

**SECTION 00 01 01
PROJECT TITLE PAGE**

PROJECT MANUAL

FOR

**BUILDING D & K HVAC UNIT REPLACEMENT
1215 HOUBOLT RD
JOLIET, IL 60431**

OWNER

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END OF DOCUMENT

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END OF DOCUMENT

SECTION 23 05 19
METERS AND GAGES FOR HVAC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pressure gages and pressure gage taps.
- B. Thermometers and thermometer wells.
- C. Static pressure gages.
- D. Filter gages.

1.02 RELATED REQUIREMENTS

- A. Section 23 09 23 - Direct-Digital Control System for HVAC.
- B. Section 23 21 13 - Hydronic Piping.

1.03 REFERENCE STANDARDS

- A. ASME B40.100 - Pressure Gauges and Gauge Attachments; 2013.
- B. ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers; 2014.
- C. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers; 2014.
- D. UL 393 - Indicating Pressure Gauges for Fire-Protection Service; Current Edition, Including All Revisions.

PART 2 PRODUCTS

2.01 PRESSURE GAGES

- A. Pressure Gages: ASME B40.100, UL 393 drawn steel case, phosphor bronze bourdon tube, rotary brass movement, brass socket, with front recalibration adjustment, black scale on white background.
 - 1. Case: Steel with brass bourdon tube.
 - 2. Size: 4-1/2 inch diameter.
 - 3. Mid-Scale Accuracy: One percent.
 - 4. Scale: Psi.

2.02 PRESSURE GAGE TAPPINGS

- A. Gage Cock: Tee or lever handle, brass for maximum 150 psi.
- B. Pulsation Damper: Pressure snubber, brass with 1/4 inch connections.

2.03 STEM TYPE THERMOMETERS

- A. Thermometers - Adjustable Angle: Red- or blue-appearing non-toxic liquid in glass; ASTM E1; lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device; adjustable 360 degrees in horizontal plane, 180 degrees in vertical plane.
 - 1. Size: 9 inch scale.

2. Window: Clear Lexan.
3. Stem: 3/4 inch NPT brass.
4. Accuracy: 2 percent, per ASTM E77.
5. Calibration: Degrees F.

2.04 THERMOMETER SUPPORTS

- A. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.

2.05 TEST PLUGS

- A. Test Plug: 1/4 inch or 1/2 inch brass fitting and cap for receiving 1/8 inch outside diameter pressure or temperature probe with neoprene core for temperatures up to 200 degrees F.
- B. Test Kit: Carrying case, internally padded and fitted containing one 2-1/2 inch diameter pressure gages, one gage adapters with 1/8 inch probes, two 1 inch dial thermometers.

2.06 STATIC PRESSURE GAGES

- A. 3-1/2 inch diameter dial in metal case, diaphragm actuated, black figures on white background, front recalibration adjustment, 2 percent of full scale accuracy.
- B. Accessories: Static pressure tips with compression fittings for bulkhead mounting, 1/4 inch diameter tubing.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide one pressure gage per pump, installing taps before strainers and on suction and discharge of pump. Pipe to gage.
- C. Install pressure gages with pulsation dampers. Provide gage cock to isolate each gauge. Extend nipples and siphons to allow clearance from insulation.
- D. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2 inch for installation of thermometer sockets. Ensure sockets allow clearance from insulation.
- E. Coil and conceal excess capillary on remote element instruments.
- F. Provide instruments with scale ranges selected according to service with largest appropriate scale.
- G. Install gages and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.
- H. Adjust gages and thermometers to final angle, clean windows and lenses, and calibrate to zero.
- I. Locate test plugs adjacent thermometers and thermometer sockets.

END OF SECTION

SECTION 23 05 53
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Pipe markers.

1.02 REFERENCE STANDARDS

- A. ASME A13.1 - Scheme for the Identification of Piping Systems; 2015.
- B. ASTM D709 - Standard Specification for Laminated Thermosetting Materials; 2016.

PART 2 PRODUCTS

2.01 IDENTIFICATION APPLICATIONS

- A. Air Handling Units: Nameplates.
- B. Air Terminal Units: Tags.
- C. Automatic Controls: Tags. Key to control schematic.
- D. Control Panels: Nameplates.
- E. Instrumentation: Tags.
- F. Major Control Components: Nameplates.
- G. Piping: Pipe markers.
- H. Pumps: Nameplates.
- I. Thermostats: Nameplates.
- J. Valves: Tags.

2.02 NAMEPLATES

- A. Manufacturers:
 - 1. Brimar Industries, Inc.
 - 2. Kolbi Pipe Marker Co.
 - 3. Seton Identification Products, a Tricor Direct Company.
- B. Letter Color: White.
- C. Letter Height: 1/4 inch.
- D. Background Color: Black.
- E. Plastic: Conform to ASTM D709.

2.03 TAGS

- A. Manufacturers:
 - 1. Brady Corporation.
 - 2. Kolbi Pipe Marker Co.
 - 3. Seton Identification Products, a Tricor Company.
- B. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1-1/2 inch diameter.
- C. Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

2.04 PIPE MARKERS

- A. Manufacturers:
 - 1. Brady Corporation.
 - 2. Kolbi Pipe Marker Co.
 - 3. Seton Identification Products, a Tricor Company.
- B. Color: Conform to ASME A13.1.
- C. Plastic Pipe Markers: Factory fabricated, flexible, semi- rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.
- D. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.

PART 3 EXECUTION

3.01 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.

3.02 INSTALLATION

- A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Install plastic pipe markers in accordance with manufacturer's instructions.
- D. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- E. Use tags on piping 3/4 inch diameter and smaller.
 - 1. Identify service, flow direction, and pressure.
 - 2. Install in clear view and align with axis of piping.
 - 3. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.

END OF SECTION

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

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Testing, adjustment, and balancing of air systems.
- B. Testing, adjustment, and balancing of hydronic systems.
- C. Measurement of final operating condition of HVAC systems.

1.02 REFERENCE STANDARDS

- A. AABC (NSTSB) - AABC National Standards for Total System Balance, 7th Edition; 2016.
- B. ASHRAE Std 111 - Measurement, Testing, Adjusting, and Balancing of Building HVAC Systems; 2008.
- C. NEBB (TAB) - Procedural Standards for Testing Adjusting and Balancing of Environmental Systems; 2015, Eighth Edition.
- D. SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing; 2002.

1.03 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Installer Qualifications: Submit name of adjusting and balancing agency and TAB supervisor for approval within 30 days after award of Contract.
- C. Final Report: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
 - 1. Revise TAB plan to reflect actual procedures and submit as part of final report.
 - 2. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
 - 3. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
 - 4. Units of Measure: Report data in both I-P (inch-pound) and SI (metric) units.
 - 5. Include the following on the title page of each report:
 - a. Name of Testing, Adjusting, and Balancing Agency.
 - b. Address of Testing, Adjusting, and Balancing Agency.
 - c. Telephone number of Testing, Adjusting, and Balancing Agency.
 - d. Project name.
 - e. Project location.
 - f. Project Architect/Engineer.
 - g. Project Contractor.
 - h. Report date.
- D. Project Record Documents: Record actual locations of flow measuring stations and balancing valves and rough setting.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 GENERAL REQUIREMENTS

- A. Perform total system balance in accordance with one of the following:
 - 1. AABC (NSTSB), AABC National Standards for Total System Balance.
 - 2. ASHRAE Std 111, Practices for Measurement, Testing, Adjusting and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems.
 - 3. NEBB Procedural Standards for Testing Adjusting Balancing of Environmental Systems.
 - 4. SMACNA (TAB).
- B. Begin work after completion of systems to be tested, adjusted, or balanced and complete work prior to Substantial Completion of the project.
- C. Where HVAC systems and/or components interface with life safety systems, including fire and smoke detection, alarm, and control, coordinate scheduling and testing and inspection procedures with the authorities having jurisdiction.
- D. TAB Agency Qualifications:
 - 1. Company specializing in the testing, adjusting, and balancing of systems specified in this section.
 - 2. Having minimum of three years documented experience.
 - 3. Certified by one of the following:
 - a. AABC, Associated Air Balance Council: www.aabc.com; upon completion submit AABC National Performance Guaranty.
 - b. NEBB, National Environmental Balancing Bureau: www.nebb.org.
 - c. TABB, The Testing, Adjusting, and Balancing Bureau of National Energy Management Institute: www.tabbcertified.org.
- E. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.

3.02 EXAMINATION

- A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
 - 1. Systems are started and operating in a safe and normal condition.
 - 2. Temperature control systems are installed complete and operable.
 - 3. Proper thermal overload protection is in place for electrical equipment.
 - 4. Final filters are clean and in place. If required, install temporary media in addition to final filters.
 - 5. Duct systems are clean of debris.
 - 6. Fans are rotating correctly.
 - 7. Fire and volume dampers are in place and open.
 - 8. Air coil fins are cleaned and combed.
 - 9. Access doors are closed and duct end caps are in place.
 - 10. Duct system leakage is minimized.
 - 11. Hydronic systems are flushed, filled, and vented.
 - 12. Pumps are rotating correctly.

- 13. Service and balance valves are open.
- B. Submit field reports. Report defects and deficiencies that will or could prevent proper system balance.
- C. Beginning of work means acceptance of existing conditions.

3.03 ADJUSTMENT TOLERANCES

- A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.
- B. Hydronic Systems: Adjust to within plus or minus 10 percent of design.

3.04 RECORDING AND ADJUSTING

- A. Ensure recorded data represents actual measured or observed conditions.
- B. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- C. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- D. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.05 AIR SYSTEM PROCEDURE

- A. Adjust air handling and distribution systems to provide required or design supply, return, and exhaust air quantities at site altitude.
- B. Make air quantity measurements in ducts by Pitot tube traverse of entire cross sectional area of duct.
- C. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
- D. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.
- E. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- F. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
- G. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling, and at minimum air flow rate, full heating.
- H. Measure building static pressure and adjust supply, return, and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure in areas as noted.

- I. For variable air volume system powered units set volume controller to air flow setting indicated. Confirm connections properly made and confirm proper operation for automatic variable air volume temperature control.

3.06 WATER SYSTEM PROCEDURE

- A. Adjust water systems to provide required or design quantities.
- B. Use calibrated Venturi tubes, orifices, or other metered fittings and pressure gages to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.
- C. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
- D. Effect system balance with automatic control valves fully open to heat transfer elements.
- E. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.
- F. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.

3.07 SCOPE

- A. Test, adjust, and balance the following:
 1. HVAC Pumps.
 2. Air Coils.
 3. Air Handling Units.
 4. Fans.
 5. Air Filters.
 6. Air Terminal Units.

END OF SECTION

**SECTION 23 07 13
DUCT INSULATION**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Duct insulation.
- B. Duct liner.

1.02 REFERENCE STANDARDS

- A. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2015.
- B. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2013.
- C. ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation; 2014.
- D. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material); 2012.
- E. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2016.
- F. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials; 2016.
- G. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi; 2015.
- H. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2005 (Rev. 2009).
- I. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.03 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section with not less than three years of documented experience.
- B. Applicator Qualifications: Company specializing in performing the type of work specified in this section, with minimum three years of experience and approved by manufacturer.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site in original factory packaging, labelled with manufacturer's identification, including product density and thickness.

- B. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.06 FIELD CONDITIONS

- A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
- B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.02 GLASS FIBER, FLEXIBLE

- A. Manufacturer:
 - 1. Knauf Insulation.:
 - 2. Johns Manville.:
 - 3. Owens Corning Corporation.:
 - 4. CertainTeed Corporation.:
- B. Insulation: ASTM C553; flexible, noncombustible blanket.
 - 1. 'K' value: 0.26 at 75 degrees F, when tested in accordance with ASTM C518.
 - 2. Maximum Service Temperature: 1200 degrees F.
 - 3. Maximum Water Vapor Absorption: 5.0 percent by weight.
- C. Vapor Barrier Jacket:
 - 1. Kraft paper with glass fiber yarn and bonded to aluminized film.
 - 2. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
 - 3. Secure with pressure sensitive tape.
- D. Vapor Barrier Tape:
 - 1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber based adhesive.
- E. Tie Wire: Annealed steel, 16 gage, 0.0508 inch diameter.

2.03 DUCT LINER

- A. Manufacturers:
 - 1. Knauf Insulation.:
 - 2. Johns Manville.:
 - 3. CertainTeed Corporation.:
- B. Insulation: Non-corrosive, incombustible glass fiber complying with ASTM C1071; flexible blanket, rigid board, and preformed round liner board; impregnated surface and edges coated with poly vinyl acetate polymer, acrylic polymer, or black composite.

1. Fungal Resistance: No growth when tested according to ASTM G21.
2. Apparent Thermal Conductivity: Maximum of 0.31 at 75 degrees F.
3. Service Temperature: Up to 250 degrees F.
4. Rated Velocity on Coated Air Side for Air Erosion: 5,000 fpm, minimum.
5. Minimum Noise Reduction Coefficients:
 - a. 1/2 inch Thickness: 0.30.
 - b. 1 inch Thickness: 0.45.
 - c. 1-1/2 inches Thickness: 0.60.

C. Adhesive: Waterproof, fire-retardant type, ASTM C916.

D. Liner Fasteners: Galvanized steel, self-adhesive pad with integral head.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that ducts have been tested before applying insulation materials.
- B. Verify that surfaces are clean, foreign material removed, and dry.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. Insulated ducts conveying air below ambient temperature:
 1. Provide insulation with vapor barrier jackets.
 2. Finish with tape and vapor barrier jacket.
 3. Continue insulation through walls, sleeves, hangers, and other duct penetrations.
 4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections, and expansion joints.
- D. Insulated ducts conveying air above ambient temperature:
 1. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.
- E. External Duct Insulation Application:
 1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket.
 2. Secure insulation without vapor barrier with staples, tape, or wires.
 3. Install without sag on underside of duct. Use adhesive or mechanical fasteners where necessary to prevent sagging. Lift duct off trapeze hangers and insert spacers.
 4. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.
 5. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
- F. Duct Liner Application:
 1. Adhere insulation with adhesive for 90 percent coverage.
 2. Secure insulation with mechanical liner fasteners. Refer to SMACNA (DCS) for spacing.
 3. Seal and smooth joints. Seal and coat transverse joints.
 4. Seal liner surface penetrations with adhesive.

5. Duct dimensions indicated are net inside dimensions required for air flow. Increase duct size to allow for insulation thickness.

3.03 SCHEDULES

A. Exhaust Ducts:

1. Flexible Glass Fiber Duct Insulation: 2 inches thick.

B. Outside Air Intake Ducts:

1. Flexible Glass Fiber Duct Insulation: 2 inches thick.

C. Supply Ducts:

1. Flexible Glass Fiber Duct Insulation: 1-1/2 inches thick.

D. Return Ducts:

1. Duct Liner: 1 inches thick.

END OF SECTION

**SECTION 23 07 19
HVAC PIPING INSULATION**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Piping insulation.
- B. Jackets and accessories.

