

**SECTION 23 0513
COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. General construction and requirements.
- B. Applications.
- C. Single phase electric motors.
- D. Three phase electric motors.
- E. Electronically Commutated Motors (ECM).

1.02 REFERENCE STANDARDS

- A. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings; 2015.
- B. IEEE 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators; 2004.
- C. NEMA MG 00001 - Motors and Generators; 2024.
- D. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.03 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.
- C. Manufacturer's Installation Instructions: Indicate setting, mechanical connections, lubrication, and wiring instructions.
- D. Operation Data: Include instructions for safe operating procedures.
- E. Maintenance Data: Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacture of electric motors for HVAC use, and their accessories, with minimum three years documented product development, testing, and manufacturing experience.
- B. Comply with NFPA 70.
- C. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather-proof covering. For extended outdoor storage, remove motors from equipment and store separately.

1.06 WARRANTY

- A. See Section 01 7800 - Closeout Submittals for additional warranty requirements.
- B. Provide five year manufacturer warranty for motors larger than 20 horsepower.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Baldor Electric Company/ABB Group; _____: www.baldor.com/#sle.
- B. EBM-Papst

- C. Regal-Beloit Corporation (Century); _____: www.centuryelectricmotor.com/#sle.
- D. Substitutions: See Section 01 6000 - Product Requirements.

2.02 GENERAL CONSTRUCTION AND REQUIREMENTS

- A. Electrical Service: Refer to Section 26 0583 for required electrical characteristics.
- B. Electrical Service:
- C. Construction:
 - 1. Open TEFC inverter rated type except where specifically noted otherwise.
 - 2. Design for continuous operation in 104 degrees F environment.
 - 3. Design for temperature rise in accordance with NEMA MG 00001 limits for insulation class, service factor, and motor enclosure type.
 - 4. Motors with frame sizes 254T and larger: Energy efficient type.
- D. Provide Aegis grounding ring on all motors.
- E. Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, efficiency.
- F. Wiring Terminations:
 - 1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
 - 2. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.

2.03 APPLICATIONS

- A. Exception: Motors less than 250 watts, for intermittent service may be the equipment manufacturer's standard and need not comply with these specifications.
- B. Single phase motors for shaft mounted fans, oil burners, and centrifugal pumps: Split phase type.
- C. Single phase motors for shaft mounted fans or blowers: Permanent split capacitor type.
- D. Single phase motors for fans, pumps, blowers, and air compressors: Capacitor start type.
- E. Single phase motors for fans, blowers, and pumps: Capacitor start, capacitor run type.
- F. Motors located in exterior locations, wet air streams downstream of sprayed coil dehumidifiers, draw through cooling towers, air cooled condensers, humidifiers, direct drive axial fans, roll filters, explosion proof environments, and dust collection systems: Totally enclosed type.
- G. Motors located in outdoors, in wet air streams downstream of sprayed coil dehumidifiers, in draw through cooling towers, and in humidifiers: Totally enclosed weatherproof epoxy-treated type.
- H. Motors located outdoors and in draw through cooling towers: Totally enclosed weatherproof epoxy-sealed type.

2.04 SINGLE PHASE POWER - SPLIT PHASE MOTORS

- A. Starting Torque: Less than 150 percent of full load torque.
- B. Starting Current: Up to seven times full load current.
- C. Breakdown Torque: Approximately 200 percent of full load torque.
- D. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve or ball bearings.
- E. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings.

2.05 SINGLE PHASE POWER - PERMANENT-SPLIT CAPACITOR MOTORS

- A. Starting Torque: Exceeding one fourth of full load torque.

- B. Starting Current: Up to six times full load current.
- C. Multiple Speed: Through tapped windings.
- D. Open Drip-proof or Enclosed Air Over Enclosure: Class A (50 degrees C temperature rise) insulation, minimum 1.0 Service Factor, prelubricated sleeve or ball bearings, automatic reset overload protector. Provide grease zerks on all motors with greasable bearings.

2.06 SINGLE PHASE POWER - CAPACITOR START MOTORS

- A. Starting Torque: Three times full load torque.
- B. Starting Current: Less than five times full load current.
- C. Pull-up Torque: Up to 350 percent of full load torque.
- D. Breakdown Torque: Approximately 250 percent of full load torque.
- E. Motors: Capacitor in series with starting winding; provide capacitor-start/capacitor-run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
- F. Drip-proof Enclosure: Class A (50 degrees C temperature rise) insulation, NEMA Service Factor, prelubricated sleeve bearings. Provide grease zerks on all motors with greasable bearings.
- G. Enclosed Motors: Class A (50 degrees C temperature rise) insulation, 1.0 Service Factor, prelubricated ball bearings. Provide grease zerks on all motors with greasable bearings.

2.07 THREE PHASE POWER - SQUIRREL CAGE MOTORS

- A. Starting Torque: Between 1 and 1-1/2 times full load torque.
- B. Starting Current: Six times full load current.
- C. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.
- D. Design, Construction, Testing, and Performance: Comply with NEMA MG 00001 for Design B motors.
- E. Insulation System: NEMA Class B or better.
- F. Testing Procedure: In accordance with IEEE 112. Load test motors to determine free from electrical or mechanical defects in compliance with performance data.
- G. Motor Frames: NEMA Standard T-Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
- H. Thermistor System (Motor Frame Sizes 254T and Larger): Three PTC thermistors embedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter; refer to Section 26 2913.
- I. Bearings: Grease lubricated anti-friction ball bearings with housings equipped with grease zerks for relubrication, rated for minimum ABMA STD 9, L-10 life of 20,000 hours. Calculate bearing load with NEMA minimum V-belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate.
- J. Sound Power Levels: To NEMA MG 00001.
- K. Part Winding Start Where Indicated: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.
- L. Weatherproof Epoxy Sealed Motors: Epoxy seal windings using vacuum and pressure with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.
- M. Nominal Efficiency: As indicated at full load and rated voltage when tested in accordance with IEEE 112.

- N. Nominal Power Factor: As indicated at full load and rated voltage when tested in accordance with IEEE 112.
- O. Shaft Grounding Rings either externally or integral to the motor on all applications using Variable Frequency Drive (VFD)

2.08 ELECTRONICALLY COMMUTATED MOTORS (ECM)

- A. Manufacturers:
 - 1. US Motors, a brand of NIDEC Motor Corporation; _____: www.usmotors.com/#sle.
 - 2. Wilo. www.wilo-usa.com
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Applications:
 - 1. Commercial:
 - a. Roof Top Unit:
 - 1) Operating Mode: Variable speed.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the roof top unit and/or specified sequence of operation.
 - 3) Shaft Extension: Single.
 - 4) RPM: 0-1750.
 - b. DX Fan Coil Unit:
 - 1) Operating Mode: Variablecfm.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the DX fan coil unit and/or specified sequence of operation.
 - 3) Shaft Extension: Single.
 - 4) Options: Remote mount control/User-Interface.
 - 5) RPM: 600 through 1800.
 - c. Hydronic Fan Coil Unit:
 - 1) Operating Mode: Variablecfm.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the fan coil unit and/or specified sequence of operation.
 - 3) Shaft Extension: Single.
 - 4) Options: User-interface.
 - 5) RPM: 600 through 1800.
 - d. Power Roof Ventilator (PRV):
 - 1) Operating Mode: Constant cfm.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the PRV and/or specified sequence of operation.
 - 3) Shaft Extension: Single.
 - 4) Options: Remote mount control.
 - e. Fan Filter Unit:
 - 1) Operating Mode: Constant cfm.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the fan filter unit and/or specified sequence of operation.
 - 3) Shaft Extension: Single.
 - 4) Options: Remote mount control.
 - f. Hydronic Pump:
 - 1) Operating Mode: Variablespeed.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the hydronic pump and/or specified sequence of operation.
 - 3) Flange Configuration: "C".
 - g. Hydronic Booster Pump:
 - 1) Operating Mode: Variable speed.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the hydronic pump and/or specified sequence of operation.

- 3) Flange Configuration: "C".
2. Residential/Commercial:
 - a. Geothermal Heat Pumps:
 - 1) Operating Mode: Multi speed cfm.
 - 2) Input: Motor manufacturer to coordinate control requirements with the control board of the geothermal heat pump and/or specified sequence of operation.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
- C. Check line voltage and phase and ensure agreement with nameplate.

3.02 SCHEDULE

- A. NEMA Open Motor Service Factors.
 1. 1/6-1/3 hp:
 - a. 1800 rpm: 1.35.
 - b. 1200 rpm: 1.35.
 - c. 900 rpm: 1.35.
 2. 1/2 hp:
 - a. 1800 rpm: 1.25.
 - b. 1200 rpm: 1.25.
 - c. 900 rpm: 1.15.
 3. 3/4 hp:
 - a. 1800 rpm: 1.25.
 - b. 1200 rpm: 1.15.
 - c. 900 rpm: 1.15.
 4. 1 hp:
 - a. 1800 rpm: 1.15.
 - b. 1200 rpm: 1.15.
 - c. 900 rpm: 1.15.
 5. 1.5-150 hp:
 - a. 1800 rpm: 1.15.
 - b. 1200 rpm: 1.15.
 - c. 900 rpm: 1.15.
- B. Three Phase - Energy Efficient, Open Drip-Proof Performance:
 1. 1200 rpm.
 - a. 1 hp:
 - 1) NEMA Frame: 145T.
 - 2) Minimum Percent Power Factor: 72.
 - 3) Minimum Percent Efficiency: 81.
 - b. 1-1/2 hp:
 - 1) NEMA Frame: 182T.
 - 2) Minimum Percent Power Factor: 73.
 - 3) Minimum Percent Efficiency: 83.
 - c. 2 hp:
 - 1) NEMA Frame: 184T.
 - 2) Minimum Percent Power Factor: 75.
 - 3) Minimum Percent Efficiency: 85.
 - d. 3 hp:
 - 1) NEMA Frame: 213T.
 - 2) Minimum Percent Power Factor: 60.

- 3) Minimum Percent Efficiency: 86.
- e. 5 hp:
 - 1) NEMA Frame: 215T.
 - 2) Minimum Percent Power Factor: 65.
 - 3) Minimum Percent Efficiency: 87.
- f. 7-1/2 hp:
 - 1) NEMA Frame: 254T.
 - 2) Minimum Percent Power Factor: 73.
 - 3) Minimum Percent Efficiency: 89.
- g. 10 hp:
 - 1) NEMA Frame: 256T.
 - 2) Minimum Percent Power Factor: 74.
 - 3) Minimum Percent Efficiency: 89.
- h. 15 hp:
 - 1) NEMA Frame: 284T.
 - 2) Minimum Percent Power Factor: 77.
 - 3) Minimum Percent Efficiency: 90.
- i. 20 hp:
 - 1) NEMA Frame: 286T.
 - 2) Minimum Percent Power Factor: 78.
 - 3) Minimum Percent Efficiency: 90.
- j. 25 hp:
 - 1) NEMA Frame: 324T.
 - 2) Minimum Percent Power Factor: 74.
 - 3) Minimum Percent Efficiency: 91.
- k. 30 hp:
 - 1) NEMA Frame: 326T.
 - 2) Minimum Percent Power Factor: 78.
 - 3) Minimum Percent Efficiency: 91.
- l. 40 hp:
 - 1) NEMA Frame: 364T.
 - 2) Minimum Percent Power Factor: 77.
 - 3) Minimum Percent Efficiency: 93.
- 2. 1800 rpm.
 - a. 1 hp:
 - 1) NEMA Frame: 143T.
 - 2) Minimum Percent Power Factor: 84.
 - 3) Minimum Percent Efficiency: 82.
 - b. 1-1/2 hp:
 - 1) NEMA Frame: 145T.
 - 2) Minimum Percent Power Factor: 85.
 - 3) Minimum Percent Efficiency: 84.
 - c. 2 hp:
 - 1) NEMA Frame: 145T.
 - 2) Minimum Percent Power Factor: 85.
 - 3) Minimum Percent Efficiency: 84.
 - d. 3 hp:
 - 1) NEMA Frame: 182T.
 - 2) Minimum Percent Power Factor: 86.
 - 3) Minimum Percent Efficiency: 86.
 - e. 5 hp:
 - 1) NEMA Frame: 184T.
 - 2) Minimum Percent Power Factor: 87.

- 3) Minimum Percent Efficiency: 87.
- f. 7-1/2 hp:
 - 1) NEMA Frame: 213T.
 - 2) Minimum Percent Power Factor: 86.
 - 3) Minimum Percent Efficiency: 88.
- g. 10 hp:
 - 1) NEMA Frame: 215T.
 - 2) Minimum Percent Power Factor: 85.
 - 3) Minimum Percent Efficiency: 89.
- h. 15 hp:
 - 1) NEMA Frame: 256T.
 - 2) Minimum Percent Power Factor: 85.
 - 3) Minimum Percent Efficiency: 91.
- i. 20 hp:
 - 1) NEMA Frame: 256T.
 - 2) Minimum Percent Power Factor: 86.
 - 3) Minimum Percent Efficiency: 91.
- j. 25 hp:
 - 1) NEMA Frame: 284T.
 - 2) Minimum Percent Power Factor: 85.
 - 3) Minimum Percent Efficiency: 91.
- k. 30 hp:
 - 1) NEMA Frame: 286T.
 - 2) Minimum Percent Power Factor: 88.
 - 3) Minimum Percent Efficiency: 92.
- l. 40 hp:
 - 1) NEMA Frame: 324T.
 - 2) Minimum Percent Power Factor: 83.
 - 3) Minimum Percent Efficiency: 92.
- m. 50 hp:
 - 1) NEMA Frame: 326T.
 - 2) Minimum Percent Power Factor: 88.
 - 3) Minimum Percent Efficiency: 93.

END OF SECTION 23 0513

SECTION 23 0516
EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Flexible pipe connectors.
- B. Expansion joints and compensators.
- C. Pipe loops, offsets, and swing joints.

1.02 RELATED REQUIREMENTS

- A. Section 23 2113 - Hydronic Piping.
- B. Section 23 2213 - Steam and Condensate Heating Piping.
- C. Section 23 2300 - Refrigerant Piping.

1.03 REFERENCE STANDARDS

- A. ASTM A269/A269M - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service; 2015.
- B. ASTM A536 - Standard Specification for Ductile Iron Castings; 1984 (Reapproved 2014).
- C. EJMA (STDS) - EJMA Standards; Tenth Edition.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data:
 - 1. Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per foot and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
 - 2. Expansion Joints: Indicate maximum temperature and pressure rating, and maximum expansion compensation.
 - 3. Provide Design Data, Calculations and Forces induced into structure for Field Fabricated Expansion Loops.
- C. Design Data: Indicate selection calculations.
- D. Manufacturer's Instructions: Indicate manufacturer's installation instructions, special procedures, and external controls.
- E. Maintenance Data: Include adjustment instructions.
- F. Project Record Documents: Record installed locations of flexible pipe connectors, expansion joints, anchors, and guides.
- G. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 6000 - Product Requirements, for additional provisions.
 - 2. Extra Packing for Packed Expansion Joints: One set for each joint.

PART 2 PRODUCTS

2.01 GENERAL

- A. Expansion joints sizes 2" and smaller: screw threads, welded or sweat, Joints 2-1/2" and Larger: 150 pound ASA std Flange
- B. All bellows joints shall be factory pre-set with temporary holding device

2.02 FLEXIBLE PIPE CONNECTORS - STEEL PIPING

- A. Manufacturers:
 - 1. Mercer Rubber Company; _____: www.mercer-rubber.com/#sle.
 - 2. The Metraflex Company; _____: www.metraflex.com/#sle.
 - 3. ADSCO Manufacturing.

- 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Inner Hose: 2 ply Stainless Steel or Bronze .
- C. Exterior Sleeve: Single braided, stainless steel.
- D. Pressure Rating: 125 psi and 450 degrees F.
- E. Joint: Flanged.
- F. Size: Use pipe sized units.
- G. Maximum offset: 3/4 inch on each side of installed center line.

2.03 FLEXIBLE PIPE CONNECTORS - COPPER PIPING

- A. Manufacturer:
 - 1. Mercer Rubber Company; _____: www.mercer-rubber.com/#sle.
 - 2. The Metraflex Company; _____: www.metraflex.com/#sle.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Inner Hose: 2 ply phosphor Bronze.
- C. Exterior Sleeve: Braided bronze.
- D. Pressure Rating: 125 psi and 450 degrees F.
- E. Size: Use pipe sized units.
- F. Maximum offset: 3/4 inch on each side of installed center line.
- G. Application: Copper piping.

2.04 EXPANSION JOINTS - STAINLESS STEEL BELLOWS TYPE

- A. Manufacturers:
 - 1. Mercer Rubber Company; _____: www.mercer-rubber.com/#sle.
 - 2. The Metraflex Company; _____: www.metraflex.com/#sle.
 - 3. ADSCO Manufacturing.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Pressure Rating: 125 psi and 400 degrees F.
- C. Maximum Compression: 1-3/4 inches.
- D. Maximum Extension: 1/4 inch.
- E. Joint: Flanged.
- F. Size: Use pipe sized units.
- G. Application: Steel piping 3 inches and under.

2.05 EXPANSION JOINTS - HOSE AND BRAID

- A. Manufacturers:
 - 1. The Metraflex Company; Metraloop: www.metraflex.com/#sle.
 - 2. The Metraflex Company; Metraloop "Nested" Installations.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Provide flexible loops with two flexible sections of hose and braid, two 90 degree elbows, and 180 degree return with support bracket and air release or drain plug.
- C. Provide flexible loops capable of movement in the x, y, and z planes. Flexible loops to impart no thrust loads to the building structure.
- D. Flexible Connectors: Flanged, braided type with wetted components of stainless steel, sized to match piping.
 - 1. Maximum Allowable Working Pressure: 150 psig at 120 degrees F.

2.06 ACCESSORIES

- A. Pipe Alignment Guides:

1. Manufacturers:
 - a. The Metraflex Company; PGQ Glide Riser Guide: www.metralflex.com/#sle.
 2. Two piece welded steel with enamel paint, bolted, with spider to fit standard pipe, frame with four mounting holes, clearance for minimum 1 inch thick insulation, minimum 3 inches travel.
- B. Engineered Riser Anchor Clamps:
1. Manufacturers:
 - a. The Metraflex Company; Engineered Riser Anchor Clamp: www.metralflex.com/#sle.
 2. Applications:
 - a. Provide one clamp above and one clamp below the slab to anchor pipe.
 - 1) Coordinate with the structural engineer to determine the maximum thrust loading calculated for the slab or floor structure. Use the maximum thrust loading calculations to verify the clamps will be a safety factor of one less than the maximum loading of clamp per the manufacturer's instructions.
 3. Provide two piece, ductile iron in compliance with ASTM A536. Use with metal pipes with an outer diameter of 2.5 inches to 8 inches.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with EJMA (Expansion Joint Manufacturers Association) Standards.
- C. Install flexible pipe connectors on pipes connected to vibration isolated equipment. Provide line size flexible connectors.
- D. Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.
- E. Anchor pipe to building structure where indicated. Provide pipe guides so movement is directed along axis of pipe only. Erect piping such that strain and weight is not on cast connections or apparatus.
 1. Coordinate Anchor placement and requirements for additional structural reinforcements with Structural Engineer/Contractor prior to installation.
- F. Provide support and equipment required to control expansion and contraction of piping. Provide loops, pipe offsets, and swing joints, or expansion joints where required.

END OF SECTION 23 0516

SECTION 23 0517
SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pipe sleeves.
- B. Manufactured sleeve-seal systems.

1.02 RELATED REQUIREMENTS

- A. Section 07 8400 - Firestopping.
- B. Section 23 0523 - General-Duty Valves for HVAC Piping.
- C. Section 23 0553 - Identification for HVAC Piping and Equipment: Piping identification.
- D. Section 23 0716 - HVAC Equipment Insulation.
- E. Section 23 0719 - HVAC Piping Insulation.

1.03 REFERENCE STANDARDS

- A. ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type); 2013.
- B. ASTM E814 - Standard Test Method for Fire Tests of Through-Penetration Fire Stops; 2013a.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate pipe materials used, jointing methods, supports, floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.
- C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 6000 - Product Requirements, for additional provisions.

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 work of the type specified this section.
 - 1. Minimum three years experience.
 - 2. Approved by manufacturer.
- C. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store sleeve and sleeve seals in shipping containers, with labeling in place.
- B. Provide temporary protective coating on cast iron and steel sleeves if shipped loose.

1.07 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Correct defective Work within a five year period after Date of Substantial Completion.

PART 2 PRODUCTS

2.01 PIPE SLEEVES

- A. Manufacturers:
 - 1. Flexicraft Industries; Pipe Wall Sleeve: www.flexicraft.com/#sle.
 - 2. Hilti.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.

- B. Vertical Piping:
 - 1. Sleeve Length: 1 inch above finished floor.
 - 2. Provide sealant for watertight joint.
 - 3. Blocked Out Floor Openings: Provide 1-1/2 inch angle set in silicon adhesive around opening.
 - 4. Drilled Penetrations: Provide 1-1/2 inch angle ring or square set in silicone adhesive around penetration.
- C. Plastic or Sheet Metal: Pipe passing through interior walls, partitions, and floors, unless steel or brass sleeves are specified below.
- D. Pipe Passing Through Below Grade Exterior Walls:
 - 1. Zinc coated or cast iron pipe.
 - 2. Provide watertight space with link rubber or modular seal between sleeve and pipe on both pipe ends.
- E. Pipe Passing Through Mechanical, Laundry, and Animal Room Floors above Basement:
 - 1. Galvanized steel pipe or black iron pipe with asphalt coating.
 - 2. Connect sleeve with floor plate except in mechanical rooms.

