: Apply raceway products as specified below unless otherwise indicated:
 - 1. Exposed, Not Subject to Physical Damage: EMT.
 - 2. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 - 3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations with lengths not less than 3-feet nor more than 6-feet.
 - 4. Damp or Wet Locations: IMC.
 - 5. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.
 - 6. Exposed, Subject to Physical Damage: RS
- C. Minimum Raceway Size: 3/4-inch trade size for lighting and ¾-inch trade size for power.
- D. Raceway Fittings: Compatible with raceways and suitable for use and location.
 - 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 - 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
 - 3. EMT: Use setscrew or compression, fittings. Comply with NEMA FB 2.10.
 - 4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
- E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.
- F. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg. F.

3.2 INSTALLATION

- A. General: All conduits shall be run straight and parallel to construction lines. Conduit shall be supported "independently" to building structure. Emergency, security, telephone, fire alarm, power, lighting, control, fiber optic cable, BEMS, data wiring, and clean power systems shall be run in separate conduits.
- B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- C. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- D. Complete raceway installation before starting conductor installation.
- E. Comply with requirements in Division 26 Section "Hangers and Supports for Electrical Systems" for hangers and supports.
- F. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- G. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches of changes in direction.
- H. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- I. A. Support conduit within 12 inches of enclosures to which attached.
- J. Raceways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot intervals.
 - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 - 3. Arrange raceways to keep a minimum of 1 inch of concrete cover in all directions.
 - 4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.
 - 5. Change from ENT to RNC, Type EPC-40-PVC, before rising above floor.
- K. Stub-ups to Above Recessed Ceilings:
 - 1. Use EMT, IMC, or RMC for raceways.
 - 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- L. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- M. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

- N. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.
- O. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- P. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.
- Q. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- R. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- S. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- T. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.
- U. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where an underground service raceway enters a building or structure.
 - 3. Where otherwise required by NFPA 70.
- V. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- W. Expansion-Joint Fittings:
 - 1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
 - 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg. F. temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg. F. temperature change.
 - d. Attics: 135 deg. F. temperature change.
 - 3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg. F. of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg. F. of temperature change for metal conduits.

4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- X. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
 2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- Y. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.
- Z. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block and install box flush with surface of wall. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.
- AA. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.
- BB. Locate boxes so that cover or plate will not span different building finishes.
- CC. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
- DD. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.
- EE. Set metal floor boxes level and flush with finished floor surface.
- FF. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
- GG. Any conduit on roof must have at least 12-inches of clearance between conduit and roof surface as noted in AISD Roofing Standards.
- HH. The use of spiral wound insulated conductors, commonly known as BX or MC cable, shall not be allowed without specific approval of AISD.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

- A. Direct-Buried Conduit:
1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches in nominal diameter.
 2. Install backfill as specified in Division 31 Section "Earth Moving."
 3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."

4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through floor unless otherwise indicated. Encase elbows for stub-up ducts throughout length of elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through floor.
 - a. Couple steel conduits to ducts with adapters designed for this purpose and encase coupling with 3 inches of concrete for a minimum of 12 inches on each side of the coupling.
 - b. For stub-ups at equipment mounted on outdoor concrete bases and where conduits penetrate building foundations, extend steel conduit horizontally a minimum of 60 inches from edge of foundation or equipment base. Install insulated grounding bushings on terminations at equipment.
6. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits but a minimum of 6 inches below grade. Align planks along centerline of conduit.
7. Underground Warning Tape: Comply with requirements in Division 26 Section "Identification for Electrical Systems."

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
- D. Install handholes with bottom below frost line, below grade.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables but short enough to preserve adequate working clearances in enclosure.
- F. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 FIRESTOPPING

- A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.7 PROTECTION

- A. Protect coatings, finishes, and cabinets from damage and deterioration.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

SECTION 26 0544

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Reference AISD's standards section 011913 for project commissioning Requirements.