1.02 RELATED REQUIREMENTS

- A. Section 23 21 13 - Hydronic Piping: Placement of hangers and hanger inserts.

1.03 REFERENCE STANDARDS

- A. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus; 2013.
- B. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation; 2015.
- C. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel; 2008 (Reapproved 2013).
- D. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2016.
- E. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials; 2016.
- F. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with not less than three years of documented experience.
- B. Applicator Qualifications: Company specializing in performing the type of work specified in this section with minimum three years of experience.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site, labeled with manufacturer's identification, product density, and thickness.

1.07 FIELD CONDITIONS

- A. Maintain ambient conditions required by manufacturers of each product.
- B. Maintain temperature before, during, and after installation for minimum of 24 hours.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

- A. Surface Burning Characteristics: Flame spread index/Smoke developed index of 25/50, maximum, when tested in accordance with ASTM E84 or UL 723.

2.02 GLASS FIBER

- A. Manufacturers:
 - 1. CertainTeed Corporation.:
 - 2. Johns Manville Corporation.:
 - 3. Knauf Insulation.:
 - 4. Owens Corning Corporation.
- B. Insulation: ASTM C547 and ASTM C795; rigid molded, noncombustible.
 - 1. 'K' Value: ASTM C177, 0.24 at 75 degrees F.
 - 2. Maximum Service Temperature: 850 degrees F.
 - 3. Maximum Moisture Absorption: 0.2 percent by volume.
- C. Vapor Barrier Jacket: White kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches.
- D. Vapor Barrier Lap Adhesive: Compatible with insulation.

2.03 JACKETS

- A. PVC Plastic.
 - 1. Jacket: One piece molded type fitting covers and sheet material, off-white color.
 - a. Minimum Service Temperature: 0 degrees F.
 - b. Maximum Service Temperature: 150 degrees F.
 - c. Moisture Vapor Permeability: 0.002 perm inch, maximum, when tested in accordance with ASTM E96/E96M.
 - d. Thickness: 10 mil.
 - e. Connections: Brush on welding adhesive.
 - 2. Covering Adhesive Mastic: Compatible with insulation.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that piping has been tested before applying insulation materials.
- B. Verify that surfaces are clean and dry, with foreign material removed.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NAIMA National Insulation Standards.
- C. Exposed Piping: Locate insulation and cover seams in least visible locations.

- D. Insulated pipes conveying fluids below ambient temperature; insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
- E. Glass fiber insulated pipes conveying fluids below ambient temperature:
 - 1. Provide vapor barrier jackets, factory-applied or field-applied; secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples and vapor barrier mastic.
 - 2. Insulate fittings, joints, and valves with molded insulation of like material and thickness as adjacent pipe. Finish with glass cloth and vapor barrier adhesive or PVC fitting covers.
- F. For hot piping conveying fluids 140 degrees F or less, do not insulate flanges and unions at equipment, but bevel and seal ends of insulation.
- G. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.
- H. Glass fiber insulated pipes conveying fluids above ambient temperature.
 - 1. Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Secure with self-sealing longitudinal laps and butt strips with pressure sensitive adhesive. Secure with outward clinch expanding staples.
 - 2. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe. Finish with glass cloth and adhesive or PVC fitting covers.
- I. Inserts and Shields:
 - 1. Application: Piping 1-1/2 inches diameter or larger.
 - 2. Shields: Galvanized steel between pipe hangers or pipe hanger rolls and inserts.
 - 3. Insert location: Between support shield and piping and under the finish jacket.
 - 4. Insert Configuration: Minimum 6 inches long, of same thickness and contour as adjoining insulation; may be factory fabricated.
 - 5. Insert Material: Hydrous calcium silicate insulation or other heavy density insulating material suitable for the planned temperature range.
- J. Pipe Exposed in Mechanical Equipment Rooms or Finished Spaces (less than 10 feet above finished floor): Finish with PVC jacket and fitting covers.

3.03 SCHEDULE

- A. Heating Systems:
 - 1. Heating Water Supply and Return:
 - a. Glass Fiber Insulation:
 - 1) Pipe Size Range: All sizes.
 - a) Thickness: 1-1/2 inch
- B. Cooling Systems:
 - 1. Chilled Water:
 - a. Glass Fiber Insulation:
 - 1) Pipe Size Range: All sizes.
 - a) Thickness: 1-1/2 inch

END OF SECTION

SECTION 23 09 13
INSTRUMENTS AND CONTROL ELEMENTS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Control panels.
- B. Control Valves:
 - 1. Globe pattern.
 - 2. Butterfly pattern.
 - 3. Electronic operators.
- C. Dampers.
- D. Damper Operators:
 - 1. Electric operators.
- E. Input/Output Sensors:
 - 1. Temperature sensors.
 - 2. Humidity sensors.
 - 3. Static pressure (air pressure) sensors.
 - 4. Equipment operation (current) sensors.
 - 5. Damper position indicators.
 - 6. Carbon dioxide sensors.
- F. Thermostats:
 - 1. Electric room thermostats.
 - 2. Room thermostat accessories.
 - 3. Outdoor reset thermostats.
 - 4. Immersion thermostats.
 - 5. Airstream thermostats.
 - 6. Electric low limit duct thermostats.
- G. Transmitters:
 - 1. Building static pressure transmitters.
 - 2. Air pressure transmitters.
 - 3. Temperature transmitters.
 - 4. Humidity transmitters.
- H. Low Coil Input Relays.
- I. Air Flow Measuring Stations.
- J. Variable Frequency Drives.

1.02 RELATED REQUIREMENTS

- A. Section 23 05 19 - Meters and Gages for HVAC Piping: Thermometer sockets, gage taps.
- B. Section 23 09 23 - Direct-Digital Control System for HVAC.

- C. Section 23 21 13 - Hydronic Piping: Installation of control valves, flow switches, temperature sensor sockets, gage taps.
- D. Section 23 21 14 - Hydronic Specialties.
- E. Section 26 27 17 - Equipment Wiring: Electrical characteristics and wiring connections.
- F. Section 26 27 26 - Wiring Devices: Elevation of exposed components.

1.03 REFERENCE STANDARDS

- A. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating; 2012.
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2014.
- C. NEMA DC 3 - Residential Controls - Electrical Wall-Mounted Room Thermostats; 2013.
- D. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2015.

1.04 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide description and engineering data for each control system component. Include sizing as requested. Provide data for each system component and software module.
- C. Shop Drawings: Indicate complete operating data, system drawings, wiring diagrams, and written detailed operational description of sequences. Submit schedule of valves indicating size, flow, and pressure drop for each valve. For automatic dampers indicate arrangement, velocities, and static pressure drops for each system.
- D. Operation and Maintenance Data: Include inspection period, cleaning methods, recommended cleaning materials, and calibration tolerances.
- E. Project Record Documents: Record actual locations of control components, including panels, thermostats, and sensors. Accurately record actual location of control components, including panels, thermostats, and sensors.
 - 1. Revise shop drawings to reflect actual installation and operating sequences.
- F. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Installer Qualifications: Company specializing in performing the work of this section with minimum 3 years experience approved by manufacturer.

PART 2 PRODUCTS

2.01 EQUIPMENT - GENERAL

- A. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

2.02 CONTROL PANELS

- A. Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet and temperature indicators, pressure gages, pilot lights, push buttons and switches flush on cabinet panel face.
- B. NEMA 250, general purpose utility enclosures with enameled finished face panel.
- C. Provide common keying for all panels.

2.03 CONTROL VALVES

- A. Globe Pattern:
 - 1. Up to 2 inches: Bronze body, bronze trim, rising stem, renewable composition disc, screwed ends with backseating capacity repackable under pressure.
 - 2. Over 2 inches: Iron body, bronze trim, rising stem, plug-type disc, flanged ends, renewable seat and disc.
 - 3. Hydronic Systems:
 - a. Rate for service pressure of 125 psig at 250 degrees F.
 - b. Replaceable plugs and seats of stainless steel.
 - c. Size for 3 psig maximum pressure drop at design flow rate.
 - d. Two-way valves shall have equal percentage characteristics, three way valves linear characteristics. Size two-way valve operators to close valves against pump shut off head.
- B. Butterfly Pattern:
 - 1. Iron body, bronze disc, resilient replaceable seat for service to 180 degrees F wafer or lug ends, extended neck.
 - 2. Hydronic Systems:
 - a. Rate for service pressure of 125 psig at 250 degrees F.
 - b. Size for 1 psig maximum pressure drop at design flow rate.
- C. Electronic Operators:
 - 1. Manufacturers:
 - a. Belimo.
 - b. Substitutions: See Section 01 60 00 - Product Requirements.
 - 2. Valves shall spring return to normal position as indicated on freeze, fire, or temperature protection.
 - 3. Select operator for full shut off at maximum pump differential pressure.

2.04 DAMPERS

- A. Performance: Test in accordance with AMCA 500-D.

- B. Frames: Extruded aluminum, welded or riveted with corner reinforcement, minimum 12 gage, 0.1046 inch.
- C. Blades: Extruded aluminum, maximum blade size 6 inches wide, 48 inches long, minimum 22 gage, 0.0299 inch, attached to minimum 1/2 inch shafts with set screws.
- D. Blade Seals: Synthetic elastomeric, inflatable, mechanically attached, field replaceable.
- E. Jamb Seals: Spring stainless steel.
- F. Shaft Bearings: Oil impregnated sintered bronze.
- G. Leakage: Less than one percent based on approach velocity of 2000 ft per min and 4 inches wg.
- H. Maximum Pressure Differential: 6 inches wg.

2.05 DAMPER OPERATORS

- A. General: Provide smooth proportional control with sufficient power for air velocities 20 percent greater than maximum design velocity and to provide tight seal against maximum system pressures. Provide spring return for two position control and for fail safe operation.
 - 1. Provide sufficient number of operators to achieve unrestricted movement throughout damper range.
 - 2. Provide one operator for maximum 36 sq ft damper section.
- B. Electric Operators:
 - 1. Manufacturers:
 - a. Belimo.
 - 2. Spring return, adjustable stroke motor having oil immersed gear train, with auxiliary end switch.

2.06 INPUT/OUTPUT SENSORS

- A. Temperature Sensors:
 - 1. Use thermistor or RTD type temperature sensing elements with characteristics resistant to moisture, vibration, and other conditions consistent with the application without affecting accuracy and life expectancy.
 - 2. Construct RTD of nickel or platinum with base resistance of 1000 ohms at 70 degrees F.
 - 3. 100 ohm platinum RTD is acceptable if used with project DDC controllers.
 - 4. Temperature Sensing Device: Compatible with project DDC controllers.
 - 5. Performance Characteristics:
 - a. RTD:
 - 1) Duct Averaging Accuracy: Plus/minus 0.50 degrees F minimum.
 - 2) Chilled Water Accuracy: Plus/minus 0.50 degrees F minimum.
 - 3) All Other Accuracy: Plus/minus 0.75 degrees F minimum.
 - 4) Range: Minus 40 degrees F through 220 degrees F minimum.
 - b. Thermistor:
 - 1) Accuracy (All): Plus/minus 0.36 degrees F minimum.
 - 2) Range: Minus 25 degrees F through 122 degrees F minimum.
 - 3) Heat Dissipation Constant: 2.7 mW per degree C.
 - c. Temperature Transmitter:

- 1) Accuracy: 0.10 degree F minimum or plus/minus 0.20 percent of span.
 - 2) Output: 4 to 20 mA.
 - d. Sensing Range:
 - 1) Provide limited range sensors if required to sense the range expected for a respective point.
 - 2) Use RTD type sensors for extended ranges beyond minus 30 degrees F to 230 degrees F.
 - 3) Use temperature transmitters in conjunction with RTD's when RTD's are incompatible with DDC controller direct temperature input.
 - e. Wire Resistance:
 - 1) Use appropriate wire size to limit temperature offset due to wire resistance to 1.0 degree F or use temperature transmitter when offset is greater than 1.0 degree F due to wire resistance.
 - 2) Compensate for wire resistance in software input definition when feature is available in the DDC controller.
 - f. Outside Air Sensors: Watertight inlet fitting shielded from direct rays of the sun.
 - g. Immersion Temperature Sensors: A sensor encased in a corrosion-resistant probe with an indoor junction box service entry body.
 - h. Temperature Averaging Elements:
 - 1) Use on duct sensors for ductwork 10 sq ft or larger.
 - 2) Use averaging elements where prone to stratification with sensor length 8 ft, or 16 ft.
 - 3) Provide for all mixed air and heating coil discharge sensors regardless of duct size.
 - i. Insertion Elements:
 - 1) Use in ducts not affected by temperature stratification or smaller than 11 sq inches.
 - 2) Provide dry type, insertion elements for liquids, installed in immersion wells, with minimum insertion length of 2.5 inches.
- B. Humidity Sensors:
- 1. Duct Mounted Sensor: Voltage type encased in a die-cast metal, weather-proof housing.
 - a. Input Power, Voltage Type: Class 2; 12-30 VDC/24 VAC, 15mA max.
 - b. Input Power, mA Type: Class 2; Loop powered 12-30 VDC only, 30 mA max.
 - c. Output Voltage Type: 3-wire observed polarity.
 - d. Output mA Type: 2-wire, not polarity sensitive (clipped and capped).
 - e. Humidity:
 - 1) HS Element: Digitally profiled thin-film capacitive.
 - 2) Accuracy 1 percent at 10 to 80 percent relative humidity at 77 degrees F, multi-point calibration, NIST traceable.
 - a) Plus/minus 1 percent at 20 to 40 percent RH in mA output mode; (multi-point calibration, NIST traceable).
 - 3) Scaling: 0 to 100 percent RH.
 - f. Temperature Effect:
 - 1) Duct Mounted: Plus/minus 0.18 percent per degree F.
 - 2) Outdoor Mounted: 4 to 20mA version: $(0.0013 \times \%RH \times (T_{\text{degreeC}} - 25))$.
 - g. Hysteresis: 1.5 percent typical.
 - h. Linearity: Included in accuracy specification.
 - i. Reset Rate: 24 hours.

- j. Stability: Plus/minus 1 percent at 68 degrees F (20 degrees C) annually, for two years.
- k. Operating Environment:
 - 1) Operating Humidity Range: 0 to 100 percent RH noncondensing.
 - 2) Operating Temperature Range: Minus 40 degrees F to 122 degrees F.
- C. Static Pressure (Air Pressure) Sensors:
 - 1. Unidirectional with ranges not exceeding 150 percent of maximum expected input.
 - 2. Temperature compensate with typical thermal error or 0.06 percent of full scale in temperature range of 40 to 100 degrees F.
 - 3. Accuracy: One percent of full scale with repeatability 0.3 percent.
 - 4. Output: 0 to 5 vdc with power at 12 to 28 vdc.
- D. Equipment Operation (Current) Sensors:
 - 1. Status Inputs for Fans: Differential pressure switch with adjustable range of 0 to 5 inches wg.
 - 2. Status Inputs for Pumps: Differential pressure switch piped across pump with adjustable pressure differential range of 8 to 60 psi.
 - 3. Status Inputs for Electric Motors: Current sensing relay with current transformers, adjustable and set to 175 percent of rated motor current.
- E. Damper Position Indicators: Potentiometer mounted in enclosure with adjustable crank arm assembly connected to damper to transmit 0 to 100 percent damper travel.