2.02 MANUFACTURED SLEEVE-SEAL SYSTEMS

- A. Modular/Mechanical Seal:
 - 1. Synthetic rubber interlocking links continuously fill annular space between pipe and wall/casing opening.
 - 2. Provide watertight seal between pipe and wall/casing opening.
 - 3. Elastomer element size and material in accordance with manufacturer's recommendations.
 - 4. Glass reinforced plastic pressure end plates.

PART 3 EXECUTION

3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and foreign material, from inside and outside, before assembly.

3.02 INSTALLATION

- A. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.
- B. Install piping to conserve building space, to not interfere with use of space and other work.
- C. Install piping and pipe sleeves to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- D. Inserts:
 - 1. Provide inserts for placement in concrete formwork.
 - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
 - 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 - 5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- E. Structural Considerations:
 - 1. Do not penetrate building structural members unless indicated.
- F. Provide sleeves when penetrating footings, floors, walls, partitions, and _____. Seal pipe including sleeve penetrations to achieve fire resistance equivalent to fire separation required.
 - 1. Underground Piping: Caulk pipe sleeve watertight or seal with mechanically expandable chloroprene inserts with bitumen sealed metal components.
 - 2. Aboveground Piping:

- a. Pack solid using mineral fiber in compliance with ASTM C592.
 - b. Fill space with an elastomer caulk to a depth of 0.50 inch where penetrations occur between conditioned and unconditioned spaces.
- 3. All Rated Openings: Caulk tight with fire stopping material in compliance with ASTM E814 in accordance with Section 07 8400 to prevent the spread of fire, smoke, and gases.
- 4. Caulk exterior wall sleeves watertight with lead and oakum or mechanically expandable chloroprene inserts with mastic-sealed components.
- G. Manufactured Sleeve-Seal Systems:
 - 1. Install manufactured sleeve-seal systems in sleeves located in grade slabs and exterior concrete walls at piping entrances into building.
 - 2. Provide sealing elements of the size, quantity, and type required for the piping and sleeve inner diameter or penetration diameter.
 - 3. Locate piping in center of sleeve or penetration.
 - 4. Install field assembled sleeve-seal system components in annular space between sleeve and piping.
 - 5. Tighten bolting for a water-tight seal.
 - 6. Install in accordance with manufacturer's recommendations.
- H. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

3.03 CLEANING

- A. Upon completion of work, clean all parts of the installation.
- B. Clean equipment, pipes, valves, and fittings of grease, metal cuttings, and sludge that may have accumulated from the installation and testing of the system.

END OF SECTION 23 0517

SECTION 23 0519
METERS AND GAUGES FOR HVAC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Positive displacement meters.
- B. Flow meters.
- C. Pressure gauges and pressure gauge taps.
- D. Thermometers and thermometer wells.
- E. Static pressure gauges.
- F. Filter gauges.

1.02 RELATED REQUIREMENTS

- A. Section 23 0923 - Direct-Digital Control System for HVAC.
- B. Section 23 0993 - Sequence of Operations for HVAC Controls.
- C. Section 23 2113 - Hydronic Piping.
- D. Section 23 2213 - Steam and Condensate Heating Piping.

1.03 REFERENCE STANDARDS

- A. ASME B40.100 - Pressure Gauges and Gauge Attachments; 2013.
- B. ASME MFC-3M - Measurement of Fluid Flow in Pipes Using Orifice, Nozzle, and Venturi; 2004 (Reaffirmed 2017).
- C. ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers; 2014.
- D. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers; 2014 (Reapproved 2021).
- E. AWWA C700 - Cold-Water Meters -- Displacement Type, Metal Alloy Main Case; 2020.
- F. AWWA C701 - Cold-Water Meters -- Turbine Type, for Customer Service; 2012.
- G. AWWA C702 - Cold-Water Meters -- Compound Type; 2010.
- H. AWWA M6 - Water Meters -- Selection, Installation, Testing, and Maintenance; 2012, with Addendum (2018).
- I. UL 393 - Indicating Pressure Gauges for Fire-Protection Service; Current Edition, Including All Revisions.
- J. UL 404 - Gauges, Indicating Pressure, for Compressed Gas Service; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide list that indicates use, operating range, total range and location for manufactured components.
- C. Project Record Documents: Record actual locations of components and instrumentation.
- D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 6000 - Product Requirements, for additional provisions.
 - 2. Extra Gauge Oil for Inclined Manometers: One bottle.
 - 3. Extra Pressure Gauges: One of each type and size.

1.05 FIELD CONDITIONS

- A. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

PART 2 PRODUCTS

2.01 POSITIVE DISPLACEMENT METERS (LIQUID)

- A. Manufacturers:
 - 1. Dwyer Instruments, Inc; _____: www.dwyer-inst.com/#sle.
 - 2. FMC Technologies; _____: www.fmctechnologies.com/#sle.
 - 3. Venture Measurement, a Danaher Corporation Company; _____: www.venturemeasurement.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. AWWA C700, positive displacement disc type suitable for fluid with metal alloy main case and cast iron frost-proof, breakaway bottom cap, hermetically sealed register, remote reading.
- C. Meter: Brass body turbine meter with magnetic drive register.
 - 1. Service: Cold water, 122 degrees F.

2.02 PRESSURE GAUGES

- A. Manufacturers:
 - 1. Dwyer Instruments, Inc; _____: www.dwyer-inst.com/#sle.
 - 2. Moeller Instrument Company, Inc; _____: www.moellerinstrument.com/#sle.
 - 3. Omega Engineering, Inc; _____: www.omega.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Pressure Gauges: 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 and KPa.

2.03 PRESSURE GAUGE TAPPINGS

- A. Gauge Cock: Tee or lever handle, brass for maximum 150 psi.
- B. Needle Valve: Brass, 1/4 inch NPT for minimum 150 psi.
- C. Pulsation Damper: Pressure snubber, brass with 1/4 inch connections.
- D. Syphon: Steel, Schedule 40, 1/4 inch angle or straight pattern.

2.04 STEM TYPE THERMOMETERS

- A. Manufacturers:
 - 1. Dwyer Instruments, Inc; _____: www.dwyer-inst.com/#sle.
 - 2. Omega Engineering, Inc; _____: www.omega.com/#sle.
 - 3. Weksler Glass Thermometer Corp; _____: www.wekslerglass.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Thermometers - Fixed Mounting: Red- or blue-appearing non-toxic liquid in glass; ASTM E1; lens front tube, cast aluminum case with enamel finish.
 - 1. Size: 9 inch scale.
 - 2. Window: Clear Lexan.
 - 3. Stem: _____ inch brass.
 - 4. Accuracy: 2 percent, per ASTM E77.
 - 5. Calibration: Degrees F.
- C. 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.

2.05 DIAL THERMOMETERS

- A. Manufacturers:
 1. Dwyer Instruments, Inc; _____: www.dwyer-inst.com/#sle.
 2. Omega Engineering, Inc; _____: www.omega.com/#sle.
 3. Weksler Glass Thermometer Corp; _____: www.wekslerglass.com/#sle.
 4. _____.
 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Thermometers - Fixed Mounting: Dial type bimetallic actuated; ASTM E1; stainless steel case, silicone fluid damping, white with black markings and black pointer, hermetically sealed lens, stainless steel stem.
 1. Size: 5 inch diameter dial.
 2. Lens: Clear glass.
 3. Accuracy: 1 percent.
 4. Calibration: Degrees F.
- C. Thermometer: ASTM E1, stainless steel case, adjustable angle with front recalibration, bimetallic helix actuated with silicone fluid damping, white with black markings and black pointer hermetically sealed lens, stainless steel stem.
 1. Size: 3 inch diameter dial.
 2. Lens: Clear glass.
 3. Accuracy: 1 percent.
 4. Calibration: Degrees F.

2.06 THERMOMETER SUPPORTS

- A. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.
- B. Flange: 3 inch outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.07 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.

2.08 STATIC PRESSURE GAUGES

- A. Manufacturers:
 1. Dwyer Instruments, Inc; _____: www.dwyer-inst.com/#sle.
 2. Omega Engineering, Inc; _____: www.omega.com/#sle.
 3. Veris Industries; _____: www.veris.com/#sle.
 4. Weksler Glass Thermometer Corp; _____: www.wekslerglass.com/#sle.
 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. 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.
- C. Inclined manometer, red liquid on white background with black figures, front recalibration adjustment, 3 percent of full scale accuracy.
- D. 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 gauge per pump, installing taps before strainers and on suction and discharge of pump. Pipe to gauge.
- C. Install pressure gauges with pulsation dampers. Provide gauge cock to isolate each gauge. Provide siphon on gauges in steam systems. Extend nipples and siphons to allow clearance from insulation.
- D. Install thermometers in air duct systems on flanges.
- E. Locate duct mounted thermometers minimum 10 feet downstream of mixing dampers, coils, or other devices causing air turbulence.
- F. Coil and conceal excess capillary on remote element instruments.
- G. Provide instruments with scale ranges selected according to service with largest appropriate scale.
- H. Install gauges and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.
- I. Adjust gauges and thermometers to final angle, clean windows and lenses, and calibrate to zero.
- J. Locate test plugs adjacent thermometers and thermometer sockets.

END OF SECTION 23 0519

SECTION 23 0523
GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 GENERAL

1.01 REFERENCE STANDARDS

- A. ASME B31.9 - Building Services Piping; 2014.
- B. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Welding, Brazing, and Fusing Qualifications; 2015.

1.02 QUALITY ASSURANCE

- A. Manufacturer:
 - 1. Obtain valves for each valve type from single manufacturer.
 - 2. Company must specialize in manufacturing products specified in this section, with not less than three years of documented experience.
- B. Welding Materials and Procedures: Comply with ASME BPVC-IX.

PART 2 PRODUCTS

2.01 APPLICATIONS

- A. See drawings for specific valve locations.
- B. Provide the following valves for the applications if not indicated on drawings:
 - 1. Throttling (Hydronic): Butterfly, Ball, Globe, Angle, and _____.
 - 2. Throttling (Steam): Butterfly, Gate, Ball, Plug, and _____.
 - 3. Isolation (Shutoff): Butterfly, Gate, Ball, Plug, and _____.
 - 4. Swing Check (Pump Outlet):
 - a. 2 NPS and Smaller: Bronze with bronze disc.
- C. Chilled Water Valves:
 - 1. 2-1/2 NPS and Larger, Iron Valves:
 - a. 2-1/2 NPS to 4 NPS: Flanged ends.
 - b. Ball: 2-1/2 NPS to 4 NPS, Class 150.
 - c. Single-Flange Butterfly: 2-1/2 NPS to 12 NPS, stainless steel disc, EPDM seat, 200 CWP.
 - d. Single-Flange Butterfly: 14 NPS to 24 NPS, stainless steel disc, EPDM seat, 150 CWP.
 - e. Grooved-End Butterfly: 2-1/2 NPS to 12 NPS, 175 CWP.
 - f. Swing Check: Metal seats, Class 125.
 - g. Grooved-End Check: 3 NPS to 12 NPS, 300 CWP.
 - h. Center-Guided Check: Compact-wafer, metal seat, Class 125.
 - i. Gate: NRS, Class 125.
 - j. Globe: Class 125.
- D. Condenser Water Valves:
 - 1. 2 NPS and Smaller, Brass, Bronze, and _____ Valves:
 - a. Threaded ends.
 - b. Angle: Bronze disc, Class 125.
 - c. Ball: Full port, one piece, brass trim.
 - d. Swing Check: Bronze disc, Class 125.
 - e. Gate: NRS, Class 125.
 - f. Globe: Bronze disc, Class 125.
 - 2. 2-1/2 NPS and Larger, Iron Valves:
 - a. 2-1/2 NPS to 4 NPS: Flanged ends.
 - b. Ball: 2-1/2 NPS to 4 NPS, Class 150.
 - c. Single-Flange Butterfly: 2-1/2 NPS to 12 NPS, stainless steel disc, EPDM seat, 200 CWP.

- d. Single-Flange Butterfly: 14 NPS to 24 NPS, 150 CWP, stainless steel disc, EPDM seat, 150 CWP.
 - e. Grooved-End Butterfly: 2-1/2 NPS to 12 NPS, 175 CWP.
 - f. Butterfly: High performance, single flange, Class 150.
 - g. Swing Check: Metal seats, Class 125.
 - h. Swing Check with Closure Control, 2-1/2 NPS to 12 NPS: Lever and spring, Class 125.
 - i. Grooved-End Swing Check: 3 NPS to 12 NPS, 300 CWP.
 - j. Iron Center-Guided Check: 2-1/2 NPS to 24 inch, compact-wafer, metal seat, Class 125.
- E. Heating Hot Water Valves:
- 1. 2 NPS and Smaller, Brass, Bronze, and _____ Valves:
 - a. Threaded ends.
 - b. Ball: Full port, one piece, brass trim.
 - c. Swing Check: Bronze disc, Class 125.
 - d. Gate: NRS, Class 125.
 - 2. 2-1/2 NPS and Larger, Iron Valves:
 - a. 2-1/2 NPS to 4 NPS: Flanged ends.
 - b. Ball: 2-1/2 NPS to 4 NPS, Class 150.
 - c. Single-Flange Butterfly: 2-1/2 NPS to 12 NPS, stainless steel disc, EPDM seat, 200 CWP.
 - d. Single-Flange Butterfly: 14 NPS to 24 NPS, stainless steel disc, EPDM seat, 150 CWP.
 - e. Butterfly: High performance, single flange, Class 150.
 - f. Swing Check: Metal seats, Class 125.
 - g. Swing Check: 2-1/2 NPS to 12 NPS, lever and spring closure control, Class 125.
 - h. Grooved-End Swing Check: 3 NPS to 12 NPS, 300 CWP.
 - i. Center-Guided Check: Compact-wafer, metal seat, Class 125.
- F. Low Pressure Steam Valves (15 PSIG or Less):
- 1. 2 NPS and Smaller, Brass, Bronze, and _____ Valves:
 - a. Ball: Full port, one piece, brass trim.
 - b. Swing Check: Bronze disc, Class 125.
 - c. Gate: NRS, Class 125.
 - d. Globe: Bronze disc, Class 125.
 - 2. 2-1/2 NPS and Larger, Iron Valves:
 - a. 2-1/2 NPS to 10 NPS: Flanged ends.
 - b. Butterfly: High performance, single flange, Class 150.
 - c. Swing Check: Metal seats, Class 125.
 - d. Swing Check: 2-1/2 NPS to 12 NPS, lever and spring closure. control, Class 125.
 - e. Gate: NRS, Class 125.
 - f. Globe: 2-1/2 NPS to 12 NPS: Class 125.
- G. High Pressure Steam Valves (Greater than 15 PSIG):
- 1. 2 NPS and Smaller, Brass, Bronze, and _____ Valves:
 - a. Ball: Full port, one piece, brass trim.
 - b. Swing Check: Bronze disc, Class 125.
 - c. Gate: NRS, Class 125.
 - d. Globe: Bronze disc, Class 125.
 - 2. 2-1/2 NPS and Larger, Iron Valves:
 - a. Ball: 2-1/2 NPS to 10 NPS, Class 150.
 - b. Butterfly: High performance, single flange, Class 150.
 - c. Swing Check: Metal seats, Class 125.
 - d. Swing Check: 2-1/2 NPS to 12 NPS, lever and spring closure. control, Class 125.

- e. Gate: NRS, Class 125.
 - f. Globe: 2-1/2 NPS to 12 NPS, Class 125.
- H. Steam-Condensate Valves:
- 1. 2 NPS and Smaller, Brass, Bronze, and _____ Valves:
 - a. Gate: NRS, RS, and _____, Class 125.
 - b. Ball: Full port, one piece, brass trim.
 - c. Globe: Bronze disc, Class 125.
 - 2. 2-1/2 NPS and Larger, Iron Valves:
 - a. Provide 2-1/2 NPS to 4 NPS with flanged ends.
 - b. Ball: 2-1/2 NPS to 10 NPS, Class 150.
 - c. Butterfly: High performance, single flange, Class 300.
 - d. Swing Check: Metal seats, Class 125.
 - e. Swing Check: Lever and spring closure control, Class 125.
 - f. Gate: NRS, Class 125.
 - g. Globe: 2-1/2 NPS to 12 NPS, Class 125.

2.02 GENERAL REQUIREMENTS

- A. Valve Pressure and Temperature Ratings: No less than rating indicated; as required for system pressures and temperatures.
- B. Valve Sizes: Match upstream piping unless otherwise indicated.
- C. Valve Actuator Types:
 - 1. Handwheel: Valves other than quarter-turn types.
 - 2. Hand Lever: Quarter-turn valves 6 NPS and smaller _____.
 - 3. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator, of size and with chain for mounting height, as indicated in the "Valve Installation" Article.
- D. Valves in Insulated Piping: Provide 2 NPS stem extensions and the following features:
 - 1. Gate Valves: Rising stem.
 - 2. Ball Valves: Extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
 - 3. Butterfly Valves: Extended neck.
 - 4. Memory Stops: Fully adjustable after insulation is installed.
- E. Memory Stops: Fully adjustable after insulation is installed.
- F. Valve-End Connections:
- G. General ASME Compliance:
 - 1. Building Services Piping Valves: ASME B31.9.

2.03 IRON, FLANGED END SWING CHECK VALVES

2.04 IRON, GROOVED-END SWING CHECK VALVES

2.05 IRON, CENTER-GUIDED CHECK VALVES

END OF SECTION 23 0523

SECTION 23 0529
HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Support and attachment components for equipment, piping, and other HVAC/hydronic work.

1.02 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 05 5000 - Metal Fabrications: Materials and requirements for fabricated metal supports.

1.03 REFERENCE STANDARDS

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2009.
- C. ASTM A181/A181M - Standard Specification for Carbon Steel Forgings, for General - Purpose Piping; 2013.
- D. ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2019.
- E. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings; 1999 (Reapproved 2014).
- F. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; 2013.
- G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2023d.
- H. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials; 2014.
- I. MFMA-4 - Metal Framing Standards Publication; 2004.
- J. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2009.
- K. NFPA 101 - Life Safety Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- L. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
 - 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
 - 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.
 - 4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
 - 5. Notify Architect of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
 - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 03 3000.

1.05 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for channel (strut) framing systems, non-penetrating rooftop supports, post-installed concrete and masonry anchors, and thermal insulated pipe supports.
- C. Shop Drawings: Include details for fabricated hangers and supports where materials or methods other than those indicated are proposed for substitution.
 - 1. Application of protective inserts, saddles, and shields at pipe hangers for each type of insulation and hanger.
- D. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.06 QUALITY ASSURANCE

- A. Comply with applicable building code.
- B. Installer Qualifications for Powder-Actuated Fasteners (when specified): Certified by fastener system manufacturer with current operator's license.
- C. Installer Qualifications for Field-Welding: As specified in Section 05 5000.

PART 2 PRODUCTS

2.01 SUPPORT AND ATTACHMENT COMPONENTS

- A. General Requirements:
 - 1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of plumbing work.
 - 2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
 - 3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of _____. Include consideration for vibration, equipment operation, and shock loads where applicable.
 - 4. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
 - 5. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
 - a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
 - c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
 - d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
- B. Metal Channel (Strut) Framing Systems: Factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
 - 1. Manufacturers:
 - a. Cooper B-Line, a division of Eaton Corporation; _____: www.cooperindustries.com/#sle.
 - b. Ferguson Enterprises Inc; _____: www.fnw.com/#sle.
 - c. Thomas & Betts Corporation; _____: www.tnb.com/#sle.
 - d. Unistrut, a brand of Atkore International Inc; _____: www.unistrut.com/#sle.
 - e. Substitutions: See Section 01 6000 - Product Requirements.

- f. Source Limitations: Furnish channels (struts) and associated fittings, accessories, and hardware produced by a single manufacturer.
 2. Provide factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
 3. Comply with MFMA-4.
 4. Channel Material:
 - a. Indoor Dry Locations: Use painted steel, zinc-plated steel, or galvanized steel.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.
 5. Minimum Channel Thickness: Steel sheet, 12 gage, 0.1046 inch.
 6. Minimum Channel Dimensions: 1-5/8 inch width by 13/16 inch height.
- C. Hanger Rods: Threaded zinc-plated steel unless otherwise indicated.
 1. Minimum Size, Unless Otherwise Indicated or Required:
 - a. Equipment Supports: 1/2 inch diameter.
 - b. Piping up to 1 inch (27 mm) nominal: 1/4 inch diameter.
 - c. Piping larger than 1 inch (27 mm) nominal: 3/8 inch diameter.
 - d. Trapeze Support for Multiple Pipes: 3/8 inch diameter.
- D. Steel Cable:
 1. Manufacturers:
 - a. Ductmate Industries, Inc, a DMI Company; Clutcher Cable Hanging System: www.ductmate.com/#sle.
 - b. Substitutions: See Section 01 6000 - Product Requirements.
 - c. Source Limitations: Furnish associated fittings, accessories, and hardware produced by a single manufacturer.
 - d. Steel Cable system shall allow height adjustment after installation, permanently crimped cable fasteners shall be avoided.
- E. Thermal Insulated Pipe Supports:
 1. Manufacturers:
 - a. Aeroflex USA, Inc; _____: www.aeroflexusa.com/#sle.
 - b. Buckaroos, Inc; _____: www.buckaroos.com/#sle.
 - c. Substitutions: See Section 01 6000 - Product Requirements.
 2. General Construction and Requirements:
 - a. Insulated pipe supports to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.
 - b. Surface Burning Characteristics: Flame spread index/smoke developed index of 5/30, maximum, when tested in accordance with ASTM E84 or UL 723.
 - c. Pipe supports to be provided for nominally sized, 1/2 inch to 30 inch iron pipes.
 - d. Insulation inserts to consist of rigid polyisocyanurate (urethane) insulation surrounded by a 360 degree, PVC jacketing.
 3. PVC Jacket:
 - a. Pipe insulation protection shields to be provided with a ball bearing hinge and locking seam.
 - b. Moisture Vapor Transmission: 0.0071 perm inch, when tested in accordance with ASTM E96/E96M.
 - c. Thickness: 60 mil.
 4. Pipe insulation protection shields to be provided at the hanger points and guide locations on pipes requiring insulation as indicated on drawings.
 5. Products:
 - a. Substitutions: See Section 01 6000 - Product Requirements.
- F. Pipe Supports:
 1. Manufacturers:
 2. Liquid Temperatures Up To 122 degrees F:
 - a. Overhead Support: MSS SP-58 Types 1, 3 through 12.