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
 - 2. Sleeve-seal systems.
 - 3. Sleeve-seal fittings.
 - 4. Grout.
 - 5. Silicone sealants.
- B. Related Requirements:
 - 1. Division 07 Section "Penetration Firestopping" for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Wall Sleeves:
 - 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.
- C. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
- D. Molded-PVC Sleeves: With nailing flange for attaching to wooden forms.
- E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

- F. Sleeves for Rectangular Openings:
1. Material: Galvanized sheet steel.
 2. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches and with no side larger than 16 inches, thickness shall be 0.052 inch.
 - b. For sleeve cross-section rectangle perimeter 50 inches or more and one or more sides larger than 16 inches, thickness shall be 0.138 inch.

2.2 SLEEVE-SEAL SYSTEMS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Advance Products & Systems, Inc.
 - b. CALPICO, Inc.
 - c. Metraflex Company (The).
 - d. Pipeline Seal and Insulator, Inc.
 - e. Proco Products, Inc.
 2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 3. Pressure Plates: Carbon steel Plastic Stainless steel.
 4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, Stainless steel of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

- A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Presealed Systems.

2.4 GROUT

- A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
 - 1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
 - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 3. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
 - 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 - 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches Insert dimension above finished floor level. Install sleeves during erection of floors.
- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
 - 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

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

END OF SECTION

SECTION 26 0553

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Reference AISD's standards section 011913 for project commissioning Requirements.

1.2 SUMMARY

- A. Section Includes:
 - 1. Identification for raceways.
 - 2. Identification of power and control cables.
 - 3. Identification for conductors.
 - 4. Underground-line warning tape.
 - 5. Warning labels and signs.
 - 6. Instruction signs.
 - 7. Equipment identification labels.
 - 8. Miscellaneous identification products.

1.3 ACTION SUBMITTALS

- A. Product Data: For each electrical identification product indicated.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and IEEE C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.5 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual; and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 POWER RACEWAY IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
- B. Colors for Raceways Carrying Circuits at 600 V or Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage and system or service type.
- C. Colors for Raceways Carrying Circuits at More Than 600 V:
 - 1. Black letters on an orange field.
 - 2. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- high letters on 20-inch centers.
- D. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- E. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- F. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: 4-inch- wide black stripes on 10-inch centers diagonally over orange background that extends full length of raceway or duct and is 12 inches wide. Stop stripes at legends.
- G. Write-On Tags: Polyester tag, 0.010 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.2 ARMORED AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Colors for Raceways Carrying Circuits at 600 V and Less:
 - 1. Black letters on an orange field.
 - 2. Legend: Indicate voltage and system or service type.
- C. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- D. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches wide; compounded for outdoor use.

2.3 POWER AND CONTROL CABLE IDENTIFICATION MATERIALS

- A. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Write-On Tags: Polyester tag, 0.010 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.
- D. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

2.4 CONDUCTOR IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils thick by 1 to 2 inches wide.
- B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
- C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

- D. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, 2 inches long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- E. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
- F. Write-On Tags: Polyester tag, 0.010 inch thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
 - 1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
 - 2. Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.

2.5 UNDERGROUND-LINE WARNING TAPE

- A. Tape:
 - 1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
 - 2. Printing on tape shall be permanent and shall not be damaged by burial operations.
 - 3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
- B. Color and Printing:
 - 1. Comply with ANSI Z535.1 through ANSI Z535.5.
 - 2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE.
 - 3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.
- C. Tag: Type I:
 - 1. Pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
 - 2. Thickness: 4 mils.
 - 3. Weight: 18.5 lb/1000 sq. ft.
 - 4. 3-Inch Tensile According to ASTM D 882: 30 lbf, and 2500 psi.

2.6 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.
- C. Baked-Enamel Warning Signs:
 - 1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
 - 2. 1/4-inch grommets in corners for mounting.
 - 3. Nominal size, 7 by 10 inches.

- D. Warning label and sign shall include, but are not limited to, the following legends:
 - 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."

2.7 INSTRUCTION SIGNS

- A. Engraved laminated acrylic or melamine plastic, minimum 1/16 inch thick for signs up to 20 sq. inches and 1/8 inch thick for larger sizes.
 - 1. Engraved legend with black letters on white face.
 - 2. Punched or drilled for mechanical fasteners.
 - 3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
- B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.
- C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

2.8 EQUIPMENT IDENTIFICATION LABELS

- A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch.
- B. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.
- C. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch.
- D. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch.