2.07 THERMOSTATS

- A. Electric Room Thermostats: Matching Campus standard
 - 1. Provide sensor type matching existing campus standard.
 - 2. Type: NEMA DC 3, 24 volts, with setback/setup temperature control.
 - 3. Service: Cooling and heating.
 - 4. Room thermostats shall be equipped with setpoint adjustment.
 - 5. Thermostats shall match owner standard.
- B. Room Thermostat Accessories:
 - 1. Insulating Bases: For thermostats located on exterior walls.
- C. Outdoor Reset Thermostats:
 - 1. Remote bulb or bimetal rod and tube type, proportioning action with adjustable throttling range, adjustable setpoint.
- D. Immersion Thermostats:
 - 1. Remote bulb or bimetallic rod and tube type, proportional action with adjustable setpoint and adjustable throttling range.
- E. Airstream Thermostats:
 - 1. Remote bulb or bimetallic rod and tube type, proportional action with adjustable setpoint in middle of range and adjustable throttling range.
- F. Electric Low Limit Duct Thermostats:
 - 1. Snap acting, single pole, single throw, manual reset switch that trips if temperature sensed across any 12 inches of bulb length is equal to or below setpoint,
 - 2. Bulb length: Minimum 20 feet.

3. Provide one thermostat for every 20 sq ft of coil surface.

2.08 TRANSMITTERS

A. Building Static Pressure Transmitters:

1. One pipe, direct acting, double bell, scale range 0.01 to 6.0 inch wg positive or negative, and sensitivity of 0.0005 inch wg. Transmit electronic signal to receiver with matching scale range.

B. Air Pressure Transmitters:

1. General: Provide dry media differential pressure transducers to monitor duct and room pressure.
 - a. Media Compatibility: Dry air.
 - b. Input Power: Class 2; 12 to 30 VDC; 2-wire: 20 mA max.
 - c. Output: Field selectable, 2-wire, loop-powered 4 to 20 mA (DC only, clipped and capped).
 - d. Pressure Ranges: 4 and 7, field selectable.
 - e. Response Time:
 - 1) Standard: T95 in 20 seconds.
 - 2) Fast: T95 in 2 seconds.
 - 3) Switch selectable.
 - f. Mode: Switch selectable, unidirectional.

C. Temperature Transmitters:

1. One pipe, directly proportional output signal to measured variable, linearity within plus or minus 1/2 percent of range for 200 degrees F span and plus or minus 1 percent for 50 degrees F span, with 50 degrees F. temperature range, compensated bulb, averaging capillary, or rod and tube operation on 20 psig input pressure and 3 to 15 psig output.

D. Humidity Transmitters:

1. One pipe, directly proportioned output signal to measured variable, linearity within plus or minus 1 percent for 70 percent relative humidity span, capable of withstanding 95 percent relative humidity without loss of calibration.

2.09 LOW COIL INPUT RELAYS

A. Manufacturers

1. Functional Devices, Inc.; RIB
 - a. Encoded relay Hi/Low separation 20 amp DPDT +Override.
 - b. UL Listed, UL916, UL864, C-UL and UL Accepted for use in Plenum, NEMA 1.
 - c. Power input: 120 Vac, 50-60 Hz or 208-277 Vac, 50-60 Hz as applicable.
 - d. Control Input: 5-25 Vac/dc. 50-60 Hz.
 - e. Relay status: LED on = activated.

2.10 AIR FLOW MEASURING STATION

A. Manufacturers:

1. Ebtron, Inc.; Model Advantage II Gold Series.
2. Air Monitor Corp.

- ### B. Thermal dispersion airflow measurement device. Measuring device shall consist of one or more multi-point measuring probes and a single microprocessor-based transmitter. Transmitter shall

have an LCD display capable of displaying airflow and temperature. Airflow shall be field configurable to be displayed as a velocity or volumetric rate.

- C. Transmitter shall be operate on 24 VAC.
- D. Transmitter shall be capable of communicating with building automation system using one of the following interface options:
 1. Linear analog output signal: Field selectable, fuse protected and isolated, 0-10 VDC and 4-20 mA (4-wire).
 2. RS-485: Field selectable ModBus.
 3. 10 Base-T Ethernet: Field selectable ModBus TCP and TCP/IP.
 4. LonWorks Free Topology.
- E. Sensors shall be fabricated of anodized aluminum alloy tube with 303/304 stainless steel mounting brackets.
- F. Airflow/temperature measuring devices shall be UL listed.

2.11 VARIABLE FREQUENCY DRIVES

- A. Manufacturer: Danfoss VLT.
- B. Rated input voltage: See schedules.
- C. Variable torque horsepower: See schedules.
- D. Enclosure: Power electronics and control electronics housed in NEMA 1 enclosure.
- E. Electro-mechanical construction:
 1. Input voltage +/- 10 percent.
 2. Output current overload rating of 125 percent of motor FLA for 1 minute.
 3. Voltage source design using PWM inverter technology.
 4. Microprocessor based control circuit generating sine coded PWM output current waveform.
- F. Non-volatile memory (NV RAM); all programming is maintained when disconnected from power.
- G. Corrects displacement power factor to 98 percent throughout the motor speed range and eliminates power line notching, through the use of diode bridge input section or power factor correction capacitors and isolation transformer.
- H. Input phase insensitive, sequencing of the 3 phase input lines is not required.
- I. Fused DC bus with capacitive filtering.
- J. Insulated Gate Bipolar Transistors (IGBT) output, allowing motor noise, at 60 Hz, less than 2 dB (@ 1 meter) above that resulting from across the line operation.
- K. Three current transformers detect the output current to provide: Electronic thermal overload protection, Three phase current limit, Ground fault protection, Short circuit protection and Speed search capability.
- L. Digital operator keypad and display.
- M. Power electronics provide efficiency of 97 percent (minimum).

- N. Materials of construction UL 94-VO rated.
- O. Non-fused disconnect provided for motor service.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify existing conditions before starting work.
- B. Verify that systems are ready to receive work.
- C. Beginning of installation means installer accepts existing conditions.
- D. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Check and verify location of thermostats with plans and room details before installation. Locate 60 inches above floor. Align with lighting switches and humidistats. Refer to Section 26 27 26.
- C. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors with sun shield.
- D. Provide separable sockets for liquids and flanges for air bulb elements.
- E. Provide valves with position indicators and with pilot positioners where sequenced with other controls.
- F. Provide mixing dampers of opposed blade construction arranged to mix streams. Provide pilot positioners on mixed air damper motors.
- G. Provide isolation (two position) dampers of parallel blade construction.
- H. Install damper motors on outside of duct in warm areas. Do not install motors in locations at outdoor temperatures.
- I. Mount control panels adjacent to associated equipment on vibration free walls or free standing angle iron supports. One cabinet may accommodate more than one system in same equipment room. Provide engraved plastic nameplates for instruments and controls inside cabinet and engraved plastic nameplates on cabinet face.
- J. Install "hand/off/auto" selector switches to override automatic interlock controls when switch is in "hand" position.
- K. Provide conduit and electrical wiring in accordance with Section 26 27 17. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.

END OF SECTION

SECTION 23 09 23
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. System description.
- B. Operator interface.
- C. Controllers.
- D. Power supplies and line filtering.
- E. System software.
- F. Controller software.
- G. HVAC control programs.

1.02 RELATED REQUIREMENTS

- A. Section 23 09 13 - Instruments and Control Elements.

1.03 REFERENCE STANDARDS

- A. MIL-STD-810 - Environmental Engineering Considerations and Laboratory Tests; Revision G, 2014.
- B. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Expand building Delta Controls Enteliweb Enterprise building control system to interface with new equipment and perform the sequence of operation specified. Modify automation system graphics to delete removed equipment and add new equipment.
- B. Provide a color graphical representation of all systems. The graphical display shall include all points indicated in the pints list and any others required to achieve the sequences of operation. The graphical user interface shall consist of the following as a minimum;
 - 1. Menu bar navigation via windows-like bars.
 - 2. Navigation will also be available via an image of the building profile from which the user clicks on floors to bring up individual floor plans.
 - 3. The individual floor plan zones shall change color based upon the difference between the actual zone temperature and zone set point so that the operator can tell at a glance if zones are in, above or below acceptable ranges. A minimum of five (5) colors are required: Color 1 = within acceptable range of set point, Color 2 = warning - zone is above acceptable range of set point and approaching high temperature alarm; Color 3 = zone is in high temperature alarm; Color 4 = warning - zone is below acceptable range of set point and approaching low temperature alarm; Color 5 = zone is in low temperature alarm.
 - 4. Clicking on a floor plan zone shall bring up a dynamic color graphic of the mechanical equipment that serves that zone.

5. Each major piece of mechanical equipment (terminal unit, AHU, boiler, chillers, cooling towers, etc.) shall have a pictorial dynamic color graphic. The central plant equipment may be combined as appropriate on one or more graphic page.
6. Text-based (non-pictorial) summary screens will also be provided so that the operator may view critical information on multiple units at once. Summary screens will be provided for terminal units and air handling units. Summary screens for VAV/FPVAV boxes will contain as a minimum room temperature, room temperature set point, occ/unocc status and CFM for each box. Summary screens for AHUs will contain as a minimum space temperature (CV units) or discharge temperature (VAV units) and the corresponding set point, static pressure (VAV units), OA damper position, mixed air temperature, fan status and occ/unocc status.
7. Clicking on a unit on any summary screen shall bring up the complete graphic for that unit.
8. Outside air temperature shall be displayed on each graphic screen.

1.05 OPEN, INTEROPERABLE, INTEGRATED ARCHITECTURES

- A. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate both the ANSI/ASHRAE Standard 135-1995 BACnet and LonWorks technology communication protocols in one open, interoperable system.
- B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including ANSI/ASHRAE Standard 135-1995, BACnet and LonMark to assure interoperability between all system components is required. For each LonWorks device that does not have LonMark certification, the device supplier must provide a XIF file for the device. For each BACnet device, the device supplier must provide a PICS document showing the installed device = s-compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet.
- C. All components and controllers supplied under this contract shall be true peer-to-peer communicating devices. Components or controllers requiring polling by a host to pass data shall not be acceptable.
- D. The supplied system must incorporate the ability to access all data using Java enabled browsers without requiring proprietary operator interface and configuration programs. An Open Database Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable.
- E. The installed system shall provide secure password access to all features, functions and data contained in the overall Building Management Control System (BMCS). Secure Socket Layer (SSL) encryption shall be an available option for remote access.
- F. The installed system must be totally scalable to allow for future expansion with the addition of controllers and/or input/output devices. It shall not be necessary to remove equipment supplied under this contract to expand the system.
- G. The failure of any single component or network shall not interrupt the control functions of non-affected devices. A single network failure shall only affect shared communications or shared

data; individual application controllers and network controllers shall continue normal operation minus only the data from a remote device from the affected network. Automatic default values for all network transported data shall be provide to allow continued operation until the network is restored.

- H. The BMCS shall provide support for ODBC or SQL. An embedded database must be an ODBC-compliant database or must provide an ODBC data access mechanism to read and write dated stored within it. A minimum offering would be the documentation of database schemes to allow users to read/write data into other applications using appropriate ODBS syntax.
- I. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data.
 - 1. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
 - 2. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

1.06 WEB BROWSER CLIENTS

- A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacturer-specific browsers shall not be acceptable.
- B. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the BMCS 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 (GUI). 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-in 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. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
 - 4. Storage of the graphical screens shall be in the Network Area Controller (NAC) without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.

1.07 SUBMITTALS

- A. Product Data: Provide data for each system component and software module.
- B. Shop Drawings:
 - 1. Indicate trunk cable schematic showing programmable control unit locations, and trunk data conductors.
 - 2. Indicate system graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations. Provide demonstration diskette containing graphics.
 - 3. Show system configuration with peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
 - 4. Indicate description and sequence of operation of operating, user, and application software.
- C. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors.
 - 1. Revise shop drawings to reflect actual installation and operating sequences.
- D. Operation and Maintenance Data:
 - 1. Include interconnection wiring diagrams complete field installed systems with identified and numbered, system components and devices.
 - 2. Include keyboard illustrations and step-by-step procedures indexed for each operator function.
 - 3. Include inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
- E. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Delta Controls.
- B. Installing Contractors;
 - 1. Delta Controls Chicago, Inc. Contact Charlie McLauchlan, 630-589-3800
 - 2. Murphy Miller.
 - 3. F.E. Moran.

2.02 SYSTEM DESCRIPTION

- A. Automatic temperature control field monitoring and control system using field programmable micro-processor based units.
- B. Base system on distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire and conduit.
- C. Include computer software and hardware, operator input/output devices, control units, local area networks (LAN), sensors, control devices, actuators.

- D. Controls for variable air volume terminals, radiation, reheat coils, unit heaters, fan coils, and the like when directly connected to the control units. Individual terminal unit control is specified in Section 23 09 13.
- E. Provide control systems consisting of thermostats, control valves, dampers and operators, indicating devices, interface equipment and other apparatus and accessories required to operate mechanical systems, and to perform functions specified.
- F. Include installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.

2.03 OPERATOR INTERFACE

- A. Interface new controller into existing Campus building automation system.

2.04 CONTROLLERS

A. BUILDING CONTROLLERS

- 1. General:
 - a. Manage global strategies by one or more, independent, standalone, microprocessor based controllers.
 - b. Provide sufficient memory to support controller's operating system, database, and programming requirements.
 - c. Share data between networked controllers.
 - d. Controller operating system manages input and output communication signals allowing distributed controllers to share real and virtual object information and allowing for central monitoring and alarms.
 - e. Utilize real-time clock for scheduling.
 - f. Continuously check processor status and memory circuits for abnormal operation.
 - g. Controller to assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
 - h. Communication with other network devices to be based on assigned protocol.
- 2. Communication:
 - a. Controller to reside on a BACnet network using ISO 8802-3 (ETHERNET) Data Link/Physical layer protocol.
 - b. Perform routing when connected to a network of custom application and application specific controllers.
 - c. Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.
- 3. Anticipated Environmental Ambient Conditions:
 - a. Conditioned Space:
 - 1) Mount within dustproof enclosures.
 - 2) Rated for operation at 32 to 120 degrees F.
- 4. Provisions for Serviceability:
 - a. Diagnostic LEDs for power, communication, and processor.
 - b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.

5. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
6. Power and Noise Immunity:
 - a. Maintain operation at 90 to 110 percent of nominal voltage rating.
 - b. Perform orderly shutdown below 80 percent of nominal voltage.
 - c. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.