- b. Support From Below: MSS SP-58 Types 35 through 38.
 - 3. Operating Temperatures from 122 to 446 degrees F:
 - a. Overhead Support: MSS SP-58 Type 1 or 3 through 12, with appropriate saddle of MSS SP-58 Type 40 for insulated pipe.
 - b. Roller Support: MSS SP-58 Types 41 or 43 through 46, with appropriate saddle of MSS SP-58 Type 39 for insulated pipe.
 - c. Sliding Support: MSS SP-58 Types 35 through 38.
- G. Beam Clamps: MSS SP-58 Types 19 through 23, 25 or 27 through 30 based on required load.
 - 1. Manufacturers:
 - a. Ferguson Enterprises Inc; _____: www.fnw.com/#sle.
 - b. Substitutions: See Section 01 6000 - Product Requirements.
 - 2. Material: ASTM A36/A36M carbon steel or ASTM A181/A181M forged steel.
 - 3. Provide clamps with hardened steel cup-point set screws and lock-nuts for anchoring in place.
- H. Riser Clamps:
 - 1. Manufacturers:
 - a. Ferguson Enterprises Inc; _____: www.fnw.com/#sle.
 - b. Substitutions: See Section 01 6000 - Product Requirements.
 - 2. Provide copper plated clamps for copper tubing support.
 - 3. For insulated pipe runs, provide two bolt-type clamps designed for installation under insulation.
- I. Offset Pipe Clamps: Double-leg design two-piece pipe clamp.
 - 1. Manufacturers:
 - a. _____.
 - b. Substitutions: See Section 01 6000 - Product Requirements.
- J. Strut Clamps: Two-piece pipe clamp.
 - 1. Manufacturers:
 - a. Ferguson Enterprises Inc; _____: www.fnw.com/#sle.
 - b. Substitutions: See Section 01 6000 - Product Requirements.
- K. Insulation Clamps: Two bolt-type clamps designed for installation under insulation.
 - 1. Manufacturers:
 - a. Ferguson Enterprises Inc; _____: www.fnw.com/#sle.
 - b. Substitutions: See Section 01 6000 - Product Requirements.
- L. Pipe Hangers: For a given pipe run use hangers of the same type and material.
 - 1. Manufacturers:
 - a. Ferguson Enterprises Inc; _____: www.fnw.com/#sle.
 - b. Substitutions: See Section 01 6000 - Product Requirements.
 - 2. Material: Malleable iron, ASTM A47/A47M; or carbon steel, ASTM A36/A36M.
 - 3. Provide coated or plated hangers to isolate steel hangers from dissimilar metal tube or pipe.
- M. Intermediate Pipe Guides: Use pipe clamps with oversize pipe sleeve that provides clearance around pipe.
 - 1. Pipe Diameter 6 inches and Smaller: Provide minimum clearance of 0.16 inch.
 - 2. Pipe Diameter 8 inches: Provide U-bolts with double nuts providing minimum clearance of 0.28 inch.
 - 3. Pipe Diameter 8 inches: 0.625 inch U-bolt.
 - 4. Pipe Diameter 10 inches: 0.75 inch U-bolt.
 - 5. Pipe Diameter 12 to 16 inches: 0.875 inch U-bolt.
 - 6. Pipe Diameter 18 to 30 inches: 1 inch U-bolt.
- N. Pipe Alignment Guides: Galvanized steel.
 - 1. Manufacturers:

- a. Substitutions: See Section 01 6000 - Product Requirements.
2. Pipe Diameter 8 inches and Smaller: Spider or sleeve type.
3. Pipe Diameter 10 inches and Larger: Roller type.
4. Pipe Diameter 18 to 30 inches: 1 inch U-bolt.
- O. Dielectric Barriers: Provide between metallic supports and metallic piping and associated items of dissimilar type; acceptable dielectric barriers include rubber or plastic sheets or coatings attached securely to pipe or item.
 1. Manufacturers:
 - a. _____.
 - b. Substitutions: See Section 01 6000 - Product Requirements.
- P. Non-Penetrating Rooftop Supports for Low-Slope Roofs:
 1. Manufacturers:
 - a. Cooper B-Line, a division of Eaton Corporation; _____: www.cooperindustries.com/#sle.
 - b. Erico International Corporation, a brand of Pentair; _____: www.erico.com/#sle.
 - c. Ferguson Enterprises Inc; _____: www.fnw.com/#sle.
 - d. PHP Systems/Design; _____: www.phpsd.com/#sle.
 - e. Unistrut, a brand of Atkore International Inc; _____: www.unistrut.com/#sle.
 - f. _____.
 2. Provide steel pedestals with thermoplastic or rubber base that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified.
 3. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
 4. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports.
 5. Mounting Height: Provide minimum clearance of 6 inches under supported component to top of roofing.
 6. Manufacturers - Mechanical Anchors:
 - a. Hilti, Inc; _____: www.us.hilti.com/#sle.
 - b. ITW Red Head, a division of Illinois Tool Works, Inc; _____: www.itwredhead.com/#sle.
 - c. Powers Fasteners, Inc; _____: www.powers.com/#sle.
 - d. Simpson Strong-Tie Company Inc; _____: www.strongtie.com/#sle.
 - e. _____.
 - f. Substitutions: See Section 01 6000 - Product Requirements.
 7. Manufacturers - Powder-Actuated Fastening Systems:
 - a. Hilti, Inc; _____: www.us.hilti.com/#sle.
 - b. ITW Ramset, a division of Illinois Tool Works, Inc; _____: www.ramset.com/#sle.
 - c. Powers Fasteners, Inc; _____: www.powers.com/#sle.
 - d. Simpson Strong-Tie Company Inc; _____: www.strongtie.com/#sle.
 8. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
 9. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
 10. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
 11. Hollow Masonry: Use toggle bolts.
 12. Hollow Stud Walls: Use toggle bolts.
 13. Steel: Use beam clamps, machine bolts, or welded threaded studs.
 14. Wood: Use wood screws.
 15. Plastic and lead anchors are not permitted.

16. Powder-actuated fasteners are not permitted without Architect/Engineer/Owner application review and approval.
 17. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
 - a. Comply with MFMA-4.
 - b. Channel Material: Use galvanized steel.
 - c. Manufacturer: Same as manufacturer of metal channel (strut) framing system.
- Q. Pipe Installation Accessories:
1. Copper Pipe Supports:
 - a. Manufacturers:
 - 1) HoldRite, a brand of Reliance Worldwide Corporation; _____: www.holdrite.com/#sle.
 - 2) _____.
 - 3) Substitutions: See Section 01 6000 - Product Requirements.
 2. Thermal Insulated Pipe Supports:
 - a. Manufacturers:
 - 1) HoldRite, a brand of Reliance Worldwide Corporation; _____: www.holdrite.com/#sle.
 - 2) _____.
 - 3) Substitutions: See Section 01 6000 - Product Requirements.
 3. Overhead Pipe Supports:
 - a. Manufacturers:
 - 1) HoldRite, a brand of Reliance Worldwide Corporation; _____: www.holdrite.com/#sle.
 - 2) _____.
 - 3) Substitutions: See Section 01 6000 - Product Requirements.
 4. Inserts and Clamps:
 - a. Manufacturers:
 - 1) HoldRite, a brand of Reliance Worldwide Corporation; _____: www.holdrite.com/#sle.
 - 2) _____.
 - 3) Substitutions: See Section 01 6000 - Product Requirements.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive support and attachment components.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Provide independent support from building structure. Do not provide support from piping, ductwork, conduit, or other systems.
- C. Unless specifically indicated or approved by Architect, do not provide support from suspended ceiling support system or ceiling grid.
- D. Unless specifically indicated or approved by Architect, do not provide support from roof deck.
- E. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- F. Provide thermal insulated pipe supports complete with hangers and accessories. Install thermal insulated pipe supports during the installation of the piping system.
- G. Equipment Support and Attachment:

1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
4. Unless otherwise indicated, mount floor-mounted equipment on properly sized 4 inch high concrete pad constructed in accordance with Section 03 3000.

3.03 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Inspect support and attachment components for damage and defects.
- C. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- D. Correct deficiencies and replace damaged or defective support and attachment components.

END OF SECTION 23 0529

SECTION 23 0533
HEAT TRACING FOR HVAC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Self-regulating parallel resistance electric heating cable.

1.02 RELATED REQUIREMENTS

- A. Section 23 0553 - Identification for HVAC Piping and Equipment.
- B. Section 23 0719 - HVAC Piping Insulation.
- C. Section 23 0913 - Instrumentation and Control Devices for HVAC.
- D. Section 23 0923 - Direct-Digital Control System for HVAC.
- E. Section 23 0993 - Sequence of Operations for HVAC Controls.
- F. Section 23 2113 - Hydronic Piping.
- G. Section 23 2114 - Hydronic Specialties.
- H. Section 26 0519 - Low-Voltage Electrical Power Conductors and Cables.
- I. Section 26 0526 - Grounding and Bonding for Electrical Systems.
- J. Section 26 0533.13 - CONDUIT.
- K. Section 26 0533.16 - Boxes for Electrical Systems.
- L. Section 26 0583 - Wiring Connections.

1.03 REFERENCE STANDARDS

- A. IEEE 515.1 - IEEE Standard for the Testing, Design, Installation, and Maintenance of Electrical Resistance Trace Heating for Commercial Applications; 2012.
- B. ITS (DIR) - Directory of Listed Products; current edition.
- C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D. UL (DIR) - Online Certifications Directory; current listings at database.ul.com.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.
- B. Coordinate the work with other trades to provide ground fault protection for electric heat tracing circuits as required by NFPA 70.
- C. Coordinate the work with other trades to provide circuit breaker ratings suitable for installed circuit lengths.

1.05 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data for electric heat tracing.
- C. Shop Drawings: Indicate electric heat tracing layout, electrical terminations, thermostats, controls, branch circuit connections, and power source.
- D. Manufacturer's Installation Instructions: Indicate installation instructions and recommendations.
- E. Field Quality Control Submittals: Indicate test reports and inspection reports.
- F. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions of equipment and controls, maintenance and repair data, and parts listings.
- G. Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

- H. Project Record Documents: Record actual locations of electric heat tracing lines and thermostats.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with at least three years of documented experience.
- B. Installer Qualifications: Company specializing in performing work of the type specified and with at least three years of documented experience.
- C. Copies of Documents at Project Site: Maintain at the project site a copy of each referenced document that prescribes execution requirements.

1.07 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide two year manufacturer warranty for cables, connection kits, accessories, and controls.

PART 2 PRODUCTS

2.01 SELF-REGULATING PARALLEL RESISTANCE ELECTRIC HEATING CABLE

- A. Manufacturers:
 - 1. Chromalox, Inc: www.chromalox.com/#sle.
 - 2. Pentair: www.pentairthermal.com/#sle.
 - 3. Thermon Manufacturing Company: www.thermon.com/#sle.
 - 4. Raychem
 - 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Provide products listed, classified, and labeled by UL (DIR), ITS (DIR), or testing firm acceptable to authorities having jurisdiction (AHJ).
- C. Factory Rating and Testing: Comply with IEEE 515.1.
- D. Heating Element:
 - 1. Provide pair of parallel No. 16 tinned or nickel coated stranded copper bus wires embedded in cross linked conductive polymer core with varying heat output in response to temperature along its length.
 - 2. Terminations: Waterproof, factory assembled, non-heating leads with connector at one end and water-tight seal at opposite end.
 - 3. Capable of crossing over itself without overheating.
- E. Insulated Jacket: Flame retardant polyolefin.
- F. Cable Cover: Provide tinned copper and polyolefin outer jacket with UV inhibitor.
- G. Electrical Characteristics:

2.02 OUTER JACKET MARKINGS

- A. Name of manufacturer, trademark, or other recognized symbol of identification.
- B. Catalog number, reference number, or model.
- C. Month and year of manufacture, date coding, applicable serial number, or equivalent.
- D. Agency listing or approval.
- E. Applicable environmental or area use requirements, such as NEMA 4, Type 4, IP ratings, and hazardous (classified) location markings including temperature rating.
- F. Any applicable warning/caution statements such as "WARNING: De-energize circuit before removing cover.

2.03 CONNECTION KITS

- A. Name of manufacturer, trademark, or other recognized symbol of identification.
- B. Provide power connection, splice/tee, and end seal kits compatible with the heating cable and without requiring cutting of the cable core to expose bus wires.

- C. Furnish with NEMA 4X rating for prevention of corrosion and water ingress.
- D. Provide UV stabilized components.

2.04 ACCESSORIES

- A. Provide Accessories As Indicated or As Required for Complete Installation, Including but Not Limited To:
 - 1. High temperature, glass filament tape for attachment of heating cable to metal piping.
 - 2. Aluminum self-adhesive tape for attachment of heating cable to plastic piping.
 - 3. Silicone end seals and splice kits.
 - 4. Installation clips.
 - 5. Warning labels for attachment to exterior of piping insulation. Refer to Section 23 0553.

2.05 CONTROLS

- A. Pipe Mounted Thermostats:
 - 1. Remote bulb unit with adjustable temperature range from 30 to 50 degrees F.
 - 2. Snap-action, open-on-rise, single pole switch with minimum current rating adequate for the connected cable.
 - 3. Remote bulb on capillary, resistance temperature device (RTD) or thermistor for direct sensing of pipe wall temperature.
 - 4. Control Enclosure: Corrosion resistant and waterproof.
- B. Provide minimum 30 ampere contactor to indicate operational status and on/off control.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that piping and equipment are ready to receive work.
- B. Verify field measurements are as indicated on shop drawings.
- C. Verify required power is available, in proper location, and ready for use.

3.02 PREPARATION

- A. Clean all surfaces prior to installation.
- B. Prepare surfaces using the methods recommended by the manufacturer.

3.03 INSTALLATION

- A. Install in accordance with manufacturer's recommendations.
- B. Comply with installation requirements of IEEE 515.1 and NFPA 70, Article 427.
- C. Apply heating cable linearly on pipe with fiberglass tape only after piping has successfully completed any required pressure testing.
- D. Heat Trace cable and associated sensing and control devices shall be located/installed to allow access for service, repair, and replacement without requiring destructive demolition to associated building envelope, column enclosures or similar building enclosure Architectural components.
- E. Comply with all national and local code requirements.
- F. Controls:
 - 1. Control System Devices: Refer to Section 23 0913.
 - 2. Digital Control: Refer to Section 23 0923.
 - 3. Sequence of Operation: Refer to Section 23 0993.
- G. Identification:
 - 1. After thermal insulation installation, apply external pipeline decals to indicate presence of the thermal insulation cladding at intervals not to exceed 20 ft including cladding over each valve or other equipment that may require maintenance.

3.04 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Perform start-up by factory technician or factory representative as per Owner's requirements.
- C. Field Testing and Inspections:
 - 1. Commission system in accordance with installation and operation manual.
 - 2. Inspect for sources of water entry and proper sealing.
 - 3. Inspect weather barrier to confirm that no sharp edges are contacting the trace heating.
 - 4. Minimum Acceptable Insulation Resistance: 20 megohms or greater at a test voltage of 2500 VDC for polymer insulated trace heaters.
 - 5. Test heating cable integrity with megohmmeter at the following intervals:
 - a. Before installing the cable.
 - b. After cable has been installed onto the piping.
 - c. After installing the connection kits.
 - d. After the installation of thermal insulation onto the piping.
 - e. Prior to initial start-up (commissioning).
 - 6. Measure voltage and current at each unit.
 - 7. Controls:
 - a. Verify control parameters are set to the application requirements.
 - b. Verify factory provided digital temperature controller is correctly configured with the building automation system.
 - 8. Submit written test report showing values measured on each test for each cable.

3.05 CLOSEOUT ACTIVITIES

- A. See Section 01 7800 - Closeout Submittals.
- B. See Section 01 7900 - Demonstration and Training, for additional requirements.

3.06 PROTECTION

- A. Protect installed products from damage until Date of Substantial Completion.

END OF SECTION 23 0533

SECTION 23 0548
VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Vibration-isolated equipment support bases.
- B. Vibration isolators.

1.02 RELATED REQUIREMENTS

- A. Section 01 4533 - Code-Required Special Inspections and Procedures.
- B. Section 03 3000 - Cast-in-Place Concrete.
- C. Section 23 0529 - Hangers and Supports for HVAC Piping and Equipment.

1.03 REFERENCE STANDARDS

- A. ASCE 7 - Minimum Design Loads for Buildings and Other Structures; 2010, with 2013 Supplements and Errata.
- B. ASHRAE (HVAC) - ASHRAE Handbook - HVAC Applications; 2015.
- C. ICC (IBC) - International Building Code; 2015.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for products, including materials, fabrication details, dimensions, and finishes.
 - 1. Vibration Isolators: Include rated load capacities and deflections; include information on color coding or other identification method for spring element load capacities.
- C. Shop Drawings - Vibration Isolation Systems:
 - 1. Include dimensioned plan views and sections indicating proposed arrangement of vibration isolators; indicate equipment weights and static deflections.
 - 2. Vibration-Isolated Equipment Support Bases: Include base weights, including concrete fill where applicable; indicate equipment mounting provisions.

1.05 QUALITY ASSURANCE

PART 2 PRODUCTS

2.01 VIBRATION ISOLATION REQUIREMENTS

- A. Provide vibration isolation systems to reduce vibration transmission to supporting structure from vibration-producing HVAC equipment and/or HVAC connections to vibration-isolated equipment.
- B. Comply with applicable general recommendations of ASHRAE (HVAC), where not in conflict with other specified requirements:
- C. General Requirements:
 - 1. Select vibration isolators to provide required static deflection.
 - 2. Select vibration isolators for uniform deflection based on distributed operating weight of actual installed equipment.
 - 3. Select vibration isolators for outdoor equipment to comply with wind design requirements.
- D. Piping Isolation:
 - 1. Minimum Static Deflection:
 - a. First Three Supports Closest to Isolated Equipment: Same as static deflection of equipment; maximum of 2 inch deflection required.
- E. Thrust Restraint Applications:

1. Use thrust restraints to resist horizontal motion due to thrust for fan heads, suspended fans, and base-mounted and suspended air handling equipment operating at 2.0 inches wg or greater total static pressure.

2.02 VIBRATION-ISOLATED EQUIPMENT SUPPORT BASES

- A. Manufacturers:
 1. Vibration-Isolated Equipment Support Bases:
 - a. Kinetics Noise Control, Inc; _____: www.kineticsnoise.com/#sle.
 - b. Mason Industries; _____: www.mason-ind.com/#sle.
 - c. Vibration Eliminator Company, Inc; _____: www.veco-nyc.com/#sle.
 2. Source Limitations: Furnish vibration-isolated equipment support bases and associated components and accessories produced by the same manufacturer as the vibration isolators and obtained from a single supplier.
- B. Vibration-Isolated Concrete Inertia Bases:
 1. Description: Concrete-filled engineered steel forms with integral mounting provisions for vibration isolators, sized and configured for mounting of equipment.
 2. Minimum Base Depth: 6 inches.
 3. Minimum Base Mass (Including Concrete): 1.5 times weight of supported equipment.
 4. Concrete Reinforcement: Welded or tied reinforcing bars running both ways in a single layer.
 5. Concrete: Filled on site with minimum 3000 psi concrete in accordance with Section 03 3000.

2.03 VIBRATION ISOLATORS

- A. Manufacturers:
 1. Vibration Isolators:
 - a. Kinetics Noise Control, Inc; _____: www.kineticsnoise.com/#sle.
 - b. Mason Industries; _____: www.mason-ind.com/#sle.
 - c. Vibration Eliminator Company, Inc; _____: www.veco-nyc.com/#sle.
- B. General Requirements:
 1. Resilient Materials for Vibration Isolators: Oil, ozone, and oxidant resistant.
 2. Spring Elements for Spring Isolators:
 - a. Color code or otherwise identify springs to indicate load capacity.
 - b. Lateral Stability: Minimum lateral stiffness to vertical stiffness ratio of 0.8.
 - c. Designed to operate in the linear portion of their load versus deflection curve over deflection range of not less than 50 percent above specified deflection.
 - d. Designed to provide additional travel to solid of not less than 50 percent of rated deflection at rated load.
 - e. Selected to provide designed deflection of not less than 75 percent of specified deflection.
 - f. Selected to function without undue stress or overloading.