2.9 CABLE TIES

- A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 deg. F., According to ASTM D 638: 12,000 psi.
 - 3. Temperature Range: Minus 40 to plus 185 deg. F.
 - 4. Color: Black except where used for color-coding.
- B. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 deg. F., According to ASTM D 638: 12,000 psi.
 - 3. Temperature Range: Minus 40 to plus 185 deg. F.
 - 4. Color: Black.

- C. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.
 - 1. Minimum Width: 3/16 inch.
 - 2. Tensile Strength at 73 deg. F., According to ASTM D 638: 7000 psi.
 - 3. UL 94 Flame Rating: 94V-0.
 - 4. Temperature Range: Minus 50 to plus 284 deg. F.
 - 5. Color: Black.

2.10 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
- F. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.
- G. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
 - 1. Outdoors: UV-stabilized nylon.
 - 2. In Spaces Handling Environmental Air: Plenum rated.
- H. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches overall.
- I. Painted Identification: Comply with requirements in Division 09 painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

- A. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Identify with self-adhesive vinyl label. Install labels at 10-foot maximum intervals.
- B. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
 - 1. Emergency Power.
 - 2. Power.
 - 3. UPS.
- C. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
 - 1. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service feeder and branch-circuit conductors.
 - a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
 - b. Colors for 208/120-V Circuits:
 - 1) Phase A: Red.
 - 2) Phase B: Black.
 - 3) Phase C: Blue.
 - c. Colors for 480/277-V Circuits:
 - 1) Phase A: Brown.
 - 2) Phase B: Yellow.
 - 3) Phase C: Purple.
 - d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- D. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
- E. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels Baked-enamel warning signs.
 - 1. Comply with 29 CFR 1910.145.
 - 2. Identify system voltage with black letters on an orange background.
 - 3. Apply to exterior of door, cover, or other access.
 - 4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
 - a. Power transfer switches.
 - b. Controls with external control power connections.
- F. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

- G. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
1. Labeling Instructions:
 - a. Indoor Equipment: Adhesive film label. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high.
 - b. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 - c. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
 2. Equipment to Be Labeled:
 - a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive, engraved engraved, laminated acrylic or melamine label.
 - b. Enclosures and electrical cabinets.
 - c. Access doors and panels for concealed electrical items.
 - d. Enclosed circuit breakers.
 - e. Push-button stations.
 - f. Contactors.
 - g. Remote-controlled switches, dimmer modules, and control devices.

END OF SECTION

SECTION 26 2726

WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Reference AISD's standards section 011913 for project commissioning Requirements.

1.2 SUMMARY

- A. Section Includes:
 - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
 - 2. Weather-resistant receptacles.
 - 3. Snap switches and wall-box dimmers.
 - 4. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D. RFI: Radio-frequency interference.
- E. UTP: Unshielded twisted pair.

1.4 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Receptacles for Owner-Furnished Equipment: Match plug configurations.

1.5 ACTION SUBMITTALS

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

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
 - 1. Cooper Wiring Devices; Division of Cooper Industries, Inc. (Cooper).
 - 2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
 - 3. Leviton Mfg. Company Inc. (Leviton).
 - 4. Pass & Seymour/Legrand (Pass & Seymour).
- B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.2 GENERAL WIRING-DEVICE REQUIREMENTS

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with NFPA 70.
- C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:
 - 1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
 - 2. Devices shall comply with the requirements in this Section.

2.3 STRAIGHT-BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. Cooper; 5351 (single), CR5362 (duplex).
 - b. Hubbell; HBL5351 (single), HBL5352 (duplex).
 - c. Leviton; 5891 (single), 5352 (duplex).
 - d. Pass & Seymour; 5361 (single), 5362 (duplex).

2.4 GFCI RECEPTACLES

- A. General Description:
 - 1. Straight blade, non-feed-through type.
 - 2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.
 - 3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.
- B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. Cooper; VGF20.
 - b. Hubbell; GFR5352L.
 - c. Pass & Seymour; 2095.
 - d. Leviton; 7590.