B. CUSTOM APPLICATION CONTROLLERS

1. General:
 - a. Provide sufficient memory to support controller's operating system, database, and programming requirements.
 - b. Share data between networked, microprocessor based controllers.
 - c. Controller operating system manages input and output communication signals allowing distributed controllers to share real and virtual object information and allowing for central monitoring and alarms.
 - d. Utilize real-time clock for scheduling.
 - e. Continuously check processor status and memory circuits for abnormal operation.
 - f. Controller to assume predetermined failure mode and generate alarm notification upon detection of abnormal operation.
 - g. Communication with other network devices to be based on assigned protocol.
2. Communication:
 - a. Controller to reside on a BACnet network using MS/TP Data Link/Physical layer protocol.
 - b. Provide service communication port for connection to a portable operator's terminal or hand held device with compatible protocol.
3. Anticipated Environmental Ambient Conditions:
 - a. Outdoors and/or in Wet Ambient Conditions:
 - 1) Mount within waterproof enclosures.
 - 2) Rated for operation at 40 to 150 degrees F.
 - b. Conditioned Space:
 - 1) Mount within dustproof enclosures.
 - 2) Rated for operation at 32 to 120 degrees F.
4. Provisions for Serviceability:
 - a. Diagnostic LED's for power, communication, and processor.
 - b. Make all wiring connections to field removable, modular terminal strips, or to a termination card connected by a ribbon cable.
5. Memory: In the event of a power loss, maintain all BIOS and programming information for a minimum of 72 hours.
6. Power and Noise Immunity:
 - a. Maintain operation at 90 to 110 percent of nominal voltage rating.
 - b. Perform orderly shutdown below 80 percent of nominal voltage.
 - c. Operation protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W. at 3 feet.

C. INPUT/OUTPUT INTERFACE

1. Hardwired inputs and outputs tie into the DDC system through building, custom application, or application specific controllers.
2. All Input/Output Points:
 - a. Protect controller from damage resulting from any point short-circuiting or grounding and from voltage up to 24 volts of any duration.
 - b. Provide universal type for building and custom application controllers where input or output is software designated as either binary or analog type with appropriate properties.
3. Binary Inputs:
 - a. Allow monitoring of On/Off signals from remote devices.
 - b. Provide wetting current of 12 mA minimum, compatible with commonly available control devices and protected against the effects of contact bounce and noise.
 - c. Sense dry contact closure with power provided only by the controller.
4. Pulse Accumulation Input Objects: Conform to all requirements of binary input objects and accept up to 10 pulses per second.
5. Analog Inputs:
 - a. Allow for monitoring of low voltage 0 to 10 VDC, 4 to 20 mA current, or resistance signals (thermistor, RTD).
 - b. Compatible with and field configurable to commonly available sensing devices.
6. Binary Outputs:
 - a. Used for On/Off operation or a pulsed low-voltage signal for pulse width modulation control.
 - b. Outputs provided with three position (On/Off/Auto) override switches.
 - c. Status lights for building and custom application controllers to be selectable for normally open or normally closed operation.
7. Analog Outputs:
 - a. Monitoring signal provides a 0 to 10 VDC or a 4 to 20 mA output signal for end device control.
 - b. Provide status lights and two position (AUTO/MANUAL) switch for building and custom application controllers with manually adjustable potentiometer for manual override on building and custom application controllers.
 - c. Drift to not exceed 0.4 percent of range per year.
8. Tri State Outputs:
 - a. Coordinate two binary outputs to control three point, floating type, electronic actuators without feedback.
 - b. Limit the use of three point, floating devices to the following zone and terminal unit control applications:
 - c. Control algorithms run the zone actuator to one end of its stroke once every 24 hours for verification of operator tracking.
9. System Object Capacity:
 - a. System size to be expandable to twice the number of input output objects required by providing additional controllers, including associated devices and wiring.
 - b. Hardware additions or software revisions for the installed operator interfaces are not to be required for future, system expansions.

2.05 POWER SUPPLIES AND LINE FILTERING

A. Power Supplies:

1. Provide UL listed control transformers with Class 2 current limiting type or over-current protection in both primary and secondary circuits for Class 2 service as required by the NEC.
 2. Limit connected loads to 80 percent of rated capacity.
 3. Match DC power supply to current output and voltage requirements.
 4. Unit to be full wave rectifier type with output ripple of 5.0 mV maximum peak to peak.
 5. Regulation to be 1 percent combined line and load with 100 microsecond response time for 50 percent load changes.
 6. Provide over-voltage and over-current protection to withstand a 150 percent current overload for 3 seconds minimum without trip-out or failure.
 7. Operational Ambient Conditions: 32 to 120 degrees F.
 8. EM/RF meets FCC Class B and VDE 0871 for Class B and MIL-STD 810 for shock and vibration.
 9. Line voltage units UL recognized and CSA approved.
- B. Power Line Filtering:
1. Provide external or internal transient voltage and surge suppression component for all workstations and controllers.
 2. Minimum surge protection attributes:
 - a. Dielectric strength of 1000 volts minimum.
 - b. Response time of 10 nanoseconds or less.
 - c. Transverse mode noise attenuation of 65 dB or greater.
 - d. Common mode noise attenuation of 150 dB or greater at 40 to 100 Hz.

2.06 FIELD DEVICES

- A. Networked Thermostat (NT)
1. The NT shall communicate over the Field Controller Bus using BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9.
 - a. The NT shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
 - b. The NT shall be tested and certified as a BACnet Application Specific Controller (B-ASC).
 - c. A BACnet Protocol Implementation Conformance Statement shall be provided for the NT.
 - d. The Conformance Statement shall be submitted 10 days prior to bidding.
 2. The Networked Thermostat shall support remote read/write and parameter adjustment from the web based User Interface through a Network Automation Engine.
 3. The Networked Thermostat shall include an intuitive User Interface providing plain text messages.
 - a. Two line, 8 character backlit display
 - b. LED indicators for Fan, Heat, and Cool status
 - c. Five (5) User Interface Keys
 - 1) Mode
 - 2) Fan
 - 3) Override
 - 4) Degrees C/F
 - 5) Up/Down
 - d. The display shall continuously scroll through the following parameters:
 - 1) Room Temperature
 - 2) System Mode

- 3) Schedule Status - Occupied/Unoccupied/Override
- 4) Applicable Alarms
- 4. The Networked Thermostat shall provide the flexibility to support any one of the following inputs:
 - a. Integral Indoor Air Temperature Sensor
 - b. Duct Mount Air Temperature Sensor
 - c. Remote Indoor Air Temperature Sensor with Occupancy Override and LED Indicator
 - d. Two configurable binary inputs
- 5. The Networked Thermostat shall provide the flexibility to support any one of the following outputs:
 - a. Three Speed Fan Control
 - b. Two On/Off
 - c. Two Floating
 - d. Two Proportional (0 to 10V)
- 6. The Networked Thermostat shall provide a minimum of six (6) levels of keypad lockout.
- 7. The Networked Thermostat shall provide the flexibility to adjust the following parameters:
 - a. Adjustable Temporary Occupancy from 0 to 24 hours
 - b. Adjustable heating/cooling deadband from 2° F to 5° F
 - c. Adjustable heating/cooling cycles per hour from 4 to 8
- 8. Where required by application and indicated on plans or room schedules provide the Networked Thermostat with an integral Passive Infra-Red (PIR) occupancy sensor.
- 9. The Networked Thermostat shall employ nonvolatile electrically erasable programmable read-only memory (EEPROM) for all adjustable parameters.

2.07 LOCAL AREA NETWORK (LAN)

- A. Provide communication between control units over local area network (LAN).
- B. Break in Communication Path: Alarm and automatically initiate LAN reconfiguration.
- C. LAN Data Speed: Minimum 19.2 Kb.
- D. Communication Techniques: Allow interface into network by multiple operation stations and by auto-answer/auto-dial modems. Support communication over telephone lines utilizing modems.
- E. Transmission Median: Fiber optic or single pair of solid 24 gage twisted, shielded copper cable.
- F. Network Support: Time for global point to be received by any station, shall be less than 3 seconds. Provide automatic reconfiguration if any station is added or lost. If transmission cable is cut, reconfigure two sections with no disruption to system's operation, without operator intervention.

2.08 CONTROLLER SOFTWARE

- A. All applications reside and operate in the system controllers and editing of all applications occurs at the operator workstation.
- B. System Security:
 - 1. User access secured via user passwords and user names.

2. Passwords restrict user to the objects, applications, and system functions as assigned by the system manager.
 3. User Log On/Log Off attempts are recorded.
 4. Automatic Log Off occurs following the last keystroke after a user defined delay time.
- C. Object or Object Group Scheduling:
1. Weekly Schedules Based on Separate, Daily Schedules:
 - a. Include start, stop, optimal stop, and night economizer.
 - b. 10 events maximum per schedule.
 - c. Start/stop times adjustable for each group object.
- D. Provide standard application for equipment coordination and grouping based on function and location to be used for scheduling and other applications.
- E. Alarms:
1. Binary object is set to alarm based on the operator specified state.
 2. Analog object to have high/low alarm limits.
 3. All alarming is capable of being automatically and manually disabled.
 4. Alarm Reporting:
 - a. Operator determines action to be taken for alarm event.
 - b. Alarms to be routed to appropriate workstation.
 - c. Reporting Options:
- F. Maintenance Management: System monitors equipment status and generates maintenance messages based upon user-designated run-time limits.
- G. Sequencing: Application software based upon specified sequences of operation shown on the Drawings.
- H. PID Control Characteristics:
1. Direct or reverse action.
 2. Anti-windup.
 3. Calculated, time-varying, analog value, positions an output or stages a series of outputs.
 4. User selectable controlled variable, set-point, and PED gains.
- I. Staggered Start Application:
1. Prevents all controlled equipment from simultaneously restarting after power outage.
 2. Order of equipment startup is user selectable.
- J. On-Off Control with Differential:
1. Algorithm allows binary output to be cycled based on a controlled variable and set-point.
 2. Algorithm to be direct-acting or reverse-acting incorporating an adjustable differential.
- K. Run-Time Totalization:
1. Totalize run-times for all binary input objects.
 2. Provides operator with capability to assign high run-time alarm.

2.09 HVAC CONTROL PROGRAMS

- A. General:
1. Support Inch-pounds and SI (metric) units of measurement.

2. Identify each HVAC Control system.
- B. Optimal Run Time:
1. Control start-up and shutdown times of HVAC equipment for both heating and cooling.
 2. Base on occupancy schedules, outside air temperature, seasonal requirements, and interior room mass temperature.
 3. Start-up systems by using outside air temperature, room mass temperatures, and adaptive model prediction for how long building takes to warm up or cool down under different conditions.
 4. Use outside air temperature to determine early shut down with ventilation override.
- C. Supply Air Reset:
1. Monitor heating and cooling loads in building spaces, terminal reheat systems, and single zone unit discharge temperatures.
- D. Enthalpy Switchover:
1. Calculate outside and return air enthalpy using measured temperature and relative humidity; determine energy expended and control outside and return air dampers.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify existing conditions before starting work.
- B. Verify that conditioned power supply is available to the control units and to the operator work station. Verify that field end devices, wiring, and pneumatic tubing is installed prior to installation proceeding.

3.02 INSTALLATION

- A. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.
- B. Install software in control units and in operator work station. Implement all features of programs to specified requirements and appropriate to sequence of operation.
- C. Provide conduit and electrical wiring in accordance with Section 26 06 20.26. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.
1. Provide conduit for all control wiring exposed to view. This includes but is not limited to all storage rooms, mechanical rooms, and similar spaces.
 2. Provide conduit for all control wiring concealed in inaccessible spaces. This includes but is not limited to wiring above/behind drywall and plaster ("hard") ceilings or soffits, and wiring within vertical chase spaces, regardless of whether access doors are provided or not.
 3. Control wiring that is concealed above readily accessible ceilings such as acoustical lay-in ceilings, need not be run in conduit.
- D. All exposed conduit wiring that is not located above an accessible ceiling shall be installed in conduit. This includes all storage room, mechanical rooms, etc.

3.03 DEMONSTRATION AND INSTRUCTIONS

A. Demonstrate complete and operating system to Owner.

END OF SECTION

SECTION 23 21 13 HYDRONIC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Hydronic system requirements.
- B. Heating water piping, above grade.
- C. Chilled water piping, above grade.
- D. Pipe hangers and supports.
- E. Unions, flanges, mechanical couplings, and dielectric connections.
- F. Valves:
 - 1. Ball valves.
 - 2. Butterfly valves.
 - 3. Check valves.
- G. Flow controls.

1.02 RELATED REQUIREMENTS

- A. Section 23 07 19 - HVAC Piping Insulation.
- B. Section 23 21 14 - Hydronic Specialties.

1.03 REFERENCE STANDARDS

- A. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; 2016.
- B. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; 2012.
- C. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2013.
- D. ASME B31.9 - Building Services Piping; 2014.
- E. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2012.
- F. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2016.
- G. ASTM B32 - Standard Specification for Solder Metal; 2008 (Reapproved 2014).
- H. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2016.
- I. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric); 2016.
- J. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers; 1992 (Reapproved 2014).
- K. ASTM F1476 - Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications; 2007 (Reapproved 2013).

- L. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding; 2011-AMD 1.
- M. AWS D1.1/D1.1M - Structural Welding Code - Steel; 2015 (with March 2016 Errata).
- N. AWWA C606 - Grooved and Shouldered Joints; 2015.
- O. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2009.

1.04 SUBMITTALS

- A. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- B. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Company specializing in performing work of the type specified in this section, with minimum three years of experience.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- B. Provide temporary protective coating on cast iron and steel valves.
- C. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- D. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.07 WARRANTY

- A. Provide 50 year limited warranty on press fittings from date of installation.

PART 2 PRODUCTS

2.01 HYDRONIC SYSTEM REQUIREMENTS

- A. Comply with ASME B31.9 and applicable federal, state, and local regulations.
- B. Piping: Provide piping, fittings, hangers and supports as required, as indicated, and as follows:
 - 1. Where more than one piping system material is specified, provide joining fittings that are compatible with piping materials and ensure that the integrity of the system is not jeopardized.
 - 2. Use non-conducting dielectric connections whenever jointing dissimilar metals.
 - 3. Provide pipe hangers and supports in accordance with ASME B31.9 or MSS SP-58 unless indicated otherwise.
- C. Pipe-to-Valve and Pipe-to-Equipment Connections: Use flanges, unions, or grooved couplings to allow disconnection of components for servicing; do not use direct welded, soldered, or threaded connections.
 - 1. Where grooved joints are used in piping, provide grooved valve/equipment connections if available; if not available, provide flanged ends and grooved flange adapters.