2.04 VIBRATION-ISOLATED AND/OR SEISMICALLY ENGINEERED ROOF CURBS

- A. Manufacturers:
 1. Vibration-Isolated and/or Seismically Engineered Roof Curbs:
 - a. Kinetics Noise Control, Inc; _____: www.kineticsnoise.com/#sle.
 - b. Mason Industries; _____: www.mason-ind.com/#sle.
 - c. Vibration Eliminator Company, Inc; _____: www.veco-nyc.com/#sle.
 - d. Substitutions: See Section 01 6000 - Product Requirements.
 2. Source Limitations: Furnish vibration-isolated roof curbs and associated accessories produced by the same manufacturer as the vibration isolators and obtained from a single supplier.
- B. Vibration Isolation Curbs:
 1. Non-Seismic Curb Rail:

- a. Location: Between existing roof curb and rooftop equipment.
 - b. Construction: Aluminum.
 - c. Integral vibration isolation to comply with requirements of this section.
 - d. Weather exposed components consist of corrosion resistant materials.
2. Non-Seismic Curb:
 - a. Location: Between structure and rooftop equipment.
 - b. Construction: Aluminum.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Vibration Isolation Systems:
 1. Vibration-Isolated Equipment Support Bases:
 - a. Provide specified minimum clearance beneath base.
 2. Spring Isolators:
 - a. Position equipment at operating height; provide temporary blocking as required.
 - b. Lift equipment free of isolators prior to lateral repositioning to avoid damage to isolators.
 - c. Level equipment by adjusting isolators gradually in sequence to raise equipment uniformly such that excessive weight or stress is not placed on any single isolator.
 3. Isolator Hangers:
 - a. Use precompressed isolator hangers where required to facilitate installation and prevent damage to equipment utility connection provisions.
 - b. Locate isolator hangers at top of hanger rods in accordance with manufacturer's instructions.
 4. Thrust Restraints:
 - a. Adjust restraint movement under normal operating static pressure.
 5. Clean debris from beneath vibration-isolated equipment that could cause short circuiting of isolation.
 6. Use elastomeric grommets for attachments where required to prevent short circuiting of isolation.
 7. Adjust isolators to be free of isolation short circuits during normal operation.
 8. Do not overtighten fasteners such that resilient material isolator pads are compressed beyond manufacturer's maximum recommended deflection.

3.02 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.

END OF SECTION 23 0548

SECTION 23 0553
IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Nameplates.
- B. Tags.
- C. Adhesive-backed duct markers.
- D. Stencils.
- E. Pipe markers.
- F. Ceiling tacks.
- G. Warning signs and labels

1.02 RELATED REQUIREMENTS

- A. Section 09 9123 - Interior Painting: Identification painting.

1.03 REFERENCE STANDARDS

- A. ASME A13.1 - Scheme for the Identification of Piping Systems; 2007.
- B. ASTM D709 - Standard Specification for Laminated Thermosetting Materials; 2013.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. List: Submit list of wording, symbols, letter size, and color coding for mechanical identification.
- C. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- D. Product Data: Provide manufacturers catalog literature for each product required.
- E. Manufacturer's Installation Instructions: Indicate special procedures, and installation.
- F. Project Record Documents: Record actual locations of tagged valves.

PART 2 PRODUCTS

2.01 IDENTIFICATION APPLICATIONS

- A. Air Handling Units: Nameplates, Owner furnished asset sticker.
- B. Air Terminal Units: Tags.
- C. Automatic Controls: Tags. Key to control schematic.
- D. Control Panels: Nameplates.
- E. Fire Dampers: Ceiling tacks, where located above lay-in ceiling.
- F. Ductwork: Stencils or Adhesive-backed duct markers.
- G. Heat Transfer Equipment: Nameplates, Owner furnished asset sticker.
- H. Instrumentation: Tags.
- I. Major Control Components: Nameplates.
- J. Piping: Stencils or Adhesive-backed duct markers.
- K. Pumps: Nameplates, Owner furnished asset sticker.
- L. Relays: Tags.
- M. Small-sized Equipment: Tags.
- N. Tanks: Nameplates, Owner furnished asset sticker.
- O. Thermostats: Tags.

- P. Valves: Tags and ceiling tacks where located above lay-in ceiling.
- Q. Water Treatment Devices: Nameplates, Owner furnished asset sticker.

2.02 NAMEPLATES

- A. Manufacturers:
 - 1. Advanced Graphic Engraving, LLC; _____: www.advancedgraphicengraving.com/#sle.
 - 2. Brimar Industries, Inc; _____: www.pipemarker.com/#sle.
 - 3. Kolbi Pipe Marker Co; _____: www.kolbipipemarkers.com/#sle.
 - 4. Seton Identification Products, a Tricor Direct Company; _____: www.seton.com/#sle.
 - 5. Substitutions: See Section 01 6000 - Product Requirements.

2.03 TAGS

- A. Manufacturers:
 - 1. Advanced Graphic Engraving; _____: www.advancedgraphicengraving.com/#sle.
 - 2. Brady Corporation; _____: www.bradycorp.com/#sle.
 - 3. Brimar Industries, Inc; _____: www.pipemarker.com/#sle.
 - 4. Kolbi Pipe Marker Co; _____: www.kolbipipemarkers.com/#sle.
 - 5. Seton Identification Products, a Tricor Company; _____: www.seton.com/#sle.
 - 6. Substitutions: See Section 01 6000 - Product Requirements.
- 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. Metal Tags: Brass with stamped letters; tag size minimum 1-1/2 inch diameter with smooth edges.
- D. Valve Tag Chart: Typewritten letter size list in anodized aluminum frame.

2.04 ADHESIVE-BACKED DUCT MARKERS

- A. Manufacturers:
 - 1. Brimar Industries, Inc; _____: www.pipemarker.com/#sle.
 - 2. Craftmark Pipe Markers; _____: www.craftmarkid.com/#sle.
 - 3. Seton Identification Products, a Tricor Company.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Material: High gloss acrylic adhesive-backed vinyl film 0.0032 inch; printed with UV and chemical resistant inks.
- C. Style: Individual Label.
- D. Color: Yellow/Black. Colors to match individual facility standard

2.05 STENCILS

- A. Stencils: With clean cut symbols and letters of following size:
 - 1. 3/4 to 1-1/4 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 1/2 inch high letters.
 - 2. 1-1/2 to 2 inch Outside Diameter of Insulation or Pipe: 8 inch long color field, 3/4 inch high letters.
 - 3. 8 to 10 inch Outside Diameter of Insulation or Pipe: 24 inch long color field, 2-1/2 inch high letters.
 - 4. Over 10 inch Outside Diameter of Insulation or Pipe: 32 inch long color field, 3-1/2 inch high letters.
 - 5. Ductwork and Equipment: 2-1/2 inch high letters.
- B. Stencil Paint: As specified in Section 09 9123, semi-gloss enamel, colors complying with ASME A13.1.

2.06 PIPE MARKERS

- A. Manufacturers:
 - 1. Brady Corporation; _____: www.bradycorp.com/#sle.

2. Brimar Industries, Inc; _____: www.pipemarker.com/#sle.
 3. Kolbi Pipe Marker Co; _____: www.kolbipipemarkers.com/#sle.
 4. MIFAB, Inc; _____: www.mifab.com/#sle.
 5. Seton Identification Products, a Tricor Company; _____: www.seton.com/#sle.
 6. Substitutions: See Section 01 6000 - Product Requirements.
- B. Color: Comply with 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. Color code as follows:
1. Heating: Yellow with Black Letters
 2. Cooling, and Boiler Feedwater: Green with white letters.
 3. Toxic and Corrosive Fluids: Orange with black letters.
 4. Compressed Air: Blue with white letters.

2.07 CEILING TACKS

- A. Manufacturers:
1. Craftmark Pipe Markers; _____: www.craftmarkid.com/#sle.
 2. Substitutions: See Section 01 6000 - Product Requirements.
- B. Description: Steel with 3/4 inch diameter color coded head.

2.08 OWNER FURNISHED ASSET STICKERS

- A. Stickers to be furnished to CM by owner. CM to hand over to contractor.
- B. Contractor to apply sticker to designated pieces of equipment.
- C. Contractor to complete Asset Check In Sheet for each piece of equipment.

PART 3 EXECUTION

3.01 PREPARATION

- A. Degrease and clean surfaces to receive adhesive for identification materials.
- B. Prepare surfaces in accordance with Section 09 9123 for stencil painting.

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. 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 10 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.
- E. Locate ceiling tacks to locate valves or dampers above lay-in panel ceilings. Locate in corner of panel closest to equipment.

END OF SECTION 23 0553

SECTION 23 0593
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, steam, and refrigerating systems.
- C. Measurement of final operating condition of HVAC systems.
- D. Commissioning activities.

1.02 RELATED REQUIREMENTS

- A. Section 01 2100 - Allowances: Inspection and testing allowances.
- B. Section 01 4000 - Quality Requirements: Employment of testing agency and payment for services.
- C. Section 01 9113 - General Commissioning Requirements: Commissioning requirements that apply to all types of work.
- D. Section 23 0800 - Commissioning of HVAC.

1.03 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 Standard for Testing, Adjusting and Balancing of Environmental Systems; 2019, with Errata (2022).
- D. SMACNA (TAB) - HVAC Systems Testing, Adjusting and Balancing; 2002.

1.04 SUBMITTALS

- A. See Section 01 3000 - 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. TAB Plan: Submit a written plan indicating the testing, adjusting, and balancing standard to be followed and the specific approach for each system and component.
 - 1. Submit to Design engineer and facilities engineering.
 - 2. Submit to the Commissioning Authority.
 - 3. Submit six weeks prior to starting the testing, adjusting, and balancing work.
 - 4. Include at least the following in the plan:
 - a. Preface: An explanation of the intended use of the control system.
 - b. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
 - c. Copy of field checkout sheets and logs to be used, listing each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
 - d. Identification and types of measurement instruments to be used and their most recent calibration date.
 - e. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
 - f. Final test report forms to be used.
 - g. Detailed step-by-step procedures for TAB work for each system and issue, including:
 - 1) Terminal flow calibration (for each terminal type).
 - 2) Diffuser proportioning.
 - 3) Branch/submain proportioning.

- 4) Total flow calculations.
- 5) Rechecking.
- 6) Diversity issues.
- h. Details of how TOTAL flow will be determined; for example:
 - 1) Air: Via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA or OA flow stations MUST be verified for accuracy .
 - 2) Water: circuit setter, flow station, ultrasonic, etc verified against pump curve.
- i. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and methods to verify this.
- j. Confirmation of understanding of the outside air ventilation criteria under all conditions.
- k. Method of verifying and setting minimum outside air flow rate will be verified and set and for what level (total building, zone, etc.).
- l. Method of checking building static and exhaust fan and/or relief damper capacity.
- m. Method of verifying all measurements under varying loads and seasonal condition changes.
- n. Methods for making coil or other system plant capacity measurements, if specified.
- o. Time schedule for TAB work to be done in phases (by floor, etc.).
- p. Description of TAB work for areas to be built out later, if any.
- q. Time schedule for deferred or seasonal TAB work, if specified.
- r. False loading of systems to complete TAB work, if specified.
- s. Exhaust fan balancing and capacity verifications, including any required room pressure differentials.
- t. Interstitial cavity differential pressure measurements and calculations, if specified.
- u. Procedures for field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).
- v. Procedures for formal progress reports, including scope and frequency.
- w. Procedures for formal deficiency reports, including scope, frequency and distribution.
- D. Field Logs: Submit at least twice a week to the Commissioning Authority.
- E. Control System Coordination Reports: Communicate in writing to the controls installer all setpoint and parameter changes made or problems and discrepancies identified during TAB that affect, or could affect, the control system setup and operation. provide copy to facilities engineering.
- F. Progress Reports.
- G. 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. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect and for inclusion in operating and maintenance manuals.
 - 3. Provide reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.
 - 4. Include actual instrument list, with manufacturer name, serial number, and date of calibration.
 - 5. Form of Test Reports: Where the TAB standard being followed recommends a report format use that; otherwise, follow ASHRAE Std 111.
 - 6. Units of Measure: Report data in both I-P (inch-pound) and SI (metric) units.

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. SMACNA (TAB).
 - 4. Maintain at least one copy of the standard to be used at project site at all times.
- 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/#sle; upon completion submit AABC National Performance Guaranty.
 - b. NEBB, National Environmental Balancing Bureau: www.nebb.org/#sle.
 - c. TABB, The Testing, Adjusting, and Balancing Bureau of National Energy Management Institute: www.tabbcertified.org/#sle.
- E. TAB Supervisor and Technician Qualifications: Certified by same organization as TAB agency.
- F. Pre-Qualified TAB Agencies:
 - 1. Mechanical Testing Services, Inc.
 - 2. Great Lakes Balancing LLC
 - 3. Third Coast Test and Balance

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. Air outlets are installed and connected.
 - 11. Duct system leakage is minimized.
 - 12. Hydronic systems are flushed, filled, treated and vented.
 - 13. Pumps are rotating correctly.
 - 14. Proper strainer baskets are clean and in place.
 - 15. Pump Start up screens to be in use for minimum 48 hours of operation. remove start up screens after initial run time.
 - 16. 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 PREPARATION

- A. Hold a pre-balancing meeting at least one week prior to starting TAB work.
 - 1. Require attendance by all installers whose work will be tested, adjusted, or balanced.
- B. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Architect to facilitate spot checks during testing.
- C. Provide additional balancing devices as required.

3.04 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. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.
- C. Design space pressure shall be maintained at all times.
- D. Hydronic Systems: Adjust to within plus or minus 5 percent of design.

3.05 RECORDING AND ADJUSTING

- A. Field Logs: Maintain written logs including:
 - 1. Running log of events and issues.
 - 2. Discrepancies, deficient or uncompleted work by others.
 - 3. Contract interpretation requests.
 - 4. Lists of completed tests.
- B. Ensure recorded data represents actual measured or observed conditions.
- C. Permanently mark settings of valves, dampers, and other adjustment devices allowing settings to be restored. Set and lock memory stops.
- D. Mark on drawings the locations where traverse and other critical measurements were taken and cross reference the location in the final report.
- E. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
- F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.06 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. Measure air quantities at air inlets and outlets.
- D. Use volume control devices to regulate air quantities only to extend that adjustments do not create objectionable air motion or sound levels. Effect volume control by duct internal devices such as dampers and splitters.
- E. Vary total system air quantities by adjustment of fan speeds. Provide drive changes required. Vary branch air quantities by damper regulation.
- F. Provide system schematic with required and actual air quantities recorded at each outlet or inlet.
- G. 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.

- H. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.
- I. Measure temperature conditions across outside air, return air, and exhaust dampers to check leakage.
- J. 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.
- K. 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 near the building entries.
- L. 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.
- M. On fan powered VAV boxes, adjust air flow switches for proper operation.

3.07 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.

3.08 COMMISSIONING

- A. See Sections 01 9113 - General Commissioning Requirements and 23 0800 for additional requirements.
- B. Perform prerequisites prior to starting commissioning activities.
- C. Fill out Prefunctional Checklists for:
 - 1. Air side systems.
 - 2. Water side systems.
- D. Furnish to the Commissioning Authority, upon request, any data gathered but not shown in the final TAB report.
- E. Re-check minimum outdoor air intake flows and maximum and intermediate total airflow rates for ____ percent of the air handlers plus a random sample equivalent to ____ percent of the final TAB report data as directed by Commissioning Authority.
 - 1. Original TAB agency shall execute the re-checks, witnessed by the Commissioning Authority.
 - 2. Use the same test instruments as used in the original TAB work.
 - 3. Failure of more than 10 percent of the re-checked items of a given system shall result in the rejection of the system TAB report; rebalance the system, provide a new system TAB report, and repeat random re-checks.
 - 4. For purposes of re-check, failure is defined as follows:
 - a. Air Flow of Supply and Return: Deviation of more than 10 percent of instrument reading.

- b. Minimum Outside Air Flow: Deviation of more than percent of instrument reading; for inlet vane or VFD OSA compensation system using linear proportional control, deviation of more than 30 percent at intermediate supply flow.
 - c. Temperatures: Deviation of more than 3 degree F.
 - d. Air and Water Pressures: Deviation of more than 10 percent of full scale of test instrument reading.
 - e. Sound Pressures: Deviation of more than 3 decibels, with consideration for variations in background noise.
- 5. For purposes of re-check, a whole system is defined as one in which inaccuracies will have little or no impact on connected systems; for example, the air distribution system served by one air handler or the hydronic chilled water supply system served by a chiller or the condenser water system.
- F. In the presence of the Commissioning Authority, verify that:
 - 1. Final settings of all valves, splitters, dampers and other adjustment devices have been permanently marked.
 - 2. The air system is being controlled to the lowest possible static pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from fan to diffuser having all balancing dampers wide open and that during full cooling of all terminal units taking off downstream of the static pressure sensor, the terminal unit on the critical leg has its damper 90 percent or more open.
 - 3. Pumps rotate in correct direction
 - 4. The water system is being controlled to the lowest possible pressure while still meeting design loads, less diversity; this shall include a review of TAB methods, established control setpoints, and physical verification of at least one leg from the pump to the coil having all balancing valves wide open and that during full cooling the cooling coil valve of that leg is 90 percent or more open.

3.09 SCOPE

- A. Test, adjust, and balance the following:
 - 1. Fire Pumps.
 - 2. Sprinkler Air Compressor.
 - 3. Electric Water Coolers.
 - 4. Plumbing Pumps.
 - 5. Steam Condensate Pumps.
 - 6. Boiler Feedwater Pumps.
 - 7. HVAC Pumps.
 - 8. Water Tube Boilers.
 - 9. Packaged Steel Water Tube Boilers.
 - 10. Packaged Steel Fire Tube Boilers.
 - 11. Forced Air Furnaces.
 - 12. Direct Fired Furnaces.
 - 13. Reciprocating Water Chillers.
 - 14. Air Cooled Water Chillers.
 - 15. Centrifugal Water Chillers.
 - 16. Absorption Water Chillers.
 - 17. Induced Draft Cooling Tower.
 - 18. Blow Through Cooling Tower.
 - 19. Air Cooled Refrigerant Condensers.
 - 20. Packaged Roof Top Heating/Cooling Units.
 - 21. Computer Room Air Conditioning Units.
 - 22. Air Coils.
 - 23. Evaporative Humidifier.
 - 24. Terminal Heat Transfer Units.

25. Air Handling Units.
26. Fans.
27. Air Filters.
28. Air Terminal Units.
29. Air Inlets and Outlets.

3.10 MINIMUM DATA TO BE REPORTED

- A. Electric Motors:
 1. Manufacturer.
 2. Model/Frame.
 3. HP/BHP.
 4. Phase, voltage, amperage; nameplate, actual, no load.
 5. RPM.
 6. Service factor.
 7. Starter size, rating, heater elements.
 8. Sheave Make/Size/Bore.
- B. V-Belt Drives:
 1. Identification/location.
 2. Required driven RPM.
 3. Driven sheave, diameter and RPM.
 4. Belt, size and quantity.
 5. Motor sheave diameter and RPM.
 6. Center to center distance, maximum, minimum, and actual.
- C. Pumps:
 1. Identification/number.
 2. Manufacturer.
 3. Size/model.
 4. Impeller.
 5. Service.
 6. Design flow rate, pressure drop, BHP.
 7. Actual flow rate, pressure drop, BHP.
 8. Discharge pressure.
 9. Suction pressure.
 10. Total operating head pressure.
 11. Shut off, discharge and suction pressures.
 12. Shut off, total head pressure.
- D. Combustion Equipment:
 1. Boiler manufacturer.
 2. Model number.
 3. Serial number.
 4. Firing rate.
 5. Overfire draft.
 6. Gas pressure at meter outlet.
 7. Gas flow rate.
 8. Heat input.
 9. Burner manifold gas pressure.
 10. Percent carbon monoxide (CO).
 11. Percent carbon dioxide (CO₂).
 12. Percent oxygen (O₂).
 13. Flue gas temperature at outlet.
 14. Ambient temperature.
 15. Net stack temperature.

16. Percent combustion efficiency.
 17. Heat output.
- E. Air Cooled Condensers:
1. Identification/number.
 2. Location.
 3. Manufacturer.
 4. Model number.
 5. Serial number.
 6. Entering DB air temperature, design and actual.
 7. Leaving DB air temperature, design and actual.
 8. Number of compressors.
- F. Chillers:
1. Identification/number.
 2. Manufacturer.
 3. Capacity.
 4. Model number.
 5. Serial number.
 6. Evaporator entering water temperature, design and actual.
 7. Evaporator leaving water temperature, design and actual.
 8. Evaporator pressure drop, design and actual.
 9. Evaporator water flow rate, design and actual.
 10. Condenser entering water temperature, design and actual.
 11. Condenser pressure drop, design and actual.
 12. Condenser water flow rate, design and actual.
- G. Cooling Tower:
1. Tower identification/number.
 2. Manufacturer.
 3. Model number.
 4. Serial number.
 5. Rated capacity.
 6. Entering air WB temperature, specified and actual.
 7. Leaving air WB temperature, specified and actual.
 8. Ambient air DB temperature.
 9. Condenser water entering temperature.
 10. Condenser water leaving temperature.
 11. Condenser water flow rate.
 12. Fan RPM.
- H. Heat Exchangers:
1. Identification/number.
 2. Location.
 3. Service.
 4. Manufacturer.
 5. Model number.
 6. Serial number.
 7. Steam pressure, design and actual.
 8. Primary water entering temperature, design and actual.
 9. Primary water leaving temperature, design and actual.
 10. Primary water flow, design and actual.
 11. Primary water pressure drop, design and actual.
 12. Secondary water leaving temperature, design and actual.
 13. Secondary water flow, design and actual.