2.5 TOGGLE SWITCHES

- A. Comply with NEMA WD 1, UL 20, and FS W-S-896.
- B. Switches, 120/277 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. Single Pole:
 - 1) Cooper; AH1221.
 - 2) Hubbell; HBL1221.
 - 3) Leviton; 1221-2.
 - 4) Pass & Seymour; CSB20AC1.
 - b. Three Way:
 - 1) Cooper; AH1223.
 - 2) Hubbell; HBL1223.
 - 3) Leviton; 1223-2.
 - 4) Pass & Seymour; CSB20AC3.
 - c. Four Way:
 - 1) Cooper; AH1224.
 - 2) Hubbell; HBL1224.
 - 3) Leviton; 1224-2.
 - 4) Pass & Seymour; CSB20AC4.
- C. Keyed Switches, 120/277 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. Single Pole:
 - 1) Leviton; 1221-2IL.
 - b. Three Way:
 - 1) Leviton; 1103-2L.

2.6 WALL-BOX DIMMERS

- A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
- B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.
- C. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
 - 1. 600 W; dimmers shall require no derating when ganged with other devices.
- D. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.7 WALL PLATES

- A. Single and combination types shall match corresponding wiring devices.
 - 1. Plate-Securing Screws: Metal with head color to match plate finish.
 - 2. Material for Finished Spaces: 0.035-inch- thick, satin-finished, Type 302 stainless steel.
 - 3. Material for Unfinished Spaces: Galvanized steel.
 - 4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover and listed and labeled for use in wet and damp locations.

- B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

2.8 FINISHES

- A. Device Color:
 - 1. Wiring Devices Connected to Normal Power System: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.
 - 2. Isolated-Ground Receptacles: Orange.
- B. Wall Plate Color: For plastic covers, match device color.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.
- B. Coordination with Other Trades:
 - 1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
 - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 - 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors:
 - 1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
 - 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 - 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
 - 4. Existing Conductors:
 - a. Cut back and pigtail or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtail existing conductors is permitted, provided the outlet box is large enough.
- D. Device Installation:
 - 1. Replace devices that have been in temporary use during construction and that were installed before building finishing operations were complete.
 - 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 - 3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
 - 4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
 - 5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.

6. Use a torque screwdriver when a torque is recommended or required by manufacturer.
 7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
 8. Tighten unused terminal screws on the device.
 9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device-mounting screws in yokes, allowing metal-to-metal contact.
- E. Receptacle Orientation:
1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the right.
 2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.
- F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
- G. Dimmers:
1. Install dimmers within terms of their listing.
 2. Verify that dimmers used for fan speed control are listed for that application.
 3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
- H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
- I. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 GFCI RECEPTACLES

- A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.3 IDENTIFICATION

- A. Comply with Division 26 Section "Identification for Electrical Systems."
- B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

END OF SECTION

SECTION 26 2816

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.
- B. Reference AISD's standards section 011913 for project commissioning Requirements.

1.2 SUMMARY

- A. Section Includes:
 - 1. Fusible switches.
 - 2. Nonfusible switches.
 - 3. Molded-case circuit breakers (MCCBs).
 - 4. Enclosures.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 - 4. Include evidence of NRTL listing for series rating of installed devices.
 - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NFPA 70.

1.5 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - 1. Ambient Temperature: Not less than minus 22 deg F and not exceeding 104 deg. F.
 - 2. Altitude: Not exceeding 6600 feet.

1.6 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. Square D; a brand of Schneider Electric.
 - 3. GE General Electric
 - 4. Siemens
- B. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 - 3. Lugs: Compression type, suitable for number, size, and conductor material.

2.2 NONFUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer (basis of design)
 - 2. Square D; a brand of Schneider Electric.
- B. Type GD, General Duty, Single Throw, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- C. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

- D. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Lugs: Compression type, suitable for number, size, and conductor material.

2.3 MOLDED-CASE CIRCUIT BREAKERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
- C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- D. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
- E. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
 - 1. Instantaneous trip.
 - 2. Long- and short-time pickup levels.
 - 3. Long- and short-time time adjustments.
 - 4. Ground-fault pickup level, time delay, and I²t response.
- F. Features and Accessories:
 - 1. Standard frame sizes, trip ratings, and number of poles.
 - 2. Lugs: Compression type, suitable for number, size, trip ratings, and conductor material.