D. Valves: Provide valves where indicated:

1. Provide drain valves where indicated, and if not indicated provide at least at main shut-off, low points of piping, bases of vertical risers, and at equipment. Use 3/4 inch gate valves with cap; pipe to nearest floor drain.
2. Isolate equipment using butterfly valves with lug end flanges or grooved mechanical couplings.
3. For throttling, bypass, or manual flow control services, use ball or butterfly valves.
4. For throttling and isolation service in chilled and condenser water systems, use only butterfly valves.
5. In heating water or chilled water systems, butterfly valves may be used interchangeably with gate and globe valves.
6. For shut-off and to isolate parts of systems or vertical risers, use ball or butterfly valves.

E. Welding Materials and Procedures: Conform to ASME BPVC-IX.

2.02 HEATING WATER PIPING, ABOVE GRADE

A. Steel Pipe: ASTM A53/A53M, Schedule 40, black, using one of the following joint types:

1. Welded Joints: ASTM A234/A234M, wrought steel welding type fittings; AWS D1.1/D1.1M welded.
2. Threaded Joints: ASME B16.3, malleable iron fittings.
3. Grooved Joints: AWWA C606 grooved pipe, fittings of same material, and mechanical couplings.

B. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), drawn, using one of the following joint types:

1. Fittings: ASME B16.18, cast brass/bronze or ASME B16.22, wrought copper and bronze.
2. Solder Joints:
 - a. Solder: ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
 - b. Braze: AWS A5.8M/A5.8 BCuP copper/silver alloy.
3. Tee Connections: Mechanically extracted collars with notched and dimpled branch tube.
4. Mechanical Press Sealed Fittings: Double pressed type complying with ASME B16.22, utilizing EPDM, non toxic synthetic rubber sealing elements. Sealing elements shall be factory installed by fitting manufacturer. Press ends shall have means to indicate non-pressed fitting during pressure test.
 - a. Manufacturers:
 - 1) Viega LLC.
 - 2) Nibco.

2.03 CHILLED WATER PIPING, ABOVE GRADE

A. Steel Pipe: ASTM A53/A53M, Schedule 40, black; using one of the following joint types:

1. Welded Joints: ASTM A234/A234M, wrought steel welding type fittings; AWS D1.1/D1.1M welded.
2. Threaded Joints: ASME B16.3, malleable iron fittings.
3. Grooved Joints: AWWA C606 grooved pipe, fittings of same material, and mechanical couplings.

B. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), hard drawn; using one of the following joint types:

1. Fittings: ASME B16.18, cast brass/bronze or ASME B16.22, wrought copper and bronze.
2. Solder Joints:
 - a. Solder: ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
 - b. Braze: AWS A5.8M/A5.8 BCuP copper/silver alloy.
3. Tee Connections: Mechanically extracted collars with notched and dimpled branch tube.
4. Mechanical Press Sealed Fittings: Double pressed type complying with ASME B16.22, utilizing EPDM, non toxic synthetic rubber sealing elements. Sealing elements shall be factory installed by fitting manufacturer. Press ends shall have means to indicate non-pressed fitting during pressure testing.
 - a. Manufacturers:
 - 1) Viega LLC.
 - 2) Nibco.

2.04 EQUIPMENT DRAINS AND OVERFLOWS

- A. Steel Pipe: ASTM A53/A53M, Schedule 40 galvanized; using one of the following joint types:
 1. Threaded Joints: Galvanized cast iron, or ASME B16.3 malleable iron fittings.
 2. Grooved Joints: AWWA C606 grooved pipe, fittings of same material, and mechanical couplings.
- B. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), drawn; using one of the following joint types:
 1. Solder Joints: ASME B16.18 cast brass/bronze or ASME B16.22 solder wrought copper fittings; ASTM B32 lead-free solder, HB alloy (95-5 tin-antimony) or tin and silver.
 2. Grooved Joints: AWWA C606 grooved pipe, fittings of same material, and mechanical couplings.

2.05 PIPE HANGERS AND SUPPORTS

- A. Provide hangers and supports that comply with MSS SP-58.
 1. If type of hanger or support for a particular situation is not indicated, select appropriate type using MSS SP-58 recommendations.
- B. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Carbon steel, adjustable swivel, split ring.
- C. Hangers for Cold Pipe Sizes 2 Inches and Greater: Carbon steel, adjustable, clevis.
- D. Hangers for Hot Pipe Sizes 2 to 4 Inches: Carbon steel, adjustable, clevis.
- E. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
- F. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
- G. Vertical Support: Steel riser clamp.
- H. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- I. Floor Support for Hot Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- J. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
- K. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

- L. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.
- M. In grooved installations, use rigid couplings with offsetting angle-pattern bolt pads or with wedge shaped grooves in header piping to permit support and hanging in accordance with ASME B31.9.

2.06 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS

- A. Unions for Pipe 2 Inches and Less:
 - 1. Ferrous Piping: 150 psig malleable iron, threaded.
 - 2. Copper Pipe: Bronze, soldered joints.
- B. Flanges for Pipe 2 Inches and Greater:
 - 1. Ferrous Piping: 150 psig forged steel, slip-on.
 - 2. Copper Piping: Bronze.
 - 3. Gaskets: 1/16 inch thick preformed neoprene.
- C. Mechanical Couplings for Grooved and Shouldered Joints: Two or more curved housing segments with continuous key to engage pipe groove, circular C-profile gasket, and bolts to secure and compress gasket.
 - 1. Dimensions and Testing: In accordance with AWWA C606.
 - 2. Mechanical Couplings: Comply with ASTM F1476.
 - 3. Housing Material: Ductile iron, galvanized complying with ASTM A536.
 - 4. Gasket Material: EPDM suitable for operating temperature range from minus 30 degrees F to 230 degrees F.
 - 5. Bolts and Nuts: Hot dipped galvanized or zinc-electroplated steel.
 - 6. When pipe is field grooved, provide coupling manufacturer's grooving tools.
- D. Dielectric Connections:
 - 1. Waterways:
 - a. Water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint.
 - b. Dry insulation barrier able to withstand 600 volt breakdown test.
 - c. Construct of galvanized steel with threaded end connections to match connecting piping.
 - d. Suitable for the required operating pressures and temperatures.
 - 2. Flanges:
 - a. Dielectric flanges with same pressure ratings as standard flanges.
 - b. Water impervious insulation barrier capable of limiting galvanic current to 1 percent of short circuit current in a corresponding bimetallic joint.
 - c. Dry insulation barrier able to withstand 600 volt breakdown test.
 - d. Construct of galvanized steel with threaded end connections to match connecting piping.
 - e. Suitable for the required operating pressures and temperatures.

2.07 BALL VALVES

- A. Manufacturers:
 - 1. Nibco, Inc; Model S-585-70-66.
 - 2. Watts.

- 3. Apollo.
- B. Up To and Including 2 Inches:
 - 1. Bronze one piece body, chrome plated brass ball, teflon seats and stuffing box ring, lever handle with balancing stops, solder ends with union.
- C. Over 2 Inches:
 - 1. Ductile iron body, chrome plated stainless steel ball, teflon or Virgin TFE seat and stuffing box seals, lever handle, flanged ends, rated to 800 psi.

2.08 BUTTERFLY VALVES

- A. Manufacturers:
 - 1. Nibco; Model LD 2000.
 - 2. Crane Valve.
 - 3. Milwaukee Valve Company.
- B. Body: Ductile iron with resilient molded-in EPDM seat, lug ends, extended neck.
- C. Disc: Construct of aluminum bronze, geometric drive (one piece stem, no pin through disc).
- D. Stem: Stainless steel with stem offset from the centerline to provide full 360 degree circumferential setting.
- E. Operator: 10 position lever handle.

2.09 SWING CHECK VALVES

- A. Manufacturers:
 - 1. Nibco, Inc.
 - 2. Stockham.
 - 3. Grinnell.
 - 4. Jomar.
- B. Up To and Including 2 Inches:
 - 1. Bronze body, bronze trim, bronze rotating swing disc, with composition disc, solder ends.
 - 2. Nibco Model S-433-Y.
- C. Over 2 Inches:
 - 1. Iron body, bronze trim, bronze faced rotating swing disc, renewable disc and seat, flanged ends.
 - 2. Nibco Model F-918-B.

2.10 SPRING LOADED CHECK VALVES

- A. Manufacturers:
 - 1. Nibco, Inc.
 - 2. Hammond Valve.
 - 3. Milwaukee Valve Company.
- B. Iron body, bronze trim, split plate, hinged with stainless steel spring, resilient seal bonded to body, wafer or threaded lug ends.

2.11 FLOW CONTROLS

- A. Construction: Class 125, Brass or bronze body with union on inlet, temperature and pressure test plug on inlet and outlet, blowdown/backflush drain.
- B. Calibration: Control flow within 5 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, maximum minimum pressure 3.5 psi.

PART 3 EXECUTION

3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Prepare pipe for grooved mechanical joints as required by coupling manufacturer.
- C. Remove scale and dirt on inside and outside before assembly.
- D. Prepare piping connections to equipment using jointing system specified.
- E. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.
- F. After completion, fill, clean, and treat systems. Refer to Section 23 25 00 for additional requirements.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Press connections: Copper and copper alloy press connections shall be made in accordance with the manufacturer's installation instructions. The tubing shall be fully inserted into the fitting and the tubing marked at the shoulder of the fitting. The fitting alignment shall be checked against the mark on the tubing to assure the tubing is fully inserted in the fitting. The joints shall be pressed using the tool(s) approved by the manufacturer.
- C. Route piping in orderly manner, parallel to building structure, and maintain gradient.
- D. Install piping to conserve building space and to avoid interfere with use of space.
- E. Group piping whenever practical at common elevations.
- F. Sleeve pipe passing through partitions, walls and floors.
- G. Provide sleeve and watertight mechanical seal on all underground floor and wall penetrations.
- H. Slope piping and arrange to drain at low points.
- I. Grooved Joints:
 - 1. Install in accordance with the manufacturer's latest published installation instructions.
 - 2. Gaskets to be suitable for the intended service, molded, and produced by the coupling manufacturer.
- J. Pipe Hangers and Supports:
 - 1. Install in accordance with ASME B31.9, ASTM F708, or MSS SP-58.
 - 2. Support horizontal piping as scheduled.

3. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
 4. Place hangers within 12 inches of each horizontal elbow.
 5. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 6. Support vertical piping at every floor. Support riser piping independently of connected horizontal piping.
 7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 8. Provide copper plated hangers and supports for copper piping.
- K. Use eccentric reducers to maintain top of pipe level.
- L. Install valves with stems upright or horizontal, not inverted.

3.03 SCHEDULES

A. Hanger Spacing for Copper Tubing.

1. 1/2 inch and 3/4 inch: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. 1 inch: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. 1-1/2 inch and 2 inch: Maximum span, 8 feet; minimum rod size, 3/8 inch.
4. 2-1/2 inch: Maximum span, 9 feet; minimum rod size, 3/8 inch.
5. 3 inch: Maximum span, 10 feet; minimum rod size, 3/8 inch.
6. 4 inch: Maximum span, 12 feet; minimum rod size, 1/2 inch.

B. Hanger Spacing for Steel Piping.

1. 1/2 inch, 3/4 inch, and 1 inch: Maximum span, 7 feet; minimum rod size, 1/4 inch.
2. 1-1/4 inches: Maximum span, 8 feet; minimum rod size, 3/8 inch.
3. 1-1/2 inches: Maximum span, 9 feet; minimum rod size, 3/8 inch.
4. 2 inches: Maximum span, 10 feet; minimum rod size, 3/8 inch.
5. 2-1/2 inches: Maximum span, 11 feet; minimum rod size, 3/8 inch.
6. 3 inches: Maximum span, 12 feet; minimum rod size, 3/8 inch.
7. 4 inches: Maximum span, 14 feet; minimum rod size, 1/2 inch.

END OF SECTION

**SECTION 23 21 14
HYDRONIC SPECIALTIES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Air vents.
- B. Strainers.
- C. Combination pump discharge valves.
- D. Balancing valves.
- E. Combination flow controls.

1.02 RELATED REQUIREMENTS

- A. Section 23 21 13 - Hydronic Piping.

1.03 SUBMITTALS

- A. Product Data: Provide product data for manufactured products and assemblies required for this project. Include component sizes, rough-in requirements, service sizes, and finishes. Include product description and model.
- B. Project Record Documents: Record actual locations of flow controls.
- C. Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
- B. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
- C. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 PRODUCTS

2.01 AIR VENTS

- A. Manufacturers:
 - 1. ITT Bell & Gossett.
 - 2. Taco, Inc.
 - 3. Armstrong Fluid Technology.
- B. Manual Type: Short vertical sections of 2 inch diameter pipe to form air chamber, with 1/8 inch brass needle valve at top of chamber.

C. Float Type:

1. Brass or semi-steel body, copper, polypropylene, or solid non-metallic float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.
2. Cast iron body and cover, float, bronze pilot valve mechanism suitable for system operating temperature and pressure; with isolating valve.

2.02 STRAINERS

A. Manufacturers:

1. Wilkins.
2. Watts Regulator.

B. Size 2 inch and Under:

1. Screwed brass or iron body for 175 psi working pressure, Y pattern with 1/32 inch stainless steel perforated screen.

C. Size 2-1/2 inch to 4 inch:

1. Provide flanged or grooved iron body for 175 psi working pressure, Y pattern with 3/64 inch stainless steel perforated screen.

2.03 COMBINATION PUMP DISCHARGE VALVES

A. Manufacturers:

1. ITT Bell & Gossett.
2. Armstrong Fluid Technology.
3. Taco, Inc.

- B. Valves: Straight or angle pattern, flanged cast-iron valve body with bolt-on bonnet for 175 psi operating pressure, non-slam check valve with spring-loaded bronze disc and seat, stainless steel stem, and calibrated adjustment permitting flow regulation.

2.04 BALANCING VALVES

A. Size 2 inch and Smaller:

1. Provide ball or globe style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and NPT threaded or soldered connections.
2. Metal construction materials consist of bronze or brass.
3. Non-metal construction materials consist of Teflon, EPDM, or engineered resin.

2.05 COMBINATION FLOW CONTROLS

A. Manufacturers:

1. ITT Bell & Gossett.
2. Armstrong Fluid Technology.
3. Taco, Inc.

B. Construction:

1. Up to 2 inches; Bronze body, bronze trim.
2. Over 2 inches; Ductile iron body, bronze trim.

- C. Control Mechanism: Y-pattern globe valve and digital handwheel with memory stop, inside screw, rubber O-ring disc, solder or screwed ends. Valve shall provide precise flow measurement, precision flow balancing, positive shut-off with no drip seat and drain port for hose bib fitting.