14. Secondary water pressure drop, design and actual.
- I. Cooling Coils:
1. Identification/number.
 2. Location.
 3. Service.
 4. Manufacturer.
 5. Air flow, design and actual.
 6. Entering air DB temperature, design and actual.
 7. Entering air WB temperature, design and actual.
 8. Leaving air DB temperature, design and actual.
 9. Leaving air WB temperature, design and actual.
 10. Water flow, design and actual.
 11. Water pressure drop, design and actual.
 12. Entering water temperature, design and actual.
 13. Leaving water temperature, design and actual.
 14. Saturated suction temperature, design and actual.
 15. Air pressure drop, design and actual.
- J. Heating Coils:
1. Identification/number.
 2. Location.
 3. Service.
 4. Manufacturer.
 5. Air flow, design and actual.
 6. Water flow, design and actual.
 7. Water pressure drop, design and actual.
 8. Entering water temperature, design and actual.
 9. Leaving water temperature, design and actual.
 10. Entering air temperature, design and actual.
 11. Leaving air temperature, design and actual.
 12. Air pressure drop, design and actual.
- K. Electric Duct Heaters:
1. Manufacturer.
 2. Identification/number.
 3. Location.
 4. Model number.
 5. Design kW.
 6. Number of stages.
 7. Phase, voltage, amperage.
 8. Test voltage (each phase).
 9. Test amperage (each phase).
 10. Air flow, specified and actual.
 11. Temperature rise, specified and actual.
- L. Air Moving Equipment:
1. Location.
 2. Manufacturer.
 3. Model number.
 4. Serial number.
 5. Arrangement/Class/Discharge.
 6. Air flow, specified and actual.
 7. Return air flow, specified and actual.
 8. Outside air flow, specified and actual.

9. Total static pressure (total external), specified and actual.
 10. Inlet pressure.
 11. Discharge pressure.
 12. Sheave Make/Size/Bore.
 13. Number of Belts/Make/Size.
 14. Fan RPM.
- M. Return Air/Outside Air:
1. Identification/location.
 2. Design air flow.
 3. Actual air flow.
 4. Design return air flow.
 5. Actual return air flow.
 6. Design outside air flow.
 7. Actual outside air flow.
 8. Return air temperature.
 9. Outside air temperature.
 10. Required mixed air temperature.
 11. Actual mixed air temperature.
 12. Design outside/return air ratio.
 13. Actual outside/return air ratio.
- N. Exhaust Fans:
1. Location.
 2. Manufacturer.
 3. Model number.
 4. Serial number.
 5. Air flow, specified and actual.
 6. Total static pressure (total external), specified and actual.
 7. Inlet pressure.
 8. Discharge pressure.
 9. Sheave Make/Size/Bore.
 10. Number of Belts/Make/Size.
 11. Fan RPM.
- O. Duct Traverses:
1. System zone/branch.
 2. Duct size.
 3. Area.
 4. Design velocity.
 5. Design air flow.
 6. Test velocity.
 7. Test air flow.
 8. Duct static pressure.
 9. Air temperature.
 10. Air correction factor.
- P. Air Monitoring Stations:
1. Identification/location.
 2. System.
 3. Size.
 4. Area.
 5. Design velocity.
 6. Design air flow.
 7. Test velocity.

8. Test air flow.
- Q. Flow Measuring Stations:
1. Identification/number.
 2. Location.
 3. Size.
 4. Manufacturer.
 5. Model number.
 6. Serial number.
 7. Design Flow rate.
 8. Design pressure drop.
 9. Actual/final pressure drop.
 10. Actual/final flow rate.
 11. Station calibrated setting.
- R. Terminal Unit Data:
1. Manufacturer.
 2. Type, constant, variable, single, dual duct.
 3. Identification/number.
 4. Location.
 5. Model number.
 6. Size.
 7. Minimum static pressure.
 8. Minimum design air flow.
 9. Maximum design air flow.
 10. Maximum actual air flow.
 11. Inlet static pressure.
- S. Air Distribution Tests:
1. Air terminal number.
 2. Room number/location.
 3. Terminal type.
 4. Terminal size.
 5. Area factor.
 6. Design velocity.
 7. Design air flow.
 8. Test (final) velocity.
 9. Test (final) air flow.
 10. Percent of design air flow.
- T. Sound Level Reports:
1. Location.
 2. Octave bands - equipment off.
 3. Octave bands - equipment on.

END OF SECTION 23 0593

**SECTION 23 0713
DUCT INSULATION**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Duct insulation.
- B. Duct liner.
- C. Insulation jackets.

1.02 RELATED REQUIREMENTS

- A. Section 01 6116 - Volatile Organic Compound (VOC) Content Restrictions.
- B. Section 07 8400 - Firestopping.
- C. Section _____: Installation and finishing outdoor insulation jacket over roofing system.
- D. Section 09 9113 - Exterior Painting: Painting insulation jackets.
- E. Section 09 9123 - Interior Painting: Painting insulation jackets.
- F. Section 22 0553 - Identification for Plumbing Piping and Equipment.
- G. Section 23 0553 - Identification for HVAC Piping and Equipment.

1.03 REFERENCE STANDARDS

- A. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2014.
- B. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric); 2014.
- C. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2010.
- D. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2014.
- E. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2013.
- F. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation; 2014.
- G. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel; 2008 (Reapproved 2013).
- H. ASTM C916 - Standard Specification for Adhesives for Duct Thermal Insulation; 2014.
- I. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material); 2012.
- J. ASTM C1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts; 2016 (Reapproved 2021).
- K. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2023d.
- L. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials; 2014.
- M. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi; 2015, with Editorial Revision (2021).
- N. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- O. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- C. Manufacturer's Instructions: Indicate installation procedures necessary to ensure acceptable workmanship and that installation standards will be achieved.

1.05 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 Five years of experience and approved by manufacturer.

1.06 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.

1.07 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, UL 723, ASTM E84, or UL 723.

2.02 GLASS FIBER, FLEXIBLE

- A. Manufacturer:
 - 1. CertainTeed Corporation; _____: www.certainteed.com/#sle.
 - 2. Johns Manville; _____: www.jm.com/#sle.
 - 3. Knauf Insulation; Atmosphere Duct Wrap: www.knaufinsulation.com/#sle.
 - 4. Owens Corning Corporation; _____: www.ocbuildingspec.com/#sle.
 - 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Insulation: ASTM C553; flexible, noncombustible blanket.
 - 1. K value: 0.36 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. Indoor Vapor Barrier Mastic:
 - 1. Manufacturers:
 - a. Design Polymeric; DP 3040 Water Based, Zero VOC, Premium Quality, Low Perm, Vapor Barrier Coating: www.designpoly.com.com/#sle.
 - b. Substitutions: See Section 01 6000 - Product Requirements
 - 2. Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.

- F. Outdoor Vapor Barrier Mastic:
 - 1. Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- G. Tie Wire: Annealed steel, 16 gage, 0.0508 inch diameter.

2.03 GLASS FIBER, RIGID

- A. Manufacturer:
 - 1. CertainTeed Corporation; _____: www.certainteed.com/#sle.
 - 2. Johns Manville; _____: www.jm.com/#sle.
 - 3. Knauf Insulation; _____: www.knaufinsulation.com/#sle.
 - 4. Owens Corning Corporation; 700 Series FIBERGLAS Insulation: www.ocbuildingspec.com/#sle.
 - 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Insulation: ASTM C612; rigid, noncombustible blanket.
 - 1. K Value: 0.24 at 75 degrees F, when tested in accordance with ASTM C518.
 - 2. Maximum Service Temperature: 450 degrees F.
 - 3. Maximum Water Vapor Absorption: 5.0 percent.
 - 4. Maximum Density: 8.0 lb/cu ft.
- 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.

2.04 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

- A. Manufacturer:
 - 1. Armacell LLC; AP Armaflex ; _____: www.armacell.us/#sle.
 - 2. Substitutions: See Section 01 6000 - Product Requirements
- B. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1, in sheet form.
 - 1. Minimum Service Temperature: Minus 40 degrees F.
 - 2. Maximum Service Temperature: 180 degrees F.
 - 3. Connection: Waterproof vapor barrier adhesive.
- C. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.
- D. Weather Barrier Coating: Air dried, contact adhesive, compatible with insulation and ASTM E84 compliant.
 - 1. Manufacturers:
 - a. Design Polymerics; DP 5050 Water Based, Zero VOC, High Strength, Weather Barrier Coating: www.designpoly.com.com/#sle.
 - b. Substitutions: See Section 01 6000 - Product Requirements

2.05 JACKETS

- A. PVC Jacket:
 - 1. Thickness: 0.016 inch sheet.
 - 2. Finish: Weather Proof, UV-Protected
 - 3. Joining: 2-inch Overlap Seams or Butt-Joint with 4 inch PVC glued bands
 - 4. Fittings: _____ inch thick pre-shaped fitting covers with factory attached protective liner.
- B. Aluminum Jacket: ASTM B209 (ASTM B209M).
 - 1. Thickness: 0.016 inch sheet.
 - 2. Finish: Embossed.

3. Joining: Longitudinal slip joints and 2 inch laps.
4. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.
5. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.
6. Metal Jacket Bands: 3/8 inch wide; 0.010 inch thick stainless steel.

2.06 DUCT LINER - ONLY WHERE SPECIFICALLY ALLOWED ON DRAWINGS

- A. Manufacturers:
 1. Armacell LLC; AP Coilflex: www.armacell.us/#sle.
 2. CertainTeed Corporation; _____: www.certainteed.com/#sle.
 3. Ductmate Industries, Inc, a DMI Company; _____: www.ductmate.com/#sle.
 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Elastomeric Foam Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1, in sheet form.
 1. Minimum Service Temperature: Minus 40 degrees F.
 2. Maximum Service Temperature: 180 degrees F.
 3. Fungal Resistance: No growth when tested according to ASTM G21.
 4. Apparent Thermal Conductivity: Maximum of 0.28 at 75 degrees F.
 5. Minimum Noise Reduction Coefficients:
 - a. 1/2 inch Thickness: 0.30.
 - b. 1 inch Thickness: 0.40.
 - c. 1-1/2 inches Thickness: 0.50.
 - d. 2 inch Thickness: 0.60.
 6. Erosion Resistance: Does not show evidence of breaking away, flaking off, or delamination at velocities of 10,000 fpm per ASTM C1071.
 7. Connection: Waterproof vapor barrier adhesive.
- C. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation. Comply with ASTM C916.

PART 3 EXECUTION

3.01 EXAMINATION

- A. 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. Provide with or without standard vapor barrier jacket.
 2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.
- E. Ducts Exposed in Mechanical Equipment Rooms or Finished Spaces (below 10 feet above finished floor): Insulate with rigid board fiberglass insulation.
- F. Exterior Applications: Provide insulation with vapor barrier jacket.
- G. 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.
- H. Duct and Plenum Liner Application: Not to be used in Health Care facilities.
1. Adhere insulation with adhesive for 90 percent coverage.
 2. Seal and smooth joints. Seal and coat transverse joints.
 3. Seal liner surface penetrations with adhesive.
 4. Duct dimensions indicated are net inside dimensions required for air flow. Increase duct size to allow for insulation thickness.

END OF SECTION 23 0713

SECTION 23 0716
HVAC EQUIPMENT INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Equipment insulation.
- B. Covering.
- C. Breeching insulation.

1.02 RELATED REQUIREMENTS

- A. Section 23 0553 - Identification for HVAC Piping and Equipment.
- B. Section 23 2113 - Hydronic Piping: Placement of hangers and hanger inserts.
- C. Section 23 2114 - Hydronic Specialties.
- D. Section 23 2300 - Refrigerant Piping: Placement of inserts.

1.03 REFERENCE STANDARDS

- A. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2014.
- B. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric); 2014.
- C. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus; 2013.
- D. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement; 2007 (Reapproved 2013).
- E. ASTM C449 - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement; 2007 (Reapproved 2013).
- F. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2010.
- G. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation; 2013.
- H. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2014.
- I. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation; 2015.
- J. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications; 2013.
- K. ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type); 2013.
- L. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation; 2014.
- M. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2023d.
- N. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials; 2014.
- O. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for equipment scheduled.

- C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

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 3 years of experience.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Accept materials on site in original factory packaging, labeled 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.

1.07 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. Manufacturers:
 - 1. CertainTeed Corporation; _____: www.certainteed.com/#sle.
 - 2. Johns Manville Corporation; _____: www.jm.com/#sle.
 - 3. Owens Corning Corporation; _____: www.ocbuildingspec.com/#sle.
- B. Insulation: ASTM C553; flexible, noncombustible.
 - 1. K Value: 0.36 at 75 degrees F, when tested in accordance with ASTM C177 or ASTM C518.
 - 2. Maximum Service Temperature: 450 degrees F.
 - 3. Maximum Water Vapor Absorption: 5.0 percent by weight.
- C. Vapor Barrier Jacket: Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
 - 1. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
 - 2. Secure with self-sealing longitudinal laps and butt strips.
- D. Vapor Barrier Lap Adhesive: Compatible with insulation.

2.03 GLASS FIBER, RIGID

- A. Manufacturer:
 - 1. CertainTeed Corporation; _____: www.certainteed.com/#sle.
 - 2. Johns Manville Corporation; _____: www.jm.com/#sle.
 - 3. Owens Corning Corporation; _____: www.ocbuildingspec.com/#sle.
- B. Insulation: ASTM C612 or ASTM C592; rigid, noncombustible.
 - 1. K Value: 0.25 at 75 degrees F, when tested in accordance with ASTM C177 or ASTM C518.
 - 2. Maximum Service Temperature: 850 degrees F.
 - 3. Maximum Water Vapor Absorption: 5.0 percent by weight.
 - 4. Maximum Density: 8.0 lb/cu ft.

- C. Vapor Barrier Jacket:
 - 1. Kraft paper reinforced 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 self-sealing longitudinal laps and butt strips.
- D. Vapor Barrier Lap Adhesive: Compatible with insulation.

2.04 CELLULAR GLASS

- A. Manufacturer:
 - 1. Owens Corning Corporation; _____: www.ocbuildingspec.com/#sle.
 - 2. Substitutions: See Section 01 6000 - Product Requirements.
- B. Pipe and Tubing Insulation: ASTM C552, Type II, Grade 6.
 - 1. K Value: 0.35 at 100 degrees F.
 - 2. Service Temperature Range: From 250 degrees F to 800 degrees F.
 - 3. Water Absorption: 0.5 percent by volume, maximum.
- C. Block Insulation: ASTM C552, Type I, Grade 6.
 - 1. K Value: 0.35 at 100 degrees F.
 - 2. Service Temperature: 800 degrees F, maximum.
 - 3. Water Vapor Permeability: 0.005 perm inch maximum per inch.
 - 4. Water Absorption: 0.5 percent by volume, maximum.
 - 5. Density: At least 6.12 lb/cu ft.

2.05 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

- A. Manufacturer:
 - 1. Aeroflex USA, Inc; _____: www.aeroflexusa.com/#sle.
 - 2. Armacell LLC; AP Armaflex FS: www.armacell.us/#sle.
 - 3. K-Flex USA LLC; Insul-Sheet: www.kflexusa.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements
- B. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1, in sheet form.
 - 1. Minimum Service Temperature: Minus 40 degrees F.
 - 2. Maximum Service Temperature: 220 degrees F.
 - 3. Connection: Waterproof vapor barrier adhesive.
- C. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

2.06 JACKETS

- A. PVC Plastic:
 - 1. Manufacturers:
 - a. Johns Manville Corporation; _____: www.jm.com/#sle.
 - b. Substitutions: See Section 01 6000 - Product Requirements.
 - 2. Jacket: Sheet material, off-white color.
 - a. Maximum Service Temperature: 150 degrees F.
 - b. Moisture Vapor Permeability: 0.02 perm inch, when tested in accordance with ASTM E96/E96M.
 - c. Thickness: 10 mil.
 - d. Connections: Brush on welding adhesive.
 - 3. Covering Adhesive Mastic: Compatible with insulation.
- B. Aluminum Jacket: ASTM B209 (ASTM B209M) formed aluminum sheet.
 - 1. Thickness: 0.016 inch sheet.
 - 2. Finish: Smooth.
 - 3. Joining: Longitudinal slip joints and 2 inch laps.
 - 4. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that equipment 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. Factory Insulated Equipment: Do not insulate.
- C. Exposed Equipment: Locate insulation and cover seams in least visible locations.
- D. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
- E. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier cement.
- F. Insulated equipment containing fluids below ambient temperature; insulate entire system.
- G. Fiber glass insulated equipment containing fluids below ambient temperature; provide vapor barrier jackets, factory-applied or field-applied. Finish with glass cloth and vapor barrier adhesive.
- H. For hot equipment containing fluids 140 degrees F or less, do not insulate flanges and unions, but bevel and seal ends of insulation.
- I. For hot equipment containing fluids over 140 degrees F, insulate flanges and unions with removable sections and jackets.
- J. Fiber glass insulated equipment containing fluids above ambient temperature; provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Finish with glass cloth and adhesive.
- K. Inserts and Shields:
 - 1. Application: Equipment 1-1/2 inches diameter or larger.
 - 2. Shields: Galvanized steel between hangers and inserts.
 - 3. Insert Location: Between support shield and equipment 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.
- L. Finish insulation at supports, protrusions, and interruptions.
- M. Equipment in Mechanical Equipment Rooms or Finished Spaces: Finish with canvas jacket sized for finish painting.
- N. Exterior Applications:
 - 1. Provide vapor barrier jacket or finish with glass mesh reinforced vapor barrier cement.
 - 2. Cover with aluminum, stainless steel, or _____.
- O. Cover glass fiber insulation with metal mesh and finish with heavy coat of insulating cement.
- P. Nameplates and ASME Stamps: Bevel and seal insulation around; do not insulate over.
- Q. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation so it can be easily removed and replaced without damage.

3.03 SCHEDULE

- A. Heating Systems:
 - 1. Pump Bodies:
 - 2. Heat Exchangers/Converters:
 - 3. Air Separators:
 - 4. Expansion Tanks:

5. Hot Thermal Storage Tanks:
 6. Boiler Feed Water Storage Tanks:
 7. Steam Condensate Receivers:
 8. Condensate Tanks:
 9. Deaerators:
 10. Flue Gas Breeching:
 11. Induced Draft Fan Scrolls:
 12. Stacks to Roof:
 13. Boiler and Flue Boxes:
- B. Cooling Systems:
1. Pump Bodies:
 2. Air Separators:
 3. Expansion Tanks:
 4. Chiller Cold Surfaces (Not Factory Insulated):
 5. Cold Thermal Storage Tanks:
 6. Equipment Exposed to Freezing with Heat Tracing:

END OF SECTION 23 0716

**SECTION 23 0719
HVAC PIPING INSULATION**

PART 1 GENERAL

1.01 SECTION INCLUDES

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

1.02 RELATED REQUIREMENTS

- A. Section 01 6116 - Volatile Organic Compound (VOC) Content Restrictions.
- B. Section 07 8400 - Firestopping.
- C. Section 09 9123 - Interior Painting: Painting insulation jacket.
- D. Section 22 1005 - Plumbing Piping: Placement of hangers and hanger inserts.
- E. Section 23 2113 - Hydronic Piping: Placement of hangers and hanger inserts.
- F. Section 23 2213 - Steam and Condensate Heating Piping: Placement of hangers and hanger inserts.
- G. Section 23 2300 - Refrigerant Piping: Placement of inserts.

1.03 REFERENCE STANDARDS

- A. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2014.
- B. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric); 2014.
- C. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus; 2013.
- D. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement; 2007 (Reapproved 2013).
- E. ASTM C449 - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement; 2007 (Reapproved 2013).
- F. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus; 2010.
- G. ASTM C533 - Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation; 2013.
- H. ASTM C534/C534M - Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form; 2014.
- I. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation; 2015.
- J. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation; 2015.
- K. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation; 2015a.
- L. ASTM C585 - Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing; 2010.
- M. ASTM C591 - Standard Specification for Unfaced Preformed Rigid Cellular Polyisocyanurate Thermal Insulation; 2015.
- N. ASTM C610 - Standard Specification for Molded Expanded Perlite Block and Pipe Thermal Insulation; 2011.
- O. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel; 2008 (Reapproved 2013).
- P. ASTM D1056 - Standard Specification for Flexible Cellular Materials--Sponge or Expanded Rubber; 2014.

- Q. ASTM D2842 - Standard Test Method for Water Absorption of Rigid Cellular Plastics; 2012.
- R. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2023d.
- S. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials; 2014.
- T. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for each service, and locations.
- C. Manufacturer's Instructions: Indicate installation procedures that ensure acceptable workmanship and installation standards will be achieved.