2.4 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
 - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
 - 2. Outdoor Locations: NEMA 4X stainless steel.
 - 3. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 - 4. Communication Capability: Circuit-breaker-mounted communication module with functions and features compatible with power monitoring and control system, specified in Section 260913 "Electrical Power Monitoring and Control."
 - 5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 - 6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - 7. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

8. Zone-Selective Interlocking: Integral with electronic and ground-fault trip units; for interlocking ground-fault protection function.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- C. Install fuses in fusible devices.
- D. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."
 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study".

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. Poles and accessories.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color-rendering index.
- C. LER: Luminaire efficacy rating.
- D. Luminaire: Complete lighting fixture, including ballast housing if provided.
- E. Pole: Luminaire support structure, including tower used for large area illumination.
- F. Standard: Same definition as "Pole" above.

1.4 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. Ice Load: Load of 3 lbf/sq. ft. (145 Pa), applied as stated in AASHTO LTS-4-M Ice Load Map.
- D. 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 50 feet (15 m) high or less is 90 mph (40 m/s).
 - a. Wind Importance Factor: 1.0.
 - b. Minimum Design Life: 25 years.
 - c. Velocity Conversion Factors: 1.0.

1.5 ACTION 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, ballasts, and accessories.
 - a. 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, including energy-efficiency data.
 - 8. Lamps, 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. Anchor-bolt templates keyed to specific poles and certified by manufacturer.

1.6 INFORMATIONAL SUBMITTALS

- A. 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.
- B. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
- C. Field quality-control reports.
- D. Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and poles to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.

- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with IEEE C2, "National Electrical Safety Code."
- E. Comply with NFPA 70.

1.9 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 metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.10 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 Period for Luminaires: Five years from date of Substantial Completion.
 - 2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
 - 3. Warranty Period for Color Retention: Five years from date of Substantial Completion.
 - 4. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Products: Subject to compliance with requirements, provide one of the products indicated on Drawings. Deviation other than basis of design shall be submitted 10 working days prior to Bid Date and will be acknowledged only by addendum.

2.2 GENERAL REQUIREMENTS FOR LUMINAIRES

- A. Exterior lighting to be LED source.
- B. Pole lighting fixtures to have integral motion sensor and daylight sensor.
- C. Fixtures to be rated full cutoff.
- D. Fixtures to be B.U.G rated.

- E. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.
 - 1. LER Tests Incandescent Fixtures: Where LER is specified, test according to NEMA LE 5A.
 - 2. LER Tests Fluorescent Fixtures: Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
 - 3. LER Tests HID Fixtures: Where LER is specified, test according to NEMA LE 5B.
- F. Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.
- G. Metal Parts: Free of burrs and sharp corners and edges.
- H. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.
- I. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.
- J. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.
- K. Exposed Hardware Material: Stainless steel.
- L. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
- M. 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.
- N. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- O. 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.
- P. 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.

2.3 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 Section 033000 "Cast-in-Place Concrete."
- F. Poles to have option to mount security devices and be structurally adequate to support devices, coordinate with project requirements.

2.4 ALUMINUM POLES

- A. Poles: ASTM B 209 (ASTM B 209M), 5052-H34 marine sheet alloy with access handhole in pole wall.
 - 1. Shape: Round, tapered.
 - 2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.
- B. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.
- C. 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 listed in that Section, and accessible through handhole.
- D. 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. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
 - 2. Finish: Same as luminaire.
- E. Prime-Coat Finish: Manufacturer's standard prime-coat finish ready for field painting.

- F. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

2.5 POLE ACCESSORIES

- A. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

- A. Install lamps in each luminaire.
- B. Fasten luminaire to indicated structural supports.
 - 1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Adjust luminaires that require field adjustment or aiming.

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).
- C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Section 033000 "Cast-in-Place Concrete."
- D. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level recommended by pole manufacturer.
 - 1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
 - 2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
 - 3. Install base covers unless otherwise indicated.
 - 4. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.
- E. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
 - 1. Dig holes large enough to permit use of tampers in the full depth of hole.
 - 2. Backfill in 6-inch (150-mm) layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.