2.06 AUTOMATIC FLOW CONTROLS

- A. Manufacturers:
1. Nexus.
 2. Flow Design.
 3. Griswold controls.
 4. Hays Fluid Controls.
- B. Construction: Brass or bronze body with union on inlet and outlet, temperature and pressure test plug on inlet and outlet with blowdown/backflush drain.
- C. Calibration: Control flow within 5 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, maximum minimum pressure 3.5 psi.
- D. Control Mechanism:
1. Stainless steel or nickel plated brass piston or regulator cup, operating against stainless steel helical or wave formed spring. Internal flow cartridge shall be permanently marked with GPM and spring range. Cartridge shall be removable for changeout.
 2. Precision sculptured brass or polyphenylsulfone orifice with high temperature elastomeric diaphragm. Internal flow parts shall be permanently marked with flow performance. Components shall be removable for changeout.
- E. Accessories: In-line strainer on inlet and ball valve on outlet.
- F. Provide a differential pressure test kit to verify flow and measure overheating. The kit shall consist of a 4-1/2" diaphragm gauge equipped with ten foot hoses and P/T adapters all housed in a vinyl case.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install specialties in accordance with manufacturer's instructions.
- B. Provide manual air vents at system high points and as indicated.
- C. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.
- D. Provide valved drain and hose connection on strainer blow down connection.
- E. Provide radiator valves on water inlet to heating and cooling coils.

END OF SECTION

SECTION 23 21 23 HYDRONIC PUMPS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. In-line circulators.

1.02 RELATED REQUIREMENTS

- A. Section 23 07 19 - HVAC Piping Insulation.
- B. Section 23 21 13 - Hydronic Piping.
- C. Section 23 21 14 - Hydronic Specialties.
- D. Section 26 27 17 - Equipment Wiring: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. UL 778 - Standard for Motor-Operated Water Pumps; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable. Include electrical characteristics and connection requirements.
- C. Operation and Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.
- D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 60 00 - Product Requirements, for additional provisions.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacture, assembly, and field performance of pumps, with minimum three years of documented experience.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Armstrong Fluid Technologies.
- B. ITT Bell & Gossett.
- C. Taco, Inc..

2.02 HVAC PUMPS - GENERAL

- A. Provide pumps that operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

- B. Products Requiring Electrical Connection: Listed and classified by UL or testing agency acceptable to Authority Having Jurisdiction as suitable for the purpose specified and indicated.

2.03 IN-LINE CIRCULATORS

- A. The pumps shall be a wet rotor inline pump, in cast iron or lead free bronze body construction specifically designed for quiet operation. Suitable standard operations at 230° F and 175 PSIG working pressure. The pump internals shall be capable of being serviced without disturbing piping connections.
- B. The pump internals shall be capable of being serviced without disturbing piping connections.
- C. Pump shall be equipped with a water-tight seal to prevent leakage.
- D. Pump volute shall be of a cast iron design for heating systems or lead free bronze for domestic water systems. The connection style on the cast iron and bronze pumps shall be flanged.
- E. Motor shall be a synchronous, permanent-magnet (PM) motor and tested with the pump as one unit. Conventional induction motors will not be acceptable.
- F. Each motor shall have an Integrated Variable Frequency Drive tested as one unit by the manufacturer.
- G. Integrated motor protection shall be verified by UL to protect the pump against over/under voltage, over temperature of motor and/or electronics, over current, locked rotor and dry run (no load condition).
- H. Pump shall have MODBUS or BACnet connections built into the VFD as standard options.
- I. Analog inputs, such as 0-10V and 4-20mA, are standard inputs built into the VFD.
- J. Pumps shall be UL 778 listed and bear the UL Listed Mark for USA and Canada with on-board thermal overload protection.
- K. Pumps shall be UL 778 listed and bear the UL Listing Mark for USA and Canada with on-board thermal overload protection.
- L. Each pump shall be factory performance tested before shipment.
- M. Operating Modes;
 - 1. Proportional Pressure - The differential pressure will continuously increase or decrease along a linear curve based on the flow demand.
 - 2. Constant Pressure - The pump maintains a constant differential pressure set by the user at any flow demand until the maximum speed is reached.
 - 3. Constant Speed - The pump maintains a constant speed at any flow rate
 - 4. Night Set Back - The pump will recognize a 10°C water temperature reduction and will switch to nighttime operation.
 - 5. T-Constant - This control will use a PI algorithm to vary the speed of the pump in order to maintain a constant temperature of the fluid media.
 - 6. Delta-T Constant - This control mode will use a PI algorithm to vary the speed of the pump in order to maintain a constant differential temperature between the built-in temperature sensor and external temperature sensor.

7. Delta-P-T - This control mode is paired with proportional or constant pressure mode. The nominal differential pressure setpoint will vary according to the fluid temperature.
8. Delta-P-Delta-T - This control mode is paired with proportional or constant pressure mode. The nominal differential pressure setpoint will vary according to the differential temperature between the built-in temperature sensor and external temperature sensor.

PART 3 EXECUTION

3.01 PREPARATION

- A. Verify that electric power is available and of the correct characteristics.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide access space around pumps for service. Provide no less than minimum space recommended by manufacturer.
- C. Provide line sized shut-off valve and strainer on pump suction, and line sized combination pump discharge valve on pump discharge.
- D. Lubricate pumps before start-up.

END OF SECTION

**SECTION 23 31 00
HVAC DUCTS AND CASINGS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Metal ductwork.

1.02 RELATED REQUIREMENTS

- A. Section 23 07 13 - Duct Insulation: External insulation and duct liner.

1.03 REFERENCE STANDARDS

- A. ASHRAE (FUND) - ASHRAE Handbook - Fundamentals; 2013.
- B. ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2014.
- C. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2015.
- D. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2016.
- E. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2015.
- F. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2005 (Rev. 2009).

1.04 REGULATORY REQUIREMENTS

- A. Construct ductwork to NFPA 90A standards.

1.05 FIELD CONDITIONS

- A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
- B. Maintain temperatures within acceptable range during and after installation of duct sealants.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Galvanized Steel for Ducts: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G90/Z275 coating.
- B. Joint Sealers and Sealants: Non-hardening, water resistant, mildew and mold resistant.
 - 1. Type: Heavy mastic or liquid used alone or with tape, suitable for joint configuration and compatible with substrates, and recommended by manufacturer for pressure class of ducts.
 - 2. VOC Content: Not more than 250 g/L, excluding water.
 - 3. Surface Burning Characteristics: Flame spread index of zero and smoke developed index of zero, when tested in accordance with ASTM E84.
- C. Hanger Rod: ASTM A36/A36M; steel, galvanized; threaded both ends, threaded one end, or continuously threaded.

- D. Ducts: Galvanized steel, unless otherwise indicated.
- E. Low Pressure Supply (System with Cooling Coils): 2 inch w.g. pressure class, galvanized steel.
- F. Medium and High Pressure Supply: 4 inch w.g. pressure class, galvanized steel.
- G. Return and Relief: 1 inch w.g. pressure class, galvanized steel.
- H. General Exhaust: 1 inch w.g. pressure class, galvanized steel.
- I. Ductmate or WDCI duct connection systems are acceptable. Ductwork constructed using these systems shall refer to manufacturer's recommendations for sheet metal gage intermediate and joint reinforcement.
- J. Outside Air Intake: 1/2 inch w.g. pressure class, galvanized steel.
- K. Interior gaskets for flanged connections shall be Ductmate 440 butyl rubber.

2.02 DUCTWORK FABRICATION

- A. Fabricate and support in accordance with SMACNA (DCS) and as indicated.
- B. No variation of duct configuration or size permitted except by written permission. Size round duct installed in place of rectangular ducts in accordance with ASHRAE (FUND) Handbook - Fundamentals.
- C. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- D. Construct T's, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows must be used, provide air foil turning vanes of perforated metal with glass fiber insulation.
- E. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- F. Fabricate continuously welded round and oval duct fittings in accordance with SMACNA (DCS).
- G. Where ducts are connected to exterior wall louvers and duct outlet is smaller than louver frame, provide blank-out panels sealing louver area around duct. Use same material as duct, painted black on exterior side; seal to louver frame and duct.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install, support, and seal ducts in accordance with SMACNA (DCS).
- B. Install in accordance with manufacturer's instructions.
- C. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
- D. Duct sizes indicated are inside clear dimensions. For lined ducts, maintain sizes inside lining.

- E. Duct sizes indicated shall be of sizes indicated. However, necessary changes in shape offsets or crossovers to clear piping, lighting, building construction obstructions, etc. shall be made without additional cost.
- F. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pilot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
- G. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- H. Use double nuts and lock washers on threaded rod supports.
- I. Connect terminal units to supply ducts with 1 foot maximum length of flexible duct. Do not use flexible duct to change direction.
- J. At exterior wall louvers, seal duct to louver frame.

3.02 CLEANING

- A. Clean duct system and force air at high velocity through duct to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment that could be harmed by excessive dirt with temporary filters, or bypass during cleaning.

END OF SECTION

**SECTION 23 33 00
AIR DUCT ACCESSORIES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Backdraft dampers - metal.
- B. Duct access doors.
- C. Duct test holes.

1.02 REFERENCE STANDARDS

- A. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2015.
- B. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2005 (Rev. 2009).

1.03 DELIVERY, STORAGE, AND HANDLING

- A. Protect dampers from damage to operating linkages and blades.

PART 2 PRODUCTS

2.01 BACKDRAFT DAMPERS - METAL

- A. Manufacturers:
 - 1. Ruskin Company.
 - 2. Greenheck.
 - 3. Vent Products.
- B. Gravity Backdraft Dampers, Size 18 by 18 inches or Smaller, Furnished with Air Moving Equipment: Air moving equipment manufacturer's standard construction.
- C. Multi-Blade, Parallel Action Gravity Balanced Backdraft Dampers: Galvanized steel, with center pivoted blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

2.02 DUCT ACCESS DOORS

- A. Manufacturers:
 - 1. Acudor Products Inc.
 - 2. Ruskin Company.
 - 3. Vent Products.
 - 4. Pottorff
- B. Fabrication: Rigid and close-fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ducts, install minimum 1 inch thick insulation with sheet metal cover.
 - 1. Larger Sizes: Provide an additional hinge.
- C. Access doors with sheet metal screw fasteners are not acceptable.

2.03 DUCT TEST HOLES

- A. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.
- B. Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

2.04 FLEXIBLE DUCT CONNECTIONS

- A. Fabricate in accordance with SMACNA (DCS) and as indicated.
- B. Flexible Duct Connections: Fabric crimped into metal edging strip.
 - 1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 30 oz per sq yd.

2.05 VOLUME CONTROL DAMPERS

- A. Manufacturers:
 - 1. Ruskin Company.
 - 2. Pottorff.
 - 3. Greenheck.
- B. Fabricate in accordance with SMACNA (DCS) and as indicated.
- C. Multi-Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 8 by 72 inch. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.
 - 1. Blade: 18 gage, 0.0478 inch, minimum.
- D. End Bearings: Except in round ducts 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon, thermoplastic elastomer, or sintered bronze bearings.
- E. Quadrants:
 - 1. Provide locking, indicating quadrant regulators on single and multi-blade dampers.
 - 2. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

PART 3 EXECUTION

3.01 PREPARATION

- A. Verify that electric power is available and of the correct characteristics.

3.02 INSTALLATION

- A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA (DCS). Refer to Section 23 31 00 for duct construction and pressure class.
- B. Provide backdraft dampers on exhaust fans or exhaust ducts nearest to outside and where indicated.
- C. Provide duct test holes where indicated and required for testing and balancing purposes.

- D. At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.
- E. At equipment supported by vibration isolators, provide flexible duct connections immediately adjacent to the equipment.

END OF SECTION

**SECTION 23 34 23
POWER VENTILATORS**

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Roof exhausters.

1.02 RELATED REQUIREMENTS

A. Section 23 33 00 - Air Duct Accessories: Backdraft dampers.

B. Section 26 27 17 - Equipment Wiring: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

A. AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program; <http://www.amca.org/certified/search/company.aspx>.

B. AMCA 99 - Standards Handbook; 2010.

C. AMCA 204 - Balance Quality and Vibration Levels for Fans; 2005.

D. AMCA 300 - Reverberant Room Method for Sound Testing of Fans; 2014.

E. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data; 2014.

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.

B. Product Data: Provide data on fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels at rated capacity, and electrical characteristics and connection requirements.

C. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

1.05 FIELD CONDITIONS

A. Permanent ventilators may not be used for ventilation during construction.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Greenheck.

B. Loren Cook Company; Model ACE-D VF.

C. Twin City Fan & Blower.

2.02 POWER VENTILATORS - GENERAL

A. Static and Dynamically Balanced: AMCA 204 - Balance Quality and Vibration Levels for Fans.

- B. Performance Ratings: Determined in accordance with AMCA 210 and bearing the AMCA Certified Rating Seal.
- C. Sound Ratings: AMCA 301, tested to AMCA 300 and bearing AMCA Certified Sound Rating Seal.
- D. Fabrication: Conform to AMCA 99.
- E. Electrical Components: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

2.03 ROOF EXHAUSTERS

- A. Fan Unit: Permanently lubricated ECM motor, direct driven, with spun aluminum housing; resilient mounted motor; 1/2 inch mesh, 0.62 inch thick aluminum wire birdscreen; square base to suit roof curb with continuous curb gaskets.
- B. Upblast or downblast as scheduled.
- C. Finish: Factory applied baked enamel/polyester of color as selected.
- D. Roof Curb: 12 inch high self-flashing of galvanized steel with continuously welded seams, built-in cant strips.
- E. Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload protected motor.
- F. Backdraft Damper: Aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked, and line voltage motor drive, power open, spring return.
- G. Motor: Electronically commutated motor rated for continuous duty and furnished with leads for connection to 0-10 VDC external controller.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Secure roof exhausters with cadmium plated steel lag screws to roof curb.
- C. Extend ducts to roof exhausters into roof curb. Counterflash duct to roof opening.
- D. Provide sheaves required for final air balance.
- E. Install backdraft dampers on inlet to roof and wall exhausters.

END OF SECTION

SECTION 23 36 00
AIR TERMINAL UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Single-duct terminal units.
 - 1. Single-duct, variable-volume units.

1.02 RELATED REQUIREMENTS

- A. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment.
- B. Section 23 09 23 - Direct-Digital Control System for HVAC.
- C. Section 23 21 13 - Hydronic Piping: Connections to heating coils.
- D. Section 23 31 00 - HVAC Ducts and Casings.

1.03 REFERENCE STANDARDS

- A. AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils; 2001 (R2011).
- B. AHRI 880 (I-P) - Performance Rating of Air Terminals; 2011 with Addendum 1.
- C. ASHRAE Std 130 - Methods of Testing Air Terminal Units; 2008 (R2014).
- D. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material); 2012.
- E. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- F. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2015.
- G. SMACNA (SRM) - Seismic Restraint Manual Guidelines for Mechanical Systems; Sheet Metal and Air Conditioning Contractors' National Association; 2008.
- H. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; current edition, including all revisions.

1.04 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings that indicate air flow, static pressure, and NC designation. Include electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate configuration, general assembly, and materials used in fabrication, and electrical characteristics and connection requirements.
 - 1. Include schedules listing discharge and radiated sound power level for each of second through sixth octave bands at inlet static pressures of 1 to 4 inch wg.