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 _____ 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

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

2.02 GLASS FIBER, RIGID

- A. Manufacturers:
 - 1. CertainTeed Corporation; _____: www.certainteed.com/#sle.
 - 2. Johns Manville Corporation; _____: www.jm.com/#sle.
 - 3. Owens Corning Corporation; Fiberglas Pipe Insulation ASJ: www.ocbuildingspec.com/#sle.
 - 4. Owens Corning Corporation; VaporWick Pipe Insulation: www.ocbuildingspec.com/#sle.
- 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. Insulation: ASTM C547 and ASTM C795; rigid molded, noncombustible, with wicking material to transport condensed water to the outside of the system for evaporation to the atmosphere.
 - 1. K Value: ASTM C177, 0.23 at 75 degrees F.
 - 2. Maximum Service Temperature: 220 degrees F.
 - 3. Maximum Moisture Absorption: 0.2 percent by volume.
- D. Insulation: ASTM C547 and ASTM C795; semi-rigid, noncombustible, end grain adhered to jacket.
 - 1. K Value: ASTM C177, 0.24 at 75 degrees F.
 - 2. Maximum Service Temperature: 650 degrees F.
 - 3. Maximum Moisture Absorption: 0.2 percent by volume.

- E. 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.
- F. Vapor Barrier Lap Adhesive: Compatible with insulation.
- G. Indoor Vapor Barrier Finish:
 - 1. Vinyl emulsion type acrylic, compatible with insulation, black color.
- H. Outdoor Vapor Barrier Mastic: Vinyl emulsion type acrylic or mastic, compatible with insulation, black color.
- I. Insulating Cement: ASTM C449.

2.03 EXPANDED POLYSTYRENE

- A. Insulation: ASTM C578; rigid closed cell.
 - 1. K Value: 0.23 at 75 degrees F.
 - 2. Maximum Service Temperature: 165 degrees F.
 - 3. Maximum Water Vapor Permeance: 5.0 perms

2.04 POLYISOCYANURATE CELLULAR PLASTIC

- A. Insulation Material: ASTM C591, rigid molded modified polyisocyanurate cellular plastic.
 - 1. Dimension: Comply with requirements of ASTM C585.
 - 2. K Value: 0.18 at 75 degrees F, when tested in accordance with ASTM C518.
 - 3. Minimum Service Temperature: Minus 70 degrees F.
 - 4. Maximum Service Temperature: 300 degrees F.
 - 5. Water Absorption: 0.5 percent by volume, maximum, when tested in accordance with ASTM D2842.
 - 6. Moisture Vapor Transmission: 4.0 perm inch.
 - 7. Connection: Waterproof vapor barrier adhesive.

2.05 FLEXIBLE ELASTOMERIC CELLULAR INSULATION

- A. Manufacturer:
 - 1. Aeroflex USA, Inc; Aerocel ULP: www.aeroflexusa.com/#sle.
 - 2. Armacell LLC; AP Armaflex: www.armacell.us/#sle.
 - 3. K-Flex USA LLC; K-Flex Titan: www.kflexusa.com/#sle.
- B. Insulation: Preformed flexible elastomeric cellular rubber insulation complying with ASTM C534/C534M Grade 1; use molded tubular material wherever possible.
 - 1. Minimum Service Temperature: Minus 40 degrees F.
 - 2. Maximum Service Temperature: 180 degrees F.
 - 3. Connection: Waterproof vapor barrier adhesive.
- C. Elastomeric Foam Adhesive: Air dried, contact adhesive, compatible with insulation.

2.06 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.
- B. ABS Plastic:
 - 1. Jacket: One piece molded type fitting covers and sheet material, off-white color.
 - a. Minimum Service Temperature: Minus 40 degrees F.
 - b. Maximum Service Temperature: 180 degrees F.

- c. Moisture Vapor Permeability: 0.012 perm inch, when tested in accordance with ASTM E96/E96M.
- d. Thickness: 30 mil.
- e. Connections: Brush on welding adhesive.
- C. Aluminum Jacket: ASTM B209 (ASTM B209M) formed aluminum sheet.
 - 1. Thickness: 0.016 inch sheet.
 - 2. Finish: Smooth.
 - 3. Joining: Longitudinal slip joints and 2 inch laps.
 - 4. Fittings: 0.016 inch thick die shaped fitting covers with factory attached protective liner.
 - 5. Metal Jacket Bands: 3/8 inch wide; 0.015 inch thick aluminum.

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. Exposed Piping: in mechanical rooms provide protective PVC jacket covering to all insulated piping below 10'-0" AFF
- E. Insulated pipes conveying fluids below ambient temperature; insulate entire system including fittings, valves, unions, flanges, strainers, flexible connections, pump bodies, and expansion joints.
- F. 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.
- G. 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.
- H. For hot piping conveying fluids over 140 degrees F, insulate flanges and unions at equipment.
- I. 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.
- J. 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.
- K. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, refer to Section 07 8400.
- L. Pipe Exposed in Mechanical Equipment Rooms or Finished Spaces (less than 10 feet above finished floor): Finish with canvas jacket sized for finish painting.

- M. Exterior Applications: Provide vapor barrier jacket. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal piping. Provide two coats of UV resistant finish for flexible elastomeric cellular insulation without jacketing.
- N. Heat Traced Piping: Insulate fittings, joints, and valves with insulation of like material, thickness, and finish as adjoining pipe. Size large enough to enclose pipe and heat tracer. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

3.03 SCHEDULE

- A. Heating Systems:
 - 1. Heating Water Supply and Return:
 - 2. Glycol Heating Supply and Return:
 - 3. Low Pressure Steam Piping:
 - 4. Low Pressure Steam Condensate:
 - 5. Gravity Steam Condensate:
 - 6. Pumped Steam Condensate:
 - 7. High Pressure Steam Piping:
 - 8. High Pressure Steam Condensate:
 - 9. Boiler Feed Water:
- B. Cooling Systems:
 - 1. Chilled Water:
 - 2. Condenser Water:
 - 3. Dual Temperature Water:
 - 4. Heat Recovery Water:
 - 5. Glycol Cooling Supply and Return:
 - 6. Cold Condensate Drains:
 - 7. Condensate Drains from Cooling Coils:
 - 8. Refrigerant Suction:
 - 9. Refrigerant Hot Gas:
 - 10. External Sprayed Coil Piping:
- C. Other Systems:
 - 1. Humidifier Piping:
 - 2. Engine Exhaust Piping:
 - 3. Piping Exposed to Freezing with Heat Tracing:

**SECTION 23 0800
COMMISSIONING OF HVAC**

PART 1 GENERAL

1.01 SUMMARY

- A. See Section 01 9113 - General Commissioning Requirements for overall objectives; comply with the requirements of Section 01 9113.
- B. This section covers the Construction Manager's responsibilities for commissioning; each subcontractor or installer responsible for the installation of a particular system or equipment item to be commissioned is responsible for the commissioning activities relating to that system or equipment item.
- C. The Commissioning Authority (CA) directs and coordinates all commissioning activities and provides Prefunctional Checklists and Functional Test Procedures for Construction Manager's use. CA to include Spectrum Health FSS Engineering and FSS-HVAC personnel in commissioning planning and execution.
- D. The Mechanical systems to be commissioned, including commissioning activities for the following specific items:
 - 1. Control system.
 - 2. Major and minor equipment items.
 - 3. Piping systems and equipment.
 - 4. Ductwork and accessories.
 - 5. Terminal units.
 - 6. Sound control devices.
 - 7. Vibration control devices.
 - 8. Variable frequency drives.
 - 9. Special Ventilation:
 - a. Fume hoods.
 - b. Laboratory pressurization.
 - c. Specialty fans.
 - d. Egress pressurization and Smoke Control Systems.
 - e. Including Building pressurization to the Outdoors.
 - f. All pressure Sensitive areas such as Lab,OR Pharmacy CSR and Isolation rooms.
 - 10. Other equipment and systems explicitly identified elsewhere in Contract Documents as requiring commissioning.
 - 11. Indoor Air Quality Procedures: The Commissioning Authority will coordinate; Contractor will execute; see Section 01 5719.
- E. The Prefunctional Checklist and Functional Test requirements specified in this section are in addition to, not a substitute for, inspection or testing specified in other sections.

1.02 RELATED REQUIREMENTS

- A. Section 01 5719 - Temporary Environmental Controls: Precautions and procedures; smoking room testing; building flush-out.
- B. Section 01 7800 - Closeout Submittals: Scope and procedures for operation and maintenance manuals and project record documents.
- C. Section 01 7900 - Demonstration and Training: Scope and procedures for Owner personnel training.
- D. Section 01 9113 - General Commissioning Requirements: Commissioning requirements that apply to all types of work.
- E. Section 23 0923 - Direct-Digital Control System for HVAC.
- F. Section 23 0913 - Instrumentation and Control Devices for HVAC.
- G. Section 23 0993 - Sequence of Operations for HVAC Controls.

H. Section 23 0593 - Testing, Adjusting, and Balancing for HVAC.

1.03 REFERENCE STANDARDS

- A. ASHRAE Guideline 1.1 - HVAC&R Technical Requirements for the Commissioning Process; 2007, with Errata (2012).

1.04 SUBMITTALS

- A. Updated Submittals: Keep the Commissioning Authority informed of all changes to control system documentation made during programming and setup; revise and resubmit when substantial changes are made.
- B. DRAFT Prefunctional Checklists and Functional Test Procedures for Control System: Detailed written plan indicating the procedures to be followed to test, checkout and adjust the control system prior to full system Functional Testing; include at least the following for each type of equipment controlled:
 - 1. System name.
 - 2. List of devices.
 - 3. Step-by-step procedures for testing each controller after installation, including:
 - a. Process of verifying proper hardware and wiring installation.
 - b. Process of downloading programs to local controllers and verifying that they are addressed correctly.
 - c. Process of performing operational checks of each controlled component.
 - d. Plan and process for calibrating valve and damper actuators and all sensors.
 - e. Description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.
 - 4. Copy of proposed log and field checkout sheets to be used to document the process; include space for initial and final read values during calibration of each point and space to specifically indicate when a sensor or controller has "passed" and is operating within the contract parameters.
 - 5. Description of the instrumentation required for testing.
 - 6. Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the Commissioning Authority and TAB contractor for this determination.
- C. Startup Reports, Prefunctional Checklists, and Trend Logs: Submit for approval of Commissioning Authority.
- D. HVAC Control System O&M Manual Requirements. In addition to documentation specified elsewhere, compile and organize at minimum the following data on the control system:
 - 1. Specific step-by-step instructions on how to perform and apply all functions, features, modes, etc. mentioned in the controls training sections of this specification and other features of this system. Provide an index and clear table of contents. Include the detailed technical manual for programming and customizing control loops and algorithms.
 - 2. Full as-built set of control drawings.
 - 3. Full as-built sequence of operations for each piece of equipment.
 - 4. Full points list; in addition to the information on the original points list submittal, include a listing of all rooms with the following information for each room:
 - a. Floor.
 - b. Room number.
 - c. Room name.
 - d. Air handler unit ID.
 - e. Reference drawing number.
 - f. Air terminal unit tag ID.
 - g. Heating and/or cooling valve tag ID.
 - h. Minimum air flow rate.
 - i. Maximum air flow rate.
 - 5. Full print out of all schedules and set points after testing and acceptance of the system.

6. Full as-built print out of software program.
7. Electronic copy on disk of the entire program for this facility.
8. Marking of all system sensors and thermostats on the as-built floor plan and HVAC drawings with their control system designations.
9. Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.
10. Control equipment component submittals, parts lists, etc.
11. Warranty requirements.
12. Copies of all checkout tests and calibrations performed by the Contractor (not commissioning tests).
13. Organize and subdivide the manual with permanently labeled tabs for each of the following data in the given order:
 - a. Sequences of operation.
 - b. Control drawings.
 - c. Points lists.
 - d. Controller and/or module data.
 - e. Thermostats and timers.
 - f. Sensors and DP switches.
 - g. Valves and valve actuators.
 - h. Dampers and damper actuators.
 - i. Program setups (software program printouts).
- E. Project Record Documents: See Section 01 7800 for additional requirements.
 1. Submit updated version of control system documentation, for inclusion with operation and maintenance data.
 2. Show actual locations of all static and differential pressure sensors (air, water and building pressure) and air-flow stations on project record drawings.
- F. Draft Training Plan: In addition to requirements specified in Section 01 7900, include:
 1. Follow the recommendations of ASHRAE Guideline 1.1.
 2. Control system manufacturer's recommended training.
 3. Demonstration and instruction on function and overrides of any local packaged controls not controlled by the HVAC control system.
- G. Training Manuals: See Section 01 7900 for additional requirements.
 1. Provide three extra copies of the controls training manuals in a separate manual from the O&M manuals.

PART 2 PRODUCTS

2.01 TEST EQUIPMENT

- A. Provide all standard testing equipment required to perform startup and initial checkout and required functional performance testing; unless otherwise noted such testing equipment will NOT become the property of Owner.
- B. Equipment-Specific Tools: Where special testing equipment, tools and instruments are specific to a piece of equipment, are only available from the vendor, and are required in order to accomplish startup or Functional Testing, provide such equipment, tools, and instruments as part of the work at no extra cost to Owner; such equipment, tools, and instruments are to become the property of Owner.

PART 3 EXECUTION

3.01 PREPARATION

- A. Cooperate with the Commissioning Authority in development of the Prefunctional Checklists and Functional Test Procedures.
- B. Furnish additional information requested by the Commissioning Authority.

- C. Prepare a preliminary schedule for HVAC pipe and duct system testing, flushing and cleaning, equipment start-up and testing, adjusting, and balancing start and completion for use by the Commissioning Authority; update the schedule as appropriate.
- D. Notify the Commissioning Authority when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and testing, adjusting, and balancing will occur; when commissioning activities not yet performed or not yet scheduled will delay construction notify ahead of time and be proactive in seeing that the Commissioning Authority has the scheduling information needed to efficiently execute the commissioning process.
- E. Put all HVAC equipment and systems into operation and continue operation during each working day of testing, adjusting, and balancing and commissioning, as required.
 - 1. Include cost of sheaves and belts that may be required for testing, adjusting, and balancing.
- F. Provide test holes in ducts and plenums where directed to allow air measurements and air balancing; close with an approved plug.
- G. Provide temperature and pressure taps in accordance with Contract Documents.

3.02 INSPECTING AND TESTING - GENERAL

- A. Submit startup plans, startup reports, and Prefunctional Checklists for each item of equipment or other assembly to be commissioned.
- B. Perform the Functional Tests directed by the Commissioning Authority for each item of equipment or other assembly to be commissioned.
- C. Provide two-way radios for use during the testing.
- D. Valve/Damper Stroke Setup and Check:
 - 1. For all /damper actuator positions checked, verify the actual position against the control system readout.
 - 2. Set pump/fan to normal operating mode.
 - 3. Command valve/damper closed; visually verify that valve/damper is closed and adjust output zero signal as required.
 - 4. Command valve/damper open; verify position is full open and adjust output signal as required.
 - 5. Command valve/damper to a few intermediate positions.
 - 6. If actual valve/damper position does not reasonably correspond, replace actuator or add pilot positioner (for pneumatics).
 - 7. Verify backup redundancy function properly and works as expected.
 - 8. Verify all safety control devices are operating as designed.
- E. Isolation Valve or System Valve Leak Check: For valves not by coils.
 - 1. With full pressure in the system, command valve closed.
 - 2. Use an ultra-sonic flow meter to detect flow or leakage.
- F. Deficiencies: Correct deficiencies and re-inspect AND re-test, as applicable, at no extra cost to Owner.

3.03 TAB COORDINATION

- A. TAB: Testing, adjusting, and balancing of HVAC.
- B. Coordinate commissioning schedule with TAB schedule.
- C. Review the TAB plan to determine the capabilities of the control system toward completing TAB.
- D. Provide all necessary unique instruments and instruct the TAB technicians in their use; such as handheld control system interface for setting terminal unit boxes, etc.
- E. Have all required Prefunctional Checklists, calibrations, startup and component Functional Tests of the system completed and approved by the Commissioning Authority prior to starting TAB.

- F. Provide a qualified control system technician to operate the controls to assist the TAB technicians or provide sufficient training for the TAB technicians to operate the system without assistance.

3.04 CONTROL SYSTEM FUNCTIONAL TESTING

- A. Prefunctional Checklists for control system components will require a signed and dated certification that all system programming is complete as required to accomplish the requirements of Contract Documents and the detailed Sequences of Operation documentation submittal.
- B. Do not start Functional Testing until all controlled components have themselves been successfully Functionally Tested in accordance with Contract Documents.
- C. Using a skilled technician who is familiar with this building, execute the Functional Testing of the control system as required by the Commissioning Authority.
- D. Functional Testing of the control system constitutes demonstration and trend logging of control points monitored by the control system.
 - 1. The scope of trend logging is partially specified; trend log up to 50 percent more points than specified at no extra cost to Owner.
 - 2. Perform all trend logging specified in Prefunctional Checklists and Functional Test procedures.
- E. Functionally Test integral or stand-alone controls in conjunction with the Functional Tests of the equipment they are attached to, including any interlocks with other equipment or systems; further testing during control system Functional Test is not required unless specifically indicated below.
- F. Demonstrate the following to the Commissioning Authority during testing of controlled equipment; coordinate with commissioning of equipment.
 - 1. Setpoint changing features and functions.
 - 2. Sensor calibrations.
- G. Demonstrate to the Commissioning Authority:
 - 1. That all specified functions and features are set up, debugged and fully operable.
 - 2. That scheduling features are fully functional and setup, including holidays.
 - 3. That all graphic screens and value readouts are completed.
 - 4. Verify date and time setting in central computer and corresponding equipment cont.
 - 5. That field panels read the same time as the central computer; sample 10 percent of field panels; if any of those fail, sample another 10 percent; if any of those fail test all remaining units at no extra cost to Owner.
 - 6. Functionality of field panels using local operator keypads and local ports (plug-ins) using portable computer/keypad; demonstrate 100 percent of panels and 10 percent of ports; if any ports fail, sample another 10 percent; if any of those fail, test all remaining units at no extra cost to Owner.
 - 7. Power failure and battery backup and power-up restart functions.
 - 8. Verify Graphic override commands features functionality.
 - 9. Security and access codes.
 - 10. Occupant over-rides (manual, telephone, key, keypad, etc.).
 - 11. O&M schedules and alarms.
 - 12. Occupancy sensors and controls.
 - 13. Fire alarm interlocks and response.
 - 14. That points that are monitored only, having no control function, are reporting properly to the control system.
 - 15. All control strategies and sequences not tested during controlled equipment testing.
 - 16. Trend logging and graphing features that are specified.

- H. If the control system, integral control components, or related equipment do not respond to changing conditions and parameters appropriately as expected, as specified and according to acceptable operating practice, under any of the conditions, sequences, or modes tested, correct all systems, equipment, components, and software required at no additional cost to Owner.

3.05 OPERATION AND MAINTENANCE MANUALS

- A. See Section 01 7800 for additional requirements.
- B. Add design intent documentation furnished by Architect to manuals prior to submission to Owner.
- C. Submit manuals related to items that were commissioned to Commissioning Authority for review; make changes recommended by Commissioning Authority.
- D. Commissioning Authority will add commissioning records to manuals after submission to Owner.

3.06 DEMONSTRATION AND TRAINING

- A. See Section 01 7900 for additional requirements.
- B. Demonstrate operation and maintenance of HVAC system to Owner's personnel; if during any demonstration, the system fails to perform in accordance with the information included in the O&M manual, stop demonstration, repair or adjust, and repeat demonstration. Demonstrations may be combined with training sessions if appropriate.
- C. These demonstrations are in addition to, and not a substitute for, Prefunctional Checklists and demonstrations to the Commissioning Authority during Functional Testing.
- D. Provide classroom and hands-on training of Owner's designated personnel on operation and maintenance of the HVAC system, control system, and all equipment items indicated to be commissioned. Provide the following minimum durations of training:
 - 1. HVAC Control System: 8 hours.
 - 2. Chillers and System: 8 hours.
 - 3. Cooling Towers: 4 hours.
 - 4. Boilers and System: 4 hours.
 - 5. Piping Systems: 1 hours.
 - 6. Chemical Treatment: 1 hours.
 - 7. Air Handling Units: 4 hours.
 - 8. Variable Speed Drives: 1 hours.
 - 9. Return Fan/Relief Fan: 1 hours.
 - 10. Air Terminal Units: 1 hours.
 - 11. Packaged Rooftop Units: 4 hours.
 - 12. Computer Room AC Units: 1 hours.
 - 13. Split System AC or Heat Pumps: 1 hours.
 - 14. Spot AC Units: 1 hours.
 - 15. Spot Unit Heaters: 1 hours.
 - 16. Elevator Shaft Fans: 1 hours.
 - 17. Stairwell Fans: 1 hours.
 - 18. Specialty Exhaust Fans: 1 hours.
 - 19. Restroom Central Exhaust Fans: 1 hours.
 - 20. Garage Exhaust Fans: 1 hours.
 - 21. All Hazardous Gas or Environment system monitoring, Alerting and operation [1] hours.
- E. TAB Review: Instruct Owner's personnel for minimum 1 hours, after completion of TAB, on the following:
 - 1. Review final TAB report, explaining the layout and meanings of each data type.
 - 2. Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.

3. Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
 4. Discuss any temporary settings and steps to finalize them for any areas that are not finished.
 5. Other Important information that may be useful for facility operations and Efficiency , relative to TAB.
- F. HVAC Control System Training: Perform training in at least three phases:
1. Phase 1 - Basic Control System: Provide minimum of 4 hours of actual training on the control system itself. Upon completion of training, each attendee, using appropriate documentation, should be able to perform elementary operations and describe general hardware architecture and functionality of the system.
 - a. This training may be held on-site or at the manufacturer's facility.
 - b. If held off-site, the training may occur prior to final completion of the system installation.
 - c. For off-site training, Construction Manager shall pay expenses of up to two attendees.
 2. Phase 2 - Integrating with HVAC Systems: Provide minimum of 4 hours of on-site, hands-on training after completion of Functional Testing. Include instruction on:
 - a. The specific hardware configuration of installed systems in this facility and specific instruction for operating the installed system, including interfaces with other systems, if any.
 - b. Security levels, alarms, system start-up, shut-down, power outage and restart routines, changing setpoints and alarms and other typical changed parameters, overrides, freeze protection, manual operation of equipment, optional control strategies that can be considered, energy savings strategies and set points that if changed will adversely affect energy consumption, energy accounting, procedures for obtaining vendor assistance, etc.
 - c. Trend logging and monitoring features (values, change of state, totalization, etc.), including setting up, executing, downloading, viewing both tabular and graphically and printing trends; provide practice in setting up trend logging and monitoring during training session.
 - d. Every display screen, allowing time for questions.
 - e. Point database entry and modifications.
 3. Phase 3 - Post-Occupancy: Six months after occupancy conduct minimum of ____ hours of training. Tailor training session to questions and topics solicited beforehand from Owner. Also be prepared to address topics brought up and answer questions concerning operation of the system.
- G. Provide the services of manufacturer representatives to assist instructors where necessary.
- H. Provide the services of the HVAC controls instructor at other training sessions, when requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

END OF SECTION 23 0800

**SECTION 23 0913
INSTRUMENTATION AND CONTROL DEVICES FOR HVAC**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Control panels.
- B. Control Valves:
 - 1. Radiation valves.
- C. Damper Operators:
 - 1. Electric operators.
- D. Humidistats:
 - 1. Room humidistats.
 - 2. Limit duct humidistats.
- E. Input/Output Sensors:
 - 1. Temperature sensors.
 - 2. Humidity sensors.
 - 3. Static pressure (air pressure) sensors.
 - 4. Equipment operation (current) sensors.
 - 5. Carbon dioxide sensors.
- F. Thermostats:
 - 1. Electric room thermostats.
 - 2. Low-limit temperature cutout switch (freezestat)
 - 3. Line voltage thermostats.
 - 4. Electric high limit duct thermostats.
- G. Transmitters:
 - 1. Building static pressure transmitters.
 - 2. Air pressure transmitters.
 - 3. Water pressure transmitters (liquid differential pressure transmitters).
 - 4. Humidity transmitters.
- H. Transducers:
 - 1. Electropneumatic transducers.
- I. Flow Sensors:
- J. Level Instruments:

1.02 RELATED REQUIREMENTS

- A. Section 22 0519 - Meters and Gauges for Plumbing Piping: Thermometer sockets and gauge taps.
- B. Section 22 0548 - Vibration and Seismic Controls for Plumbing Piping and Equipment.
- C. Section 23 0519 - Meters and Gauges for HVAC Piping: Thermometer sockets and gauge taps.
- D. Section 23 0548 - Vibration and Seismic Controls for HVAC.
- E. Section 23 0923 - Direct-Digital Control System for HVAC.
- F. Section 23 0993 - Sequence of Operations for HVAC Controls.
- G. Section 23 2113 - Hydronic Piping: Installation of control valves, flow switches, temperature sensor sockets, and gauge taps.
- H. Section 23 2114 - Hydronic Specialties.
- I. Section 23 2213 - Steam and Condensate Heating Piping: Installation of control valves, flow switches, temperature sensor sockets, and gauge taps.

- J. Section 23 3300 - Air Duct Accessories: Installation of automatic dampers.
- K. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.
- L. Section 26 2726 - Wiring Devices: Elevation of exposed components.

1.03 REFERENCE STANDARDS

- A. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating; 2012.
- B. ASME B1.20.1 - Pipe Threads, General Purpose (Inch); 2013.
- C. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2013.
- D. ASTM B32 - Standard Specification for Solder Metal; 2008 (Reapproved 2014).
- E. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2014.
- F. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric); 2013.
- G. ASTM B819 - Standard Specification for Seamless Copper Tube for Medical Gas Systems; 2000 (Reapproved 2011).
- H. ASTM D1693 - Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics; 2015.
- I. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- J. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2015.
- K. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Preinstallation Meeting: Conduct a preinstallation meeting one Month before starting work of this section; require attendance by all affected installers. Include Corewell Engineer
- B. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.05 SUBMITTALS

- A. See Section 01 3000 - 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. Manufacturer's Instructions: Provide for all manufactured components.
- E. Operation and Maintenance Data: Include inspection period, cleaning methods, recommended cleaning materials, and calibration tolerances.
- F. 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.
- G. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.06 QUALITY ASSURANCE

- A. Designer Qualifications: Design system under direct supervision of a Professional Engineer experienced in design of this work and licensed in Michigan.
- B. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

- C. Installer Qualifications: Company specializing in performing the work of this section with minimum 3 years experience approved by manufacturer.
- D. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.07 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. After Substantial Completion, All defective work Must be corrected ASAP.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Trane for all DDC Controls.

2.02 EQUIPMENT - GENERAL

- A. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.
- B. All equipment with 3rd Party Controls manufacture must be integrated into the Trane Building Automation System.

2.03 CONTROL PANELS

- A. Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet including wiring schematics. Deluxe "Bob" panel for Hospital locations.

2.04 CONTROL VALVES

- A. Ball Valves and Actuators:
 - 1. Manufacturers:
 - a. Belimo Aircontrols (USA), Inc; _____: www.belimo.com/#sle.
 - b. Substitutions: See Section 01 6000 - Product Requirements.
- B. Globe Pattern:
 - 1. Manufacturers:
 - a. Belimo Aircontrols (USA), Inc;[_____]: www.belimo.com/#sle.
 - b. Substitutions: See Section 01 6000 - Product Requirements.
- C. Butterfly Pattern:
 - 1. Manufacturers:
 - a. Belimo Aircontrols (USA), Inc;[_____]: www.belimo.com/#sle.
 - b. Substitutions: See Section 01 6000 - Product Requirements.
- D. Electronic Operators:
 - 1. Manufacturers:
 - a. Belimo Aircontrols (USA), Inc;[_____]: www.belimo.com/#sle.
 - b. Substitutions: See Section 01 6000 - Product Requirements.
- E. Radiation Valves:
 - 1. Manufacturers:
 - a. Belimo Aircontrols (USA), Inc;_____: www.belimo.com/#sle..
 - b. Substitutions: See Section 01 6000 - Product Requirements.

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 Aircontrols (USA), Inc;[____]: www.belimo.com/#sle..
 - b. Substitutions: See Section 01 6000 - Product Requirements.

2.06 HUMIDISTATS

- A. Room Humidistats:
 1. Manufacturers:
 - a. Trane.
 - b. ACI.
 - c. Substitutions: See Section 01 6000 - Product Requirements.
 2. Wall mounted, proportioning type.
- B. Limit Duct Humidistats:
 1. Manufacturers:
 - a. Barber Coleman HC-201.
 - b. Substitutions: See Section 01 6000 - Product Requirements.

2.07 INPUT/OUTPUT SENSORS

- A. Temperature Sensors:
 1. Manufacturers:
 - a. Belimo Aircontrols (USA), Inc;[____]: www.belimo.com/#sle..
 - b. Trane USA____. www.trane.com
 2. 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.
 3. Construct RTD of nickel or platinum with base resistance of 1000 ohms at 70 degrees F.
 4. 100 ohm platinum RTD is acceptable if used with project DDC controllers.
 5. Temperature Sensing Device: Compatible with project DDC controllers.
 6. Performance Characteristics:
 - a. Outside Air Sensors: Watertight inlet fitting shielded from direct rays of the sun.
 - b. Room Temperature Sensors with Integral Digital Display:
 - 1) Construct for surface.
 - 2) Provide a four button keypad with the following capabilities:
 - (a) Indication of space temperature.
 - (b) Setpoint adjustment to accommodate room setpoint.
 - (c) Display and control fan operation status.
 - (d) Manual occupancy override and indication of occupancy status.
 - (e) Controller mode status.
 - (f) Password enabled setpoint and override modes.
 - c. Temperature Averaging Elements:
 - 1) Use on duct sensors for ductwork 10 sq ft or larger.
 - 2) Use averaging elements where prone to stratification with proper sensor length installed in a proper and effective manner.
 - 3) Provide for all mixed air and heating coil discharge sensors regardless of duct size.
 - d. 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. Manufacturers:
 - a. ACI
 - b. Trane USA____. www.trane.com

2. Duct Mounted Sensor: Voltage type encased in a die-cast metal, weather-proof housing.
 - a. Output mA Type: 2-wire, not polarity sensitive (clipped and capped).
 - b. Temperature Effect:
 - 1) Duct Mounted: Plus/minus 0.18 percent per degree F.
 - 2) Outdoor Mounted: 4 to 20mA version: $(0.0013 \times \%RH \times (T_{\text{degreeC}} - 25))$.
- C. Static Pressure (Air Pressure) Sensors:
 1. Manufacturers:
 - a. MAMAC Systems
 - b. Trane USA. www.trane.com
 - c. Dwyer
- D. Carbon Dioxide Or Oxygen Sensors, Duct and Wall:
 1. Manufacturers:
 - a. Trane USA _____. www.trane.com
 - b. Dragger.
 2. Calibration Characteristics:
 - a. Automatically compensating algorithm for sensor drift due to sensor degradation.
 - b. Maximum Drift: 2 percent.
 - c. User calibratable with a minimum calibration interval of 5 years.
 3. Construction:
 - a. Provide duct mounted sensors with duct probe designed to protect sensing element from dust accumulation and mechanical damage.
 - b. Housing: High impact plastic.

2.08 THERMOSTATS

- A. Electric Room Thermostats:
 1. Manufacturers:
- B. Low-Limit Temperature Cutout Switch (low-limit thermostat or freezestat):
 1. Manufacturers:
 - a. Honeywell International, Inc; _____: buildingcontrols.honeywell.com/#sle.
 - b. Johnson Controls International, PLC; _____: www.johnsoncontrols.com/#sle.
 - c. Siemens Industry, Inc; _____: www.siemens.com/#sle.

2.09 TRANSMITTERS

- A. Building Static Pressure Transmitters:
 1. Manufacturers:
 2. 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. Pressure Transmitters:
 1. Manufacturers:
 - a. MAMAC Systems.
 2. One pipe direct acting indicating type for gas, liquid, or steam service, range suitable for system, proportional electronic output.
- C. Water Pressure Transmitters (Liquid Differential Pressure Transmitters):
 1. Manufacturers:
 - a. Dwyer.
 2. General: Provide wet media differential pressure transducers with 6 ft (1.83 m) armored cable, to allow remote pressure sensing capability using existing plumbing runs.
 - a. Input Power: Class 2; 15 to 30 VDC, 24VAC nominal, 50/60 Hz.
 - b. Maximum Current Draw:
 - 1) DC: 125 mA.
 - c. Output: 3-wire transmitter; user-selectable, 4 to 20 mA (0 to 5V/0 to 10V).

- d. Sensor:
 - 1) Media Compatibility: 17 to 4 PH stainless steel.
 - 2) Status Indication: Dual color LED.
 - 3) Proof Pressure: 2x max. F.S. range.
 - 4) Burst Pressure: 5x max. F.S. range.
 - 5) Accuracy at 77 degrees F for less than or equal 20 ft:
 - (a) Ranges A and B: Plus/minus 1 percent F.S. typical.
 - 6) Surge Damping: Electronic; 1 second averaging.
 - 7) Long Term Stability: Plus/minus 0.25 percent.
 - 8) Zero Offset (Bidirectional and Port Swap Modes Only): 0.5 percent.
- e. Reverser:
 - 1) Zero Adjust: Push button auto-zero and digital input (2-position terminal block).
 - 2) Fittings:
 - (a) 27 NPT female thread, stainless steel 17 to 4 PH.
- f. Enclosure: NEMA EN 10250, Type 4.

2.10 TRANSDUCERS

- A. Electropneumatic Transducers:
 - 1. General: Provide electropneumatic pressure transducer utilizing micro-controlled poppet valve technology for pressure sensing in multiple applications.
 - a. Input Power: Class 2; 24 VAC/DC nominal, 30 VAC max; 150 mA max.
 - b. Input Impedance: 4 to 20 mA, 250 ohms; 0 to 5 V/0 to 10 VDC; jumper selectable.
 - c. Alarm Contact: 100 mA at 30 VAC/DC (Pressure loss, manual mode, jumper selectable).
 - d. Accuracy: 1 percent.
 - e. Compensated Temperature Range: 25 degrees F to 140 degrees F.
 - f. Temperature Coefficient: Plus/minus 0.118 percent per degree F.
 - g. Operating Environment: 10 to 90 percent RH noncondensing.
 - h. Control Range: 0 to 20 psi or 3 to 15 psi.
 - i. Pressure Differential: 0.1 psi (supply to branch).
 - j. Pressure Indication: Electronic, 3-1/2 digit LCD.
 - k. Minimum Tubing Length: 15 ft.
 - l. Port Connection: 1/8 inch poly tubing.
 - m. Media Connection:
 - 1) Clean, dry air, or inert gas.
 - 2) Use with oxygen service is prohibited.

2.11 FLOW SENSORS

- A. Hydronic Flow Meter
 - 1. Manufacturers:
- B. Airflow Measurement Device:
 - 1. Manufacturers:
 - a. CRC Wing.
 - b. Trane Traq Damper.
 - c. NO EBTRON!.

2.12 LEVEL INSTRUMENTS

- A. Manufacturers:
 - 1. Vega Radar.

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. Sequence work to ensure installation of components is complementary to installation of similar components in other systems.
- E. Coordinate installation of system components with installation of mechanical systems equipment such as air handling units and air terminal units.
- F. Ensure installation of components is complementary to installation of similar components.
- G. All controls work to be pre-coordinated with the facilities team to insure no negative impact to operations prior to installation.

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 48 inches above floor. Align with Centrak room sensors where app.
- C. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors with sun shield.
- D. Provide guards on thermostats where thermostat is at risk from damage by carts/beds etc.
- E. Provide valves with position indicators and make sure they are installed so they are visible.
- F. Provide two valves in parallel where steam load exceeds 1500 lb per hr with 1/3 to 2/3 load capacities sequenced with smaller valve opening first.
- G. Provide mixing dampers of parallel blade construction arranged to mix streams.
- H. Provide isolation (two position) dampers of parallel blade construction.
- I. Install damper motors on outside of duct in warm areas. Do not install motors in locations at outdoor temperatures.
- J. 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. ALL WIRING MUST BE LABELED.
- K. Install "hand/off/auto" selector switches to override automatic interlock controls when switch is in "hand" position.
- L. Provide conduit and electrical wiring in accordance with Section 26 0583. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.

SECTION 23 0923
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.
- H. Chiller control programs.

1.02 RELATED REQUIREMENTS

- A. Section 23 0913 - Instrumentation and Control Devices for HVAC.
- B. Section 23 0993 - Sequence of Operations for HVAC Controls.
- C. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.
- D. Section 28 1000 - Access Control.
- E. Section 28 3111 - Building Intrusion Detection.
- F. Section 28 4600 - Fire Detection and Alarm.

1.03 REFERENCE STANDARDS

- A. ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks; 2012.
- B. MIL-STD-810 - Environmental Engineering Considerations and Laboratory Tests; 2019h.
- C. ASHRAE Std 147 - Reducing the Release of Halogenated Refrigerants From Refrigerating and Air-Conditioning Equipment and Systems; 2002.
- D. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E. UL (DIR) - Online Certifications Directory; current listings at database.ul.com.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers. All work must be accompanied by drawings approved by engineering. All new controls or modifications to the existing BMS to be reviewed and approved by Facilities Engineering.
- A. All pneumatic controls or obsolete DDC controls must be upgraded to direct-digital controls (DDC) as part of building or areas/zones renovation.
- B. Building automation graphic floor plans to be updated to new design layout.
- C. Scheduling, alarming, trending, temperature and pressure reset for hydronic and air systems must be included in all controls proposals

1.05 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. All mechanical equipment shall be capable of operating standalone. .
- C. All critical controls shall be on emergency power and UPS
- D. Product Data: Provide data for each system component and software module.

- E. Shop Drawings:
- F. All Medical gas systems shall be hard wired tied into the BMS system for Alarm notifications (reserve in use, high pressure, Low pressure).
- G. Air flow monitoring is required for AHU's, outdoor air, return air, relief air and supply air. Preferred manufacturers: Trane Traq-damper, CRC Wing, (Ebtron is not desired).
 - 1. Indicate Comm trunk cable schematic showing programmable control unit locations, and trunk data conductors.
 - 2. List connected data points, including connected control unit and input device.
- H. VAV's to be powered by central transformer
- I. All new Generators shall be integrated into Trane BMS.
 - 1. Indicate system graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations. Provide demonstration digital media containing graphics.
 - 2. Show system configuration with peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
 - 3. Indicate description and sequence of operation of operating, user, and application software.
- J. Manufacturer's Instructions: Indicate manufacturer's installation instructions for all manufactured components.
- K. 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.
 - 2. Include submittals data in final "Record Documents" form.
- L. 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.
- M. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.06 QUALITY ASSURANCE

- A. Perform work in accordance with NFPA 70.
- B. Designer Qualifications: Perform design of system using manufacturer's software under direct supervision of a Professional Engineer experienced in design of this type of work and licensed in Michigan.
- C. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section with minimum three years of documented experience.
- D. Installer Qualifications: Company specializing in performing work of the type specified and with minimum three years of documented experience.
- E. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for purpose specified and indicated.

1.07 WARRANTY

- A. See Section 01 7800 - Closeout Submittals for additional warranty requirements.
- B. Provide five year manufacturer's warranty for field programmable micro-processor based units.

1.08 PROTECTION OF SOFTWARE RIGHTS

- A. Prior to delivery of software, the Owner and the party providing the software will enter into a software license agreement with provisions for the following:
 - 1. Limiting use of software to equipment provided under these specifications.
 - 2. Limiting copying.
 - 3. Preserving confidentiality.
 - 4. Prohibiting transfer to a third party.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Trane USA _____. www.trane.com
- B. Substitutions: Not Permitted.

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 0913.
- 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. Workstation, controllers, and control backbone to communicate using BACnet protocol and addressing. all components shall interface with Corewell Corporate building automation system.
- B. BACnet protocol to comply with ASHRAE Std 135.
- C. Hardware:

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. All new building controllers installation or replacement to be coordinated with Corewell Engineering.
 - e. Utilize real-time clock for scheduling.
 - f. All usernames and passwords shall be confidential and shared only with facilities engineering.
 - 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.

- i. Power to device to be on a dedicated 120V standby circuit with UPS backup.
- 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. 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 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 Controller:
 - 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.
 - h. Power to device to be on a dedicated 120V standby circuit.
 - 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. Application Specific Controllers:
 - 1. General:
 - a. Not fully user programmable, microprocessor based controllers dedicated to control specific equipment.
 - b. Customized for operation within the confines of equipment served.
 - c. Communication with other network devices to be based on assigned protocol.
 - d. Power to device to be on a dedicated 120V standby circuit.
 - 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 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.
- D. 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: Comply with 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:
 - 1) Duct mounted heating coils.
 - c. Control algorithms calibrate the floating device at least
- 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. Use dedicated standby circuits for devices.
 - 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 LOCAL AREA NETWORK (LAN)

- A. All local area network (LAN) devices to be preapproved for network security vulnerability with facilities engineering.
- B. LAN Capacity: Not less than 60 stations or nodes.
- C. Break in Communication Path: Alarm and automatically initiate LAN reconfiguration.
- D. LAN Data Speed: Minimum 19.2 Kb.
- E. Communication Techniques: Allow interface into network by multiple operation stations and by auto-answer/auto-dial modems. Support communication over telephone lines utilizing modems.
- F. Transmission Median: Fiber optic or single pair of solid 24 gage twisted, shielded copper cable.
- G. 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.

2.07 SYSTEM SOFTWARE

- A. Operating System:
 - 1. Concurrent, multi-tasking capability.
 - a. All User access, access level and operating system updates to be managed by Corewell Facilities Engineering.
 - b. Acceptable Operating Systems: Trane Ensemble.
 - 2. System Graphics:
 - a. All Graphics to be commissioned and tested prior to acceptance.
 - b. Animation displayed by shifting image files based on object status.
 - c. Provide method for operator with password to perform the following:
 - 1) Move between, change size, and change location of graphic displays.
 - 2) Modify on-line.
 - 3) Add, delete, or change dynamic objects consisting of:
 - (a) Analog and binary values.
 - (b) Dynamic text.
 - (c) Static text.
 - (d) Animation files.
 - 3. Custom Graphics Generation Package:
 - a. Create, modify, and save graphic files and visio format graphics in PCX formats.
 - b. HTML graphics to support web browser compatible formats.
 - c. Capture or convert graphics from AutoCAD.
 - 4. Standard HVAC Graphics Library:
 - a. HVAC Equipment:
 - 1) Chillers.
 - 2) Boilers.
 - 3) Air Handlers.
 - 4) Terminal HVAC Units.
 - 5) Fan Coil Units.
 - b. Ancillary Equipment:
 - 1) Fans.
 - 2) Pumps.
 - 3) Coils.
 - 4) Valves.
 - 5) Piping.

- 6) Dampers.
- 7) Ductwork.