- F. Embedded Poles with Concrete Backfill: Set poles in augered holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.
 - 1. Make holes 6 inches (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 concrete dome. Arrange to drain condensation from interior of pole.
 - 4. Cure concrete a minimum of 72 hours before performing work on pole.
- G. Raise and set poles using web fabric slings (not chain or cable).

3.3 BOLLARD LUMINAIRE INSTALLATION

- A. Align units for optimum directional alignment of light distribution.
- B. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Section 033000 "Cast-in-Place Concrete."

3.4 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. Conduits: Comply with Section 260533 "Raceways and Boxes for Electrical Systems." In concrete pole foundations, use rigid nonmetallic conduit.

3.5 GROUNDING

- A. Ground metal poles and support structures according to Section 260526 "Grounding and Bonding for Electrical Systems."
 - 1. Install grounding electrode for each pole unless otherwise indicated.
 - 2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

3.6 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.

END OF SECTION

SECTION 32 3113
CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.1 SUMMARY

- A. Section Includes: Furnish and install Chain Link Fences and Gates as shown on the Drawings and as specified herein.

1.2 SUBMITTALS

- A. General: Submittals requirements are specified in Section 01 3300, Submittal Procedures.
- B. Product Data: Submit manufacturer's data for fencing and gate materials.

PART 2 PRODUCTS

2.1 MATERIALS

- A. Chain Link Fabric: Shall conform to ASTM A392, fabricated with 0.148 inch (9 gauge) nominal uncoated wire diameter woven in a 2 inch mesh. Fabric shall be continuous width for full height of fence. Splicing will not be permitted. Hot-dip galvanize after weaving (GAW) shall average not less than 2.0 ounces per square foot of actual surface area.
- B. Intermediate Line Posts: Shall be 16 g. x 1-7/8 inch O.D. or zinc coated steel pipe.
- C. Terminal and Corner Posts: End, corner and pull posts shall be 16 ga. x 2-3/8 inch O.D. zinc coated steel pipe.
- D. Top Rails: Shall be minimum 16 ga. x 1-3/8 inch O.D. zinc coated steel pipe.
- E. Gate Posts: Shall be 16 ga. x 2-3/8 inch zinc coated steel pipe, weighing 9.20 pounds per lineal foot.
- F. Brace Struts: Shall be as specified by the manufacturer for top rail.
- G. Tension Return: Shall be 3/8 inch round steel rod fitted with turnbuckle or truss tightener.
- H. Tension Wire: Shall be No. 6 galvanized steel wire.
- I. Fittings: Shall be galvanized, malleable cast iron or pressed steel.
- J. Post Tops: Shall be galvanized, heavy malleable iron with base apron to fit over posts, and designed for use with top rail.

- K. Gate Hardware: Provide the following hardware and accessories for each gate:
1. Hinges: Pressed steel or malleable iron to suite gate size, non-liftoff-type, offset to permit 180-degree gate opening.
 2. Latch: Forked type or plunger-bar type to permit operation from either side of gate. Provide padlock eye as integral part of latch.
 3. Keeper: Provide keeper for vehicle gates that automatically engages the gate leaf and holds it in the open position until manually released.
 4. Guide and Guide Channel: Shall be steel, including required brackets, channels, mounting angles and mounting hardware. Roll guides shall be 1-5/8 inch, galvanized steel pipe.
 5. Double Gates: Provide gate stops for double gates, consisting of mushroom type or flush plate with anchors. Set in concrete to engage the center drop rod or plunger bar. Provide locking device and padlock eyes as an integral part of the latch, requiring one padlock for locking both gate leaves.
- L. Concrete: Concrete for post footings, etc. shall be minimum 2500 p.s.i. unless otherwise noted on Drawings.