- D. Project Record Documents: Record actual locations of units and controls components and locations of access doors required for access of valving.
- E. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant-volume regulators.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

PART 2 PRODUCTS

2.01 SINGLE-DUCT, VARIABLE-VOLUME UNITS

- A. Manufacturers:
 - 1. Price Industries, Inc.
 - 2. Titus.
 - 3. Nailor.
 - 4. Metalaire.
- B. General:
 - 1. Factory-assembled, AHRI 880 (I-P) rated and bearing the AHRI seal, air volume control terminal with damper assembly, flow sensor, externally mounted volume controller, duct collars, and all required features.
 - 2. Control box bearing identification, including but not necessarily limited to nominal cfm, maximum and minimum factory-set airflow limits, coil type and coil (right or left hand) connection, where applicable.
- C. Unit Casing:
 - 1. Minimum 22 gage, 0.0299 inch galvanized steel.
 - a. Assembled with longitudinal lock seam construction.
 - b. Casing leakage to meet ASHRAE Std 130.
 - 2. Air Inlet Collar: Provide round, suitable for standard flexible duct sizes.
 - 3. Unit Discharge: Rectangular, with slip-and-drive connections.
 - 4. Acceptable Liners:
 - a. 1/2 inch thick, coated, fibrous-glass complying with ASTM C1071.
 - 1) Secure with adhesive.
 - 2) Coat edges exposed to airstream with NFPA 90A approved sealant.
 - 3) Cover liner with non-porous foil.
 - b. Liner not to contain pentabrominated diphenyl ether (CAS #32534-81-9) or octabrominated diphenyl ether.
- D. Damper Assembly:
 - 1. Heavy-gage, galvanized steel or extruded aluminum construction with solid steel, nickel-plated shaft pivoting on HDPE, self-lubricating bearings.
 - 2. Provide integral position indicator or alternative method for indicating damper position over full range of 90 degrees.

3. Incorporate low leak damper blades for tight airflow shutoff.
- E. Hot Water Heating Coil:
1. Coil Casing: Minimum 22 gage, 0.0299 inch galvanized steel, factory-installed on terminal discharge with rectangular outlet, duct connection type.
 - a. Right or left coil inlets.
 2. Coil Fins: Aluminum or aluminum plated fins, mechanically-bonded to seamless copper tubes.
 3. Coil leak tested to minimum 350 psig.
 4. Base performance data on tests run in accordance with AHRI 410 and units to bear AHRI 410 label.
- F. Electrical Requirements:
1. Single-point power connection.
 2. Equipment wiring to comply with requirements of NFPA 70.
- G. Control Transformers: Factory supplied and mounted for electric and electronic control applications.
- H. Controls:
1. DDC (Direct-Digital Controls):
 - a. Include a factory-installed, unit-mounted, direct-digital controller.
 - b. Bi-directional Damper Actuator: 24 volt, powered closed, spring return open.
 - c. Microprocessor-Based Controller: Air volume controller, pressure-independent with electronic airflow transducers, factory-calibrated maximum and minimum CFM's.
 - 1) Occupied and unoccupied operating mode.
 - 2) Remote reset of temperature or CFM set points.
 - 3) Proportional, plus integral control of room temperature.
 - 4) Monitoring and adjusting with portable terminal.
 2. Airflow Sensor: Differential pressure airflow device measuring total, static, and wake pressures.
 - a. Provides accuracy within 5 percent with a 90 degree sheet metal elbow directly at the inlet of the assembly.
 - b. Control tubing is protected by grommets at the wall of the air flow sensor's housing.
 - c. Provide sensor with a pressure transducer to interface with a DDC system.
 - d. Signal accuracy: Plus/minus five percent throughout terminal operating range.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that conditions are suitable for installation.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install the inlets of air terminal units and air flow sensors a minimum of four duct diameters from elbows, transitions, and duct takeoffs.
- C. Support units individually from structure in accordance with SMACNA (SRM).

- D. Do not support from ductwork.
- E. Connect to ductwork in accordance with Section 23 31 00.
- F. Verify that electric power is available and of the correct characteristics.

3.03 ADJUSTING

- A. Reset volume with damper operator attached to assembly allowing flow range modulation from 100 percent of design flow to zero percent full flow. Set units with heating coils for minimum scheduled percent full flow.

3.04 CLEANING

- A. Vacuum clean coils and inside of units.

END OF SECTION

**SECTION 23 37 00
AIR OUTLETS AND INLETS**

PART 1 GENERAL

1.01 SECTION INCLUDES

A. Louvers.

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS

A. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating; 2012.

B. SMACNA (ASMM) - Architectural Sheet Metal Manual; 2012.

1.04 SUBMITTALS

A. See Section 01 30 00 - Administrative Requirements for submittal procedures.

B. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.

1.05 QUALITY ASSURANCE

A. Test and rate louver performance in accordance with AMCA 500-L.

B. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

PART 2 PRODUCTS

2.01 LOUVERS

A. Manufacturers;

1. Ruskin; Model ELF6375DX.

2. Greenheck.

3. Pottorff.

B. Type: 6 inch deep with blades on 45 degree slope with center baffle and return bend, heavy channel frame, 1/2 inch square mesh screen over exhaust and 1/2 inch square mesh screen over intake.

C. Flange mount installation.

D. Frame: 6063T5 extruded aluminum, 0.081" nominal wall thickness.

E. Blades: 6063T5 extruded aluminum, 0.081" nominal wall thickness, drainable.

F. Color: To be selected by Architect/Engineer from manufacturer's standard range.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Comply with SMACNA (ASMM) for flashing/counter-flashing of roof penetrations and supports for roof curbs and roof mounted equipment.

END OF SECTION

SECTION 23 73 13
MODULAR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Casing construction.
- B. Fan section.
- C. Coil section.
- D. Filter section.
- E. Damper section.

1.02 RELATED REQUIREMENTS

- A. Section 23 33 00 - Air Duct Accessories: Flexible duct connections.
- B. Section 26 27 17 - Equipment Wiring: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings; 2015.
- B. AHRI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils; 2001 (R2011).
- C. AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program; <http://www.amca.org/certified/search/company.aspx>.
- D. AMCA 99 - Standards Handbook; 2010.
- E. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size; 2012, with 2015 amendments.
- F. ASHRAE Std 62.1 - Ventilation for Acceptable Indoor Air Quality; 2016.
- G. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- H. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2015.
- I. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2005 (Rev. 2009).
- J. UL (DIR) - Online Certifications Directory; current listings at database.ul.com.

1.04 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data:
 - 1. Published Literature: Indicate dimensions, weights, capacities, ratings, gages and finishes of materials, and electrical characteristics and connection requirements.
 - 2. Filters: Data for filter media, filter performance data, filter assembly, and filter frames.
 - 3. Fans: Performance and fan curves with specified operating point clearly plotted, power, RPM.

4. Sound Power Level Data: Fan outlet and casing radiation at rated capacity.
 5. Electrical Requirements: Power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
- C. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
- D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
1. Extra Fan Belts: One set for each unit.
 2. Extra Filters: One set for each unit.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.

1.06 REGULATORY REQUIREMENTS

- A. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for the purpose specified and indicated.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Accept products on site in factory-fabricated protective containers, with factory-installed shipping skids and lifting lugs. Inspect for damage.
- B. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.
- C. Do not operate units until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.08 WARRANTY

- A. See Section 01 78 00 - Closeout Submittals, for additional warranty requirements.
- B. Provide minimum one year manufacturer warranty covering repair or replacement due to defective materials or workmanship.

PART 2 PRODUCTS

2.01 PACKAGED AIR HANDLING UNITS

- A. Manufacturers;
1. Carrier Corporation.
 2. Daikin Applied.
 3. Trane Inc.

2.02 CASING CONSTRUCTION

- A. Casing:
1. Construct of one piece, insulated, double wall panels.
 2. Provide mid-span, no through metal, internal thermal break.

3. Construct outer panels of galvanized steel and inner panels of galvanized steel.
- B. Access Doors:
1. Construction, thermal and air pressure performance same as casing.
 2. Provide surface mounted handles on hinged, swing doors.
- C. Unit Flooring: Construct with sufficient strength to support expected people and equipment loads associated with maintenance activities.
- D. Casing Leakage: Seal joints and provide airtight access doors so that air leakage does not exceed one percent of design flow at the specified casing pressure.
- E. Insulation:
1. Provide minimum thermal thickness of 13 R throughout.
 2. Completely fill panel cavities in each direction to prevent voids and settling.
 3. Comply with NFPA 90A.
- F. Drain Pan Construction:
1. Provide cooling coil sections with an insulated, double wall, galvanized steel drain pan complying with ASHRAE 62.1 for indoor air quality and sufficiently sized to collect condensate.
 2. Slope in two planes to promote positive drainage and eliminate stagnate water conditions.
 3. Locate outlet of sufficient diameter at lowest point of pan to prevent overflow at normal operating conditions.
 4. Provide threaded drain connections constructed of drain pan material, extended sufficient distance beyond the base to accommodate field installed, condensate drain trapping.
 5. Louvers: Stationary, of galvanized steel, 4 inch deep with plenum, nylon bearings, 1/2 inch mesh, 0.04 inch galvanized wire bird screen in aluminum frame, and bearing AMCA Certified Ratings Seal in accordance with AMCA 500-L. Furnish adjustable louvers with hollow vinyl bulb edging on blades and foam side stops to limit leakage to maximum 2 percent at 4 inch wg differential pressure when sized for 2000 fpm face velocity.
- G. Finish:
1. Indoor Units:
 - a. Provide exterior, galvanized steel panels without paint.

2.03 FAN SECTION

- A. Type: Forward curved, single width, single inlet, centrifugal type fan, conforming to AMCA 99. Refer to Section 23 34 13.
1. Performance Ratings: Determined in accordance with AMCA 210 and labeled with AMCA Certified Rating Seal.
 2. Sound Ratings: AMCA 301; tested to AMCA 300 and label with AMCA Certified Sound Rating Seal.
- B. Bearings: Self-aligning, grease lubricated, with lubrication fittings extended to exterior of casing with plastic tube and grease fitting rigidly attached to casing.
- C. Mounting:
1. Locate fan and motor internally on welded steel base coated with corrosion resistant paint.

2. Provide access to motor, drive, and bearings through removable casing panels or hinged access doors.
 3. Mount base on vibration isolators.
- D. External Motor Junction Box: Factory mount NEMA 4 external junction box and connect to extended motor leads from internally mounted motors.
- E. Motor Wiring Conduit: Factory wire fan motor wiring to the unit mounted variable frequency drive.
- F. Drives:
1. Conform to AMCA 99.
 2. Bearings: Heavy duty pillow block type, ball bearings, with ABMA STD 9, L-10 life at 50,000 hours.
 3. Shafts: Solid, hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.
 4. V-Belt Drive: Cast iron or steel sheaves, dynamically balanced, bored to fit shafts, and keyed. Variable and adjustable pitch sheaves for motors 15 hp and under selected so required rpm is obtained with sheaves set at mid-position; fixed sheave for 20 hp and over, matched belts, and drive rated as recommended by manufacturer or minimum 1.5 times nameplate rating of the motor.
 5. Belt Guard: Fabricate to SMACNA (DCS); 0.106 inch thick, 3/4 inch diamond mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation, with provision for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

2.04 COIL SECTION

- A. Casing: Provide access to coils. Enclose coils with headers and return bends exposed outside casing. Slide coils into casing through removable end panel with blank off sheets and sealing collars at connection penetrations.
1. Drain Pans: Downstream of coil and down spouts for cooling coil banks more than one coil high.
 2. Air Coils:
 - a. Certify capacities, pressure drops, and selection procedures in accordance with AHRI 410.
 3. Fabrication:
 - a. Tubes: 5/8 inch OD seamless copper expanded into fins, brazed joints.
 - b. Fins: Aluminum.
 - c. Casing: Die formed channel frame of galvanized steel.
 4. Water Heating Coils:
 - a. Headers: Cast iron, seamless copper tube, or prime coated steel pipe with brazed joints.
 - b. Configuration: Drainable, with threaded plugs for drain and vent; serpentine type with return bends on smaller sizes and return headers on larger sizes.
 5. Water Cooling Coils:
 - a. Headers: Cast iron, seamless copper tube, or prime coated steel pipe with brazed joints.
 - b. Configuration: Drainable, with threaded plugs for drain and vent; threaded plugs in return bends and in headers opposite each tube.

2.05 FILTER SECTION

- A. General: Provide filter sections with filter racks, minimum of one access door for filter removal, and filter block-offs to prevent air bypass.
- B. Pleated Media Filters:
 - 1. Media: 2 inch, 100 percent synthetic fibers, continuously laminated to a grid with water repellent adhesive, and capable of operating up to a maximum of 625 fpm without loss of efficiency and holding capacity.
 - 2. Frame: Steel wire grid.
 - 3. Minimum Efficiency Reporting Value: 8 MERV when tested in accordance with ASHRAE 52.2.

2.06 DAMPER SECTION

- A. Mixing Section: Provide a functional section to support the damper assembly for modulating the volume of outdoor and return air.
- B. Damper Blades:
 - 1. Double-skin airfoil design with metal, compressible jamb seals and extruded-vinyl blade-edge seals on each blade.
 - 2. Self-lubricating stainless steel or synthetic sleeve bearings.
 - 3. Comply with ASHRAE 90.1 for rated maximum leakage rate.
 - 4. Provide leakage testing and pressure ratings in compliance with AMCA 500-D test methods.
 - 5. Arrange in parallel or opposed-blade configuration.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Bolt sections together with gaskets.
- C. Install flexible duct connections between fan inlet and discharge ductwork and air handling unit sections. Ensure that metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.
- D. Install assembled unit on vibration isolators. Install isolated fans with resilient mountings and flexible electrical leads. Install restraining snubbers as indicated. Refer to Section 23 05 48. Adjust snubbers to prevent tension in flexible connectors when fan is operating.
- E. Make connections to coils with unions or flanges.
- F. Hydronic Coils:
 - 1. Hydronic Coils: Connect water supply to leaving air side of coil (counterflow arrangement).
 - 2. Provide shut-off valve on supply line and lockshield balancing valve with memory stop on return line.
 - 3. Locate water supply at bottom of supply header and return water connection at top.
 - 4. Provide manual air vents at high points complete with stop valve.
 - 5. Ensure water coils are drainable and provide drain connection at low points.
- G. Cooling Coils:

1. Pipe drain and overflow to nearest floor drain.

H. Field-wire each factory provided control for field installation.

3.02 SYSTEM STARTUP

A. Prepare and start equipment and systems in accordance with manufacturers' instructions and recommendations.

END OF SECTION

SECTION 26 05 00
BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SECTION INCLUDES

- A. Basic Electrical Requirements and materials specifically applicable to Division 26 Sections, in addition to Division 1 - General Requirements. Section includes:
 1. Electrical Identification.
 2. Minor Demolition.
 3. Conductors and Devices.
 4. Raceways and Boxes.
 5. Supporting Devices.

1.03 REGULATORY REQUIREMENTS

- A. Conform to NFPA 70 - National Electrical Code, latest edition with amendments as adopted by the City of Joliet, IL.
- B. Conform to building codes as adopted by the City of Joliet, IL.
- C. Install electrical Work in accordance with the NECA Standard of Installation.

1.04 DELIVERY, STORAGE AND HANDLING

- A. Store and protect all materials as specified under the provisions of Section 01 60 00 and as specified herein.
- B. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.
- C. Ship products to the job site in their original packaging. Receive and store products in a suitable manner to prevent damage or deterioration. Keep equipment upright at all times.
- D. Investigate the spaces through which equipment must pass to reach its final destination. Coordinate with the manufacturer to arrange delivery at the proper stage of construction and to provide shipping splits where necessary.

1.05 PROJECT/SITE CONDITIONS

- A. Install work in locations shown on Drawings, unless prevented by Project conditions. Drawings have omitted certain branch circuitry in areas for ease of reading. All branch circuitry is to be provided by Contractor.
- B. Prepare drawings showing proposed rearrangement of Work to meet Project conditions, including changes to Work specified in other Sections. Obtain permission from Architect/Engineer before proceeding as specified under modification procedures.

1.06 QUALITY ASSURANCE

- A. Provide Work as required for a complete and operational electrical installation.
- B. All products shall be designed, manufactured, and tested in accordance with industry standards. Standards, organizations, and their abbreviations as used hereafter, include the following:
 - 1. American National Standards Institute, Inc (ANSI).
 - 2. American Society for Testing and Materials (ASTM).
 - 3. National Electrical Manufacturers Association (NEMA).
 - 4. Underwriters Laboratories, Inc. (UL).
- C. Install all Work in accordance with the NECA Standard of Installation.

1.07 SUBMITTALS

- A. Submit all requested items in Division 26 Sections under provisions of Section 01 30 00.

1.08 SUBSTITUTIONS

- A. Substitutions will be considered only as allowed within the provisions of Section 01 60 00.

1.09 PROJECT RECORD DOCUMENTS

- A. Cooperate and assist in the preparation of project record documents under the provisions of Section 01 78 00.

1.10 PROJECT MANAGEMENT AND COORDINATION

- A. Proper project management and coordination is critical for a successful project. Manage and coordinate the Work with all other trades in accordance with Section 01 30 00 requirements. Reliance on the Drawings and Specifications only for exact project requirements is insufficient for proper coordination.

PART 2 PRODUCTS

2.01 WIRING METHODS

- A. All locations: Building wire in raceway.
- B. Use no wire smaller than 12 AWG for power and lighting circuits, and no smaller than 14 AWG for control wiring.
 - 1. Use 10 AWG conductor for 20 ampere, 120 volt branch circuit home runs longer than 100 feet. Use minimum #10 AWG conductor wire in all the following locations:
 - a. All programmable panel branch circuits (larger where indicated).
 - b. All emergency lighting and exit branch circuits.

2.02 WIRE AND CABLE

- A. Manufacturers:
 - 1. Okonite.
 - 2. Southwire.
 - 3. Collyer.
- B. Building Wire:

1. Feeders and Branch Circuits Larger Than 6 AWG: Copper, stranded conductor, 600 volt insulation.
2. Feeders and Branch Circuits 6 AWG and Smaller: Copper conductor, 600 volt insulation. 6 and 8 AWG, stranded conductor; smaller than 8 AWG, stranded conductor (solid for device terminations).
3. Control Circuits: Copper, stranded conductor, 600 volt insulation.
4. Use 10 AWG conductors for 20 ampere, 120 volt branch circuits longer than 75 feet.
5. Use 10 AWG conductors for 20 ampere, 277 volt branch circuits longer than 200 feet.
6. Use conductor not smaller than 12 AWG for power and lighting circuits.
7. Use conductor not smaller than 16 AWG for control circuits.

C. Locations:

1. Concealed Dry Interior Locations: Use only building wire with Type THHN insulation in raceway.
2. Exposed Dry Interior Locations: Use only building wire with Type THHN insulation in raceway.
3. Above Accessible Ceilings: Use only building wire with Type THHN insulation in raceway.
4. Wet or Damp Interior Locations: Use only building wire with Type THWN insulation in raceway.
5. Exterior Locations: Use only building wire with Type XHHW insulation in raceway.
6. Underground Installations: Use only building wire with Type XHHW insulation in raceway.

2.03 RACEWAY REQUIREMENTS

A. Use only specified raceway in the following locations:

1. Branch Circuits and Feeders:
 - a. Concealed Dry Interior Locations: Electrical metallic tubing.
 - b. Exposed Dry Interior Finished Locations: Electrical metallic tubing.
 - c. Exposed Dry Interior Unfinished Locations: Electrical metallic tubing.
 - d. All other locations: Galvanized Rigid Metallic Conduit.

B. Size raceways for conductor type installed.

1. Minimum Size Conduit Homerun to Panelboard: 3/4-inch.

2.04 METALLIC CONDUIT AND FITTINGS

A. Conduit:

1. Rigid Steel Conduit: ANSI C80.1.
2. Electrical metallic tubing: ANSI C80.3.
3. Flexible Conduit: UL 1, zinc-coated steel.
 - a. Liquidtight Flexible Conduit: UL360. Fittings shall be specifically approved for use with this raceway.

B. Conduit Fittings:

1. Metal Fittings and Conduit Bodies: NEMA FB 1.
 - a. EMT fittings: Use set-screw indentor-type fittings.

2.05 NONMETALLIC TUBING

A. Manufacturers:

1. Carlon Co.
2. LCP National Plastics, Inc.

3. Pacific Western Extruded Plastics Co.

B. Description: UL651A "Type EB and A PVC Conduit and HDPE Conduit."

1. Conduit: Schedule 40. Suitable for exposure to sunlight and direct burial.

2.06 CONDUIT HANGERS

A. Manufacturers:

1. Minerrallac Electric Company.
2. Substitutions: Or Approved Equal.

B. Description:

1. Standard conduit hanger, zinc-plated steel with bolts.
2. Threaded rod and hardware: Plated finish, size and length as required for loading and conditions.

2.07 BEAM CLAMPS

A. Manufacturers:

1. Appleton.
2. Midwest.
3. Raco.

B. Description: Malleable beam clamp, zinc plated steel.

2.08 ELECTRICAL BOXES

A. Manufacturers:

1. Raco.
2. Steel City.
3. Appleton.
4. Substitutions: Or Approved Equal.

B. Sheet Metal Outlet Boxes: ANSI/NEMA OS 1, galvanized steel, suitable for installation in masonry:

C. Equipment Support Boxes: Rated for weight of equipment supported; include 2 inch male fixture studs where required.

D. Wet Location Outlet Boxes: Cast aluminum: Cast alloy, deep type, gasket cover, threaded hubs.

2.09 PENETRATION SEALANTS

A. Fire-rated assemblies: Provide firestopping of all penetrations made by Work under this Contract in accordance with provisions of Section 07 84 00 requirements.

B. Thermal and Moisture Protection: Provide thermal and moisture protection made by Work under this Contract of all exterior wall, floor and roof penetrations in accordance with Division 7 requirements.

2.10 NAMEPLATES AND LABELS

A. Nameplates: Engraved three-layer laminated plastic, black letters on white background.

- B. Locations:
 - 1. Each electrical distribution and control equipment enclosure.
- C. Letter Size:
 - 1. Use 1/8 inch letters for identifying individual equipment and loads.
 - 2. Use 1/4 inch letters for identifying grouped equipment and loads.
- D. Labels: Embossed adhesive tape, with 3/16 inch white letters on a black background. Use only for identification of individual wall switches and receptacles and control device stations.

2.11 WIRE AND CABLE MARKERS

- A. Manufacturers:
 - 1. Brady Model PCPS.
 - 2. Panduit Model PCM.
 - 3. T & B Model WM.
- B. Description: Cloth type wire markers.
- C. Locations: Each conductor at panelboard gutters, pull boxes, and each load connection.
- D. Legend:
 - 1. Power and Lighting Circuits: Branch circuit or feeder number indicated on drawings.

2.12 CONDUIT MARKERS

- A. Location: Furnish markers for each conduit longer than 6 feet.
- B. Spacing: 20 feet on center.
- C. Color:
 - 1. 480 Volt System: Orange
 - 2. 208 Volt System: Black
 - 3. Fire Alarm System: Red.

PART 3 EXECUTION

3.01 EXAMINATION AND PREPARATION

- A. Demolition Drawings are based on casual field observation and are intended to identify the limits of the construction site. Remove all electrical systems in their entirety in proper sequence with the Work.
- B. Disconnect electrical systems in walls, floors, and ceilings for removal.
- C. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.
- D. Existing Electrical Service and Emergency Electrical Service: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Obtain permission from Owner and Architect at least 24 hours before partially or

completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

- E. Existing Fire Alarm System: Maintain existing system in service until new system is accepted. Disable system only to make switchovers and connections. Notify Owner, Architect/Engineer and local fire service at least 24 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.
- F. Beginning of demolition means installer accepts existing conditions.
- G. Verify that supporting surfaces are ready to receive work.
- H. Electrical boxes are shown on Drawings, in approximate locations, unless dimensioned.
 - 1. Obtain verification from Architect/Engineer for locations of outlets throughout prior to rough-in.
- I. Degrease and clean surfaces to receive wire markers.
- J. Verify that interior of building is physically protected from weather.
- K. Verify that mechanical work which is likely to injure conductors has been completed.
- L. Completely and thoroughly swab raceway system before installing conductors.

3.02 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

- A. Remove all existing electrical installations to accommodate new construction.
- B. Remove abandoned wiring to source of supply.
- C. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.
- D. Relocate existing fire alarm devices affected by wall, ceiling and floor demolition.
- E. Repair adjacent construction and finishes damaged during demolition and extension work.
- F. Properly dispose of all ballast to approved ballast recycler. Do not land fill ballasts.

3.03 APPLICATION

- A. Install nameplate and label parallel to equipment lines.
- B. Secure nameplate to equipment front using screws.
- C. Secure nameplates to inside surface of door on panelboard that is recessed in finished locations.
- D. Identify underground conduits using underground warning tape. Install one tape per trench at 3 inches below finished grade.
- E. Neatly train and secure wiring inside boxes, equipment, and panelboards.
- F. Use wire pulling lubricant for pulling 4 AWG and larger wires.
- G. Route wire and cable as required to meet project conditions.
 - 1. Wire and cable routing indicated is approximate unless dimensioned.
 - 2. Where wire and cable destination is indicated and routing is not shown, determine exact routing and lengths required.

- H. Pull all conductors into raceway at same time.
- I. Protect exposed cable from damage.
- J. Neatly train and lace wiring inside boxes, equipment and panelboards.
- K. Support cables above accessible ceilings to keep them from resting on ceiling tiles.
- L. Make splices, taps, and terminations to carry full ampacity of conductors without perceptible temperature rise.
- M. Use split bolt connectors for copper conductor splices and taps, 6 AWG and larger. Tape uninsulated conductors and connector with electrical tape to 150 percent of insulation rating of conductor.
- N. Provide anchors, fasteners, and supports in accordance with NECA "Standard of Installation".
- O. Do not fasten supports to pipes, ducts, mechanical equipment, and conduit.
- P. Do not use powder-actuated anchors.
- Q. Do not drill or cut structural members.
- R. Fabricate supports from structural steel or steel channel. Rigidly weld members or use hexagon head bolts to present neat appearance with adequate strength and rigidity. Use spring lock washers under all nuts.
- S. Install surface-mounted cabinets and panelboards with minimum of four anchors.
- T. In wet and damp locations use steel channel supports to stand cabinets and panelboards one inch off wall.
- U. Use sheet metal channel to bridge studs above and below cabinets and panelboards recessed in hollow partitions.
- V. Terminate spare conductors with electrical tape.
- W. Do not share neutral conductor on load side of dimmers.
- X. Install wiring devices in accordance with manufacturer's instructions.
 - 1. Install wall switches at height shown on drawings, OFF position down.
 - 2. Install convenience receptacles at height shown on drawings grounding pole on bottom.
 - 3. Install specific purpose receptacles at heights shown on Drawings.
- Y. Install wall plates flush and level.
 - 1. Install decorative plates on switch, receptacle, and blank outlets in finished areas.
 - 2. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface-mounted outlets.

END OF SECTION

SECTION 26 27 17 EQUIPMENT WIRING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Electrical connections to equipment and devices not and integral part of the electrical distribution system.

1.02 RELATED REQUIREMENTS

- A. Section 26 05 00 - Basic Electrical Requirements

1.03 REFERENCE STANDARDS

- A. NEMA WD 1 - General Color Requirements for Wiring Devices; 1999 (R2015).
- B. NEMA WD 6 - Wiring Devices - Dimensional Specifications; 2016.
- C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Provide conduit rough-in and electrical connection to powered equipment and devices identified in the Project Manual and on the Drawings. Refer specifically, but not limited to, these Specification Sections for further information:
 - 1. Section 23 09 23 - Direct-Digital Control System for HVAC.
 - 2. Section 23 21 23 - Hydronic Pumps.
 - 3. Section 23 73 13 - Modular Central-Station Air-Handling Units
- B. Coordination: Determine connection locations and requirements for furniture, equipment and devices furnished or provided under other sections.
 - 1. Do not rely solely on the Drawings and Project Manual for execution of the Work of this Section.
 - 2. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions.
 - 3. Include necessary field evaluation time to inspect connection requirements.
 - 4. Coordinate with other trades to determine exact rough-in requirements.
- C. Sequencing:
 - 1. Install rough-in of electrical connections before installation of furniture and equipment is required.
 - 2. Make electrical connections before required start-up of equipment.

1.05 SUBMITTALS

- A. See Section 01 30 00 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide wiring device manufacturer's catalog information showing dimensions, configurations, and construction.

- C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.06 QUALITY ASSURANCE

- A. Conform to requirements of NFPA 70.
- B. Products: Listed, classified, and labeled as suitable for the purpose intended.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Cords and Caps: NEMA WD 6; match receptacle configuration at outlet provided for equipment.
 - 1. Colors: Conform to NEMA WD 1.
 - 2. Cord Construction: NFPA 70, Type SO, multiconductor flexible cord with identified equipment grounding conductor, suitable for use in damp locations.
 - 3. Size: Suitable for connected load of equipment, length of cord, and rating of branch circuit overcurrent protection.
 - 4. Product: Carol.
 - 5. Substitutions: See Section 01 60 00 - Product Requirements.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that equipment is ready for electrical connection, wiring, and energization.

3.02 ELECTRICAL CONNECTIONS

- A. Make electrical connections in accordance with equipment manufacturer's instructions.
- B. Make conduit connections to equipment using flexible conduit. Use liquidtight flexible conduit with watertight connectors in damp or wet locations.
- C. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.
- D. Provide receptacle outlet to accommodate connection with attachment plug.
- E. Provide cord and cap where field-supplied attachment plug is required.
- F. Install suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.
- G. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.
- H. Install terminal block jumpers to complete equipment wiring requirements.
- I. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.

END OF SECTION