2.2 FABRICATION

- A. Swing Gates: Gate frames shall be made of 16 ga. x 1-7/8 inch O.D. zinc coated steel pipe with heavy malleable iron or pressed steel corner fittings securely riveted. Fabric to match the fence shall be installed in the frame by means of tension bars and hook bolts. Each frame to be equipped with 3/8 inch diameter adjustable truss rods. Bottom hinges to be ball and socket type designed to carry the weight of the gate on the post footing. Upper hinge to be wrap around adjustable type. Gates to be equipped with a positive type latching device with provision for padlocking, center plunger rod, catch and semi-automatic outer catches to secure gates in opened position.
- B. Semi-Cantilever or Rolling Type Gates: Gate frames shall be made of 16 ga. x 1-7/8 inch O.D. zinc coated steel pipe. Weld and brace frame joints wherever necessary; cover with fabric to match fence and provide with locking device to receive padlock. Sliding gate track shall be 1 1/4 inch x 1 1/4 inch x 3/16 inch steel angle, cast onto a 2 feet-0 inches wide x 1 foot -0 inch thick concrete pad, continuous along the entire rolling length of the wheels. Wheels shall be a 2 inch x 8 inch diameter ball bearing metal in-line "V" wheel in tandem with a 6 inch diameter rubber wheel. The tires shall be at approximately 20 inches center to center, supporting the gate on a 2 inch steel tube assembly.
- C. Welding: Conform to requirements of American Welding Society, "Specification for Iron and Steel Arc-Welding Electrodes". Electrodes shall be suitable for conditions of intended use. Make joint surfaces free from fins and tears and grind rough surfaces smooth.
1. Clean welded surfaces and treat with two coats of galvanized paint applied per paint manufacturer's directions.
- D. Zinc Coating: Hot-dip method, using Grade E zinc. Weight shall be as follows:
1. 1.2 ounces for chain link fabric.
 2. 1.8 ounces for rail, post and brace.

PART 3 EXECUTION

3.1 EXCAVATION AND BACKFILLING

- A. Perform excavation and backfilling required for setting of concrete post footings. Generally conform to applicable requirements of Earthwork Section.

3.2 CONCRETE FOOTINGS

- A. Concrete Footing Sizes shall be as follows:
 - 1. End Gate and Corner Posts: 12 inches diameter by 36 inches deep post embedment.
 - 2. Line Posts: 9 inches diameter by 36 inches deep post embedment.
 - 3. Footing Tops: Shall be troweled smooth and beveled or crowned to drain moisture away from posts. Lower edge of bevel shall meet established finish grade.

3.3 ERECTION

- A. General Requirements: Securely anchor fencing plumb, true to line, complete with necessary standard fittings specified and recommended by manufacturer and in accordance with the "Standards for Chain Link Fence Installation" published by the Chain Link Fence Manufacturer's Institute.
- B. Posts: Shall be embedded in concrete footings, to depths specified and accurately located as to alignment and grade.
- C. Line Posts: Shall be equally spaced at 10 feet on centers maximum, unless otherwise indicated on the drawings.
- D. Top Rail: Shall pass through top of line posts and provide a continuous brace from end to end of each stretch of fence. Install outside sleeve type couplings at not more than 20 feet on center, with every 5th coupling a spring-loaded coupling. Fasten to terminal posts with suitable steel connections.
- E. Brace, Struts: Shall be installed at mid-point between top rail and ground, and shall extend from terminal post with tension return rods.
- F. Fencing: Shall be erected so that bottom of fabric is in full contact with the ground or paving and top of fabric is aligned with top rail. Fabric shall be stretched and securely attached to framework.
- G. Fabric: Shall be secured to line posts with fabric bands on 14 inch centers, and to top rail with tie wires on 18 inch centers. Completed fence shall be plumb and true to line and free of buckles or kinks. Fabric selvage shall be knuckled into a closed loop top and bottom.
- H. Tension Wire: Shall be stretched along bottom of fence in lengths not exceeding 150 feet and securely tied to fabric every 18 inches on center. Provide turnbuckles for each 150 lineal feet of wire. Ends of tension wire shall be securely attached to posts in a manner to prevent slipping and insure proper tension. Tension wire shall be secured to fabric with No. 14 gauge galvanized tie wire, double-wrapped at 18 inch intervals.
- I. Ends: Tie wires shall be double-knuckles so that exposed ends will not present a hazard.

3.4 CLEANING

- A. During the course of the Work and on completion of the Work, remove excess materials, equipment and debris and dispose of away from premises. Leave Work in clean condition in accordance with Section 01 5000, Temporary Facilities and Controls.

END OF SECTION