B. Workstation System Applications:

1. Automatic System Database Save and Restore Functions:
 - a. Current database copy of each Building Controller is automatically stored on hard disk.
 - b. Automatic update occurs upon change in any system panel.
 - c. In the event of database loss in any system panel, the first workstation to detect the loss automatically restores the database for that panel unless disabled by the operator.
2. Manual System Database Save and Restore Functions by Operator with Password Clearance:
 - a. Save database from any system panel.
 - b. Clear a panel database.
 - c. Initiate a download of a specified database to any system panel.
3. Software provided allows system configuration and future changes or additions by operators under proper password protection.
4. On-line Help:
 - a. Context-sensitive system assists operator in operation and editing.
 - b. Available for all applications.
 - c. Relevant screen data provided for particular screen display.
 - d. Additional help available via hypertext.
5. Security:
 - a. Operator log-on requires user name and password to view, edit, add, or delete data.
 - b. System security selectable for each operator.
 - c. System supervisor sets passwords and security levels for all other operators.
 - d. Operator passwords to restrict functions accessible to viewing and/or changing system applications, editor, and object.
 - e. Automatic, operator log-off results from keyboard or mouse inactivity during user-adjustable, time period.
 - f. All system security data stored in encrypted format.
6. System Diagnostics:
 - a. Operations Automatically Monitored:
 - 1) Workstations.
 - 2) Printers.
 - 3) Modems.
 - 4) Network connections.
 - 5) Building management panels.
 - 6) Controllers.
 - b. Device failure is annunciated to the operator.
7. Alarm Processing:
 - a. All system objects are configurable to "alarm in" and "alarm out" of normal state.
 - b. Configurable Objects:
 - 1) Alarm limits.
 - 2) Alarm limit differentials.
 - 3) States.
 - 4) Reactions for each object.
8. Alarm Messages:
 - a. To follow existing site template.
 - b. Recognizable Features:
 - 1) Source.
 - 2) Location.
 - 3)

9. Configurable Alarm Reactions by Workstation and Time of Day:
 - a. Logging.
 - b. Printing.
 - c. Starting programs.
 - d. Displaying messages.
 - e. Dialing out to remote locations.
 - f. Paging.
 - g. Providing audible annunciation.
 - h. Displaying specific system graphics.
10. Custom Trend Logs:
 - a. Definable for any data object in the system including interval, start time, and stop time.
 - b. Trend Data:
 - 1) Sampled and stored on the building controller panel.
 - 2) Archivable on hard disk.
 - 3) Retrievable for use in reports, spreadsheets and standard database programs.
 - 4) Archival on LAN accessible storage media including hard disk, tape, Raid array drive, and virtual cloud environment.
 - 5) Protected and encrypted format to prevent manipulation, or editing of historical data and event logs.
11. Alarm and Event Log:
 - a. View all system alarms and change of states from any system location.
 - b. Events listed chronologically.
 - c. Operator with proper security acknowledges and clears alarms.
 - d. Alarms not cleared by operator are archived to the workstation hard disk.
12. Object, Property Status and Control:
 - a. Provide a method to view, edit if applicable, the status of any object and property in the system.
 - b. Status Available by the Following Methods:
 - 1) Menu.
 - 2) Graphics.
 - 3) Custom Programs.
13. Reports and Logs:
 - a. Reporting Package:
 - 1) Allows operator to select, modify, or create reports.
 - 2) Definable as to data content, format, interval, and date.
 - 3) Archivable to hard disk.
 - b. Real-time logs available by type or status such as alarm, lockout, normal, etc.
 - c. Stored on hard disk and readily accessible by standard software applications, including spreadsheets and word processing.
 - d. Set to be printed on operator command or specific time(s).
14. Reports:
 - a. Standard:
 - 1) Objects with current values.
 - 2) Current alarms not locked out.
 - 3) Disabled and overridden objects, points and SNVTs.
 - 4) Objects in manual or automatic alarm lockout.
 - 5) Objects in alarm lockout currently in alarm.
 - 6) Logs:
 - (a) Alarm History.
 - (b) System messages.
 - (c) System events.
 - (d) Trends.

- b. Custom:
 - 1) Daily.
 - 2) Weekly.
 - 3) Monthly.
 - 4) Annual.
 - 5) Time and date stamped.
 - 6) Title.
 - 7) Facility name.
- c. Tenant Override:
 - 1) Monthly report showing total, requested, after-hours HVAC and lighting services on a daily basis for each tenant.
 - 2) Annual report showing override usage on a monthly basis.
- d. Electrical, Fuel, and Weather:
 - 1) Electrical Meter(s):
 - (a) Monthly showing daily electrical consumption and peak electrical demand with time and date stamp for each meter.
 - (b) Annual summary showing monthly electrical consumption and peak demand with time and date stamp for each meter.
 - 2) Fuel Meter(s):
 - (a) Monthly showing daily natural gas consumption for each meter.
 - (b) Annual summary showing monthly consumption for each meter.
 - 3) Weather:
 - (a) Monthly showing minimum, maximum, average outdoor air temperature and heating/cooling degree-days for the month.
- e. Daily Operating Condition of Chiller(s) Based on ASHRAE Std 147:
 - 1) Chilled water inlet and outlet temperature.
 - 2) Chilled water flow.
 - 3) Chilled water inlet and outlet pressure.
 - 4) Evaporator refrigerant pressure and temperature.
 - 5) Condenser refrigerant pressure and temperature.
 - 6) Condenser refrigerant pressure and liquid temperature.
 - 7) Refrigerant levels.
 - 8) Oil pressure and temperature.
 - 9) Oil level.
 - 10) Compressor refrigerant discharge temperature.
 - 11) Refrigerant suction temperature.
 - 12) Addition of refrigerant.
 - 13) Addition of oil.
 - 14) Motor amperes per phase.
 - 15) Motor volts per phase.
 - 16) Ambient temperature (dry-bulb and wet-bulb).
 - 17) Date and time logged.
- C. Workstation Applications Editors:
 - 1. Provide editing software for each system application at PC workstation.
 - 2. Downloaded application is executed at controller panel.
 - 3. Full screen editor for each application allows operator to view and change:
 - a. Configuration.
 - b. Name.
 - c. Control parameters.
 - d. Set-points.
 - 4. Scheduling:
 - a. Monthly calendar indicates schedules, holidays, and exceptions.
 - b. Allows several related objects to be scheduled and copied to other objects or dates.

- c. Start and stop times adjustable from master schedule.
- 5. Custom Application Programming:
 - a. Create, modify, debug, edit, compile, and download custom application programming during operation and without disruption of all other system applications.
 - b. Programming Features:
 - 1) English oriented language, based on BASIC, FORTRAN, C, or PASCAL syntax allowing for free form programming.
 - 2) Alternative language graphically based using appropriate function blocks suitable for all required functions and amenable to customizing or compounding.
 - 3) Insert, add, modify, and delete custom programming code that incorporates word processing features such as cut/paste and find/replace.
 - 4) Allows the development of independently, executing, program modules designed to enable and disable other modules.
 - 5) Debugging/simulation capability that displays intermediate values and/or results including syntax/execution error messages.
 - 6) Support for conditional statements (IF/THEN/ELSE/ELSE-F) using compound Boolean (AND, OR, and NOT) and/or relations (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.
 - 7) Support for floating-point arithmetic utilizing plus, minus, divide, times, square root operators; including absolute value; minimum/maximum value from a list of values for mathematical functions.
 - 8) Language consisting of resettable, predefined, variables representing time of day, day of the week, month of the year, date; and elapsed time in seconds, minutes, hours, and days where the variable values can be used in IF/THEN comparisons, calculations, programming statement logic, etc.
 - 9) Language having predefined variables representing status and results of the system software enables, disables, and changes the set points of the controller software.

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.
 - 2. Exception Schedules:
 - a. Based on any day of the year.
 - b. Defined up to one year in advance.
 - c. Automatically discarded and replaced with standard schedule for that day of the week upon execution.
 - 3. Holiday or Special Schedules:
 - a. Capability to define up to 99 schedules.
 - b. Repeated annually.
 - c. Length of each period is operator defined.

- 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 in Section 23 0993.
- 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. Energy Calculations:
 - 1. Accumulated instantaneous power or flow rates are converted to energy use data.
 - 2. Algorithm calculates a rolling average and allows window of time to be user specified in minute intervals.
 - 3. Algorithm calculates a fixed window average with a digital input signal from a utility meter defining the start of the window period that in turn synchronizes the fixed-window average with that used by the power company.
- K. Anti-Short Cycling:
 - 1. All binary output objects protected from short-cycling.
 - 2. Allows minimum on-time and off-time to be selected.
- L. 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.
- M. 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. Control Summary:

- a. HVAC Control system begin/end status.
 - b. Heating/cooling mode status.
 - c. Start/Stop times.
 - d. Occupancy and vacancy times.
 - e. Optimal run time system heating/cooling mode parameters.
- C. Supply Air Reset:
 - 1. Monitor heating and cooling loads in building spaces, terminal reheat systems, both hot deck and cold deck temperatures on dual duct and multizone systems, single zone unit discharge temperatures.
 - 2. Adjust discharge temperatures to most energy efficient levels satisfying measured load by:
 - a. Raising cooling temperatures to highest possible value.
 - b. Reducing heating temperatures to lowest possible level.
 - 3. Monitor air damper position in building spaces and adjust the static pressure setpoint as required to meet demand and avoid wasted energy.
 - 4. Control summary:
 - a. HVAC control system status (begin/end).
 - b. Supply air reset system status.
 - c. Heating and cooling loop.
 - d. High/low limits.
 - e. Deadband.
 - f. Response timer.
 - g. Reset times.
 - 5. Space load summary:
 - a. HVAC system status.
 - b. Heating/cooling loop status.
 - c. Space load point ID.
 - d. Current space load point value.
 - e. Control heat/cool limited.
 - f. Gain factor.
 - g. Calculated reset values.
 - h. Fan status point ID and status.
 - i. Control discharge temperature point ID and status.
 - j. Space load point ID and status.
 - k. Air flow rate point ID and status.
- 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.

2.10 CHILLER CONTROL PROGRAMS

- A. Control function of condenser water reset, chilled water reset, and chiller sequencing. Support inch-pounds and SI (metric) units of measurement.
- B. Chilled Water Reset: Automatically reset controlled chilled water temperature satisfying cooling coil requiring greatest cooling.
- C. Chiller Sequencing: Determine which combination of chillers will most efficiently satisfy chilled water load, by cycling chillers, based on comparing load to switchover limits defined for each chiller.

PART 3 EXECUTION

3.01 INSTALLERS

- A. Installer List:
 - 1. Trane USA; www.trane.com_____.

3.02 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.
- C. Pre-Coordinate installation with

3.03 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. Refer to Section 23 0993.
- C. Provide conduit and electrical wiring in accordance with Section 26 0583. Electrical material and installation shall be in accordance with appropriate requirements of Division 26.

3.04 MANUFACTURER'S FIELD SERVICES

- A. Start and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.
- B. Provide service engineer to instruct Owner's representative in operation of systems plant and equipment for 3 day period.

3.05 DEMONSTRATION AND INSTRUCTIONS

- A. Demonstrate complete and operating system to Owner.

3.06 MAINTENANCE

- A. See Section 01 7000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- B. Provide service and maintenance of energy management and control systems for one years from Date of Substantial Completion.
- C. Provide two complete inspections, one in each season, to inspect, calibrate, and adjust controls as required, and submit written reports.

END OF SECTION 23 0923

SECTION 23 0993
SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. This section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices, and system components required for control systems are specified in other sections.
- B. Sequence of operation for:
 - 1. Air terminal units.
 - 2. Cabinet heaters.
 - 3. Central refrigeration systems.
 - 4. Central fan systems.
 - 5. Combustion air unit heaters.
 - 6. Electrical rooms and telephone rooms.
 - 7. Elevator machine rooms.
 - 8. Emergency generators.
 - 9. Excess pressure controls.
 - 10. Fan coil units.
 - 11. Heating coils.
 - 12. Heating water zone control.
 - 13. Humidifiers.
 - 14. Induction units.
 - 15. Parking garage ventilation systems.
 - 16. Radiant panels.
 - 17. Radiation and convectors.
 - 18. Refrigeration systems.
 - 19. Unit heaters.

1.02 RELATED REQUIREMENTS

- A. Section 01 9113 - General Commissioning Requirements: Commissioning requirements that apply to all types of work.
- B. Section 23 0913 - Instrumentation and Control Devices for HVAC.
- C. Section 23 0923 - Direct-Digital Control System for HVAC.
- D. Section 26 2816.13 - Enclosed Circuit Breakers.

1.03 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Sequence of Operation Documentation: Submit written sequence of operation for entire HVAC system and each piece of equipment.
 - 1. Preface: 1 or 2 paragraph overview narrative of the system describing its purpose, components and function.
 - 2. State each sequence in small segments and give each segment a unique number for referencing in Functional Test procedures; provide a complete description regardless of the completeness and clarity of the sequences specified in Contract Documents.
 - 3. Include at least the following sequences:
 - a. Start-up.
 - b. Warm-up mode.
 - c. Normal operating mode.
 - d. Unoccupied mode.
 - e. Shutdown.
 - f. Capacity control sequences and equipment staging.

- g. Temperature and pressure control, such as setbacks, setups, resets, etc.
- h. Detailed sequences for all control strategies, such as economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
- i. Effects of power or equipment failure with all standby component functions.
- j. Sequences for all alarms and emergency shut downs.
- k. Seasonal operational differences and recommendations.
- l. Interactions and interlocks with other systems.
- 4. Include initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
- 5. For packaged controlled equipment, include manufacturer's furnished sequence of operation amplified as required to describe the relationship between the packaged controls and the control system, indicating which points are adjustable control points and which points are only monitored.
- 6. Include schedules, if known.
- C. Control System Diagrams: Submit graphic schematic of the control system showing each control component and each component controlled, monitored, or enabled.
 - 1. Label with settings, adjustable range of control and limits.
 - 2. Include flow diagrams for each control system, graphically depicting control logic.
 - 3. Include the system and component layout of all equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
 - 4. Include draft copies of graphic displays indicating mechanical system components, control system components, and controlled function status and value.
 - 5. Include all monitoring, control and virtual points specified in elsewhere.
 - 6. Include a key to all abbreviations.
- D. Points List: Submit list of all control points indicating at least the following for each point.
 - 1. Name of controlled system.
 - 2. Point abbreviation.
 - 3. Point description; such as dry bulb temperature, airflow, etc.
 - 4. Display unit.
 - 5. Control point or setpoint (Yes / No); i.e. a point that controls equipment and can have its setpoint changed.
 - 6. Monitoring point (Yes / No); i.e. a point that does not control or contribute to the control of equipment but is used for operation, maintenance, or performance verification.
 - 7. Intermediate point (Yes / No); i.e. a point whose value is used to make a calculation which then controls equipment, such as space temperatures that are averaged to a virtual point to control reset.
 - 8. Calculated point (Yes / No); i.e. a "virtual" point generated from calculations of other point values.
- E. Project Record Documents: Record actual locations of components and setpoints of controls, including changes to sequences made after submission of shop drawings.

1.04 QUALITY ASSURANCE

- A. Design system under direct supervision of a Professional Engineer experienced in design of this work and licensed at Michigan.

PART 2 PRODUCTS - NOT USED

PART 3 EXECUTION

3.01 AIR TERMINAL UNITS

- A. Single-duct Variable Volume:
 - 1. Cooling Only:

- a. On a rise in space temperature, the damper will modulate to provide maximum airflow.
 - b. As space temperature decreases, the damper will modulate down to its minimum airflow.
- 2. Cooling with Reheat:
 - a. On a rise in space temperature above the cooling set-point, the unit modulates to its maximum airflow.
 - b. As the space temperature falls below the cooling set-point, the unit modulates to its minimum airflow.
 - c. As the space temperature continues to fall to the heating set-point, the terminal modulates to its heating minimum airflow. At this point, the heat will be staged on.
- B. Fan-powered:
 - 1. Series Units:
 - a. Series-fan runs continuously via control interlock with the AHU supply fan.
 - b. The air valve modulates the primary airflow in response to space temperature with the reheat de-energized.
 - c. Reheat is activated to increase discharge temperature when further decrease in primary airflow will not maintain space temperature.
 - 2. Parallel Units:
 - a. The primary air valve delivers cooled air to the unit outlet.
 - b. Upon decrease in space temperature beyond control of the primary air valve, the fan is simultaneously energized along with the first stage of heat.
 - c. Parallel fan delivers warm plenum air from the controlled space to the unit outlet, mixing with the primary air before entering the space.

3.02 CABINET HEATERS

- A. Single temperature thermostat on return heating water line from floor mounted cabinet heaters de-energizes unit on temperatures below 95 degrees F.

3.03 CENTRAL REFRIGERATION SYSTEMS

- A. Enable based on OA temperature .
- B. Condensing Water Pump: Allow start on proof of water in cooling tower sump and on outdoor temperature above 50 degrees F. Start on demand from ventilation system.
- C. Energize chilled water pump to start and allow cooling tower fans to start when condensing water pump started.
- D. Open chiller control valve. once valve proof open, chilled water pump starts
- E. Modulate CHW Pump to maintain Min flow through chiller and control to system PSID.
- F. When chilled water flow and condensing water flow are proven by flow switches, allow refrigeration machine to start.
- G. Maintain minimum condenser water temperature of 55 degrees F by modulating tower bypass valve.
- H. Maintain minimum temperature in cooling tower sump of 40 degrees F . Outdoor thermostat set at 35 degrees F shall Activate heat tracing and sump heater.
- I. Thermostat in cooling tower sump, set at 35 degrees F, opens drain lines, closes make-up valve, and deactivates sump heaters and piping electric heat tapes. AKA winterize mode.
- J. Display:
 - 1. System graphic.
 - 2. Condensing water pump on/off indication.
 - 3. Chilled water pump on/off switch.
 - 4. Chiller on/off indication.
 - 5. Chiller condensing water supply and return temperature.

6. Chiller chilled water supply and return temperature.
7. Chiller condensing water control point adjustment.
8. Common chilled water control point adjustment.
9. Low level cooling tower sump alarm.
10. Cooling tower fan on/off indication.
11. Cooling tower sump heater on/off indication.
12. Cooling tower dump indication.
13. Chilled water control point adjustment.
14. Condensing water pump on/off switch.
15. Chilled water pump on/off/auto switch.
16. Chiller on/off switch.

3.04 CENTRAL FAN SYSTEMS

- A. Time Schedule: Start and stop supply and return fans. Determine fan status by current sensing devices. If fan fails to start as commanded, signal alarm.
- B. Safety Devices:
 1. Freeze Protection: Stop fans and close outside air dampers if temperature downstream of preheat coil is below 37 degrees F; if equipped, run the HW pump. signal alarm.
 2. High/Low Duct Static Protection: Stop fans and close outside dampers if Duct Static is above or below duct static design capabilities and signal alarm.
 3. Smoke Detector: Stop fans, close outside dampers, and close smoke dampers if smoke is detected; signal alarm.
- C. Preheat Coil:
 1. When fan is not running, and outside air temperature is below 40 degrees F, Modulate preheat coil valve to heating in order to maintain 75F mixed air temp.
- D. Outside Air Damper: When supply fan is running, open outside air damper to minimum position after predetermined start up sequence.
- E. Humidifier Enable: When supply fan is running (proven by DP sensor) , OA is below enable setpoint and the Supply duct RH% is below High Limit Setpoint, Enable the Humidifier.
- F. Humidifier PID: When the humidifier is enabled , modulates normally closed humidifier valve to control the Space RH to the space RH setpoint.
- G. Outside, Return, and Relief Dampers:
 1. When supply fan is not running, outside and relief dampers are closed and return damper is open.
 2. When supply fan is running, dampers are controlled and operate with outside and relief dampers opening, and return damper closing.
 3. For cooling and outside air temperatures in Economizer mode, modulate dampers to maintain mixed air temperature of 55 degrees F Adj.
 4. if not in economizer mode, drive outside damper to minimum, close relief damper, and open return damper.
 5. Differential enthalpy with fixed dry-bulb temperature for economizer control type is preferred.
- H. Modulate mixed air dampers in sequence to maintain constant mixed air temperature.
- I. Maintain constant supply static pressure as required by the balancer by modulating supply and return fan speeds in sequence. Locate sensor minimum 2/3 of main duct length downstream of supply fan in supply air duct.
- J. Display:
 1. System graphic.
 2. System on/off indication.
 3. System day/night mode.
 4. System fan on/off indication.

5. Return fan on/off indication.
6. Preheat coil pump on/off indication.
7. Outside air temperature indication.
8. Mixed air temperature indication.
9. Fan discharge air temperature indication.
10. Reheat zone air temperature indication.
11. Return AND Space humidity indication.
12. Fan discharge temperature control point adjustment.
13. Return AND space humidity control point adjustment.
14. Reheat zone control point adjustment.
15. Supply static pressure indication.
16. Supply static pressure control point adjustment.
17. System on/off auto switch.
18. Supply fan on/off switch.
19. Return fan on/off/auto switch.
20. Preheat coil pump on/off switch.

3.05 COMBUSTION AIR UNIT HEATERS

3.06 ELECTRICAL ROOMS AND TELEPHONE ROOMS

3.07 ELEVATOR MACHINE ROOMS

3.08 EMERGENCY GENERATORS

- A. When the generator is not running, outside and exhaust dampers are closed and recirculation damper is open.
- B. When generator is running, dampers are controlled and operate with outside and exhaust dampers opening, and recirculating dampers closing, to maintain room temperature of 85 degrees F.
- C. On room temperatures above 95 degrees F open intake damper and start exhaust fan.

3.09 EXCESS PRESSURE CONTROLS

- A. Maintain constant pressure differential between supply and return lines by varying pump speed through variable speed drive control.

3.10 FAN COIL UNITS

3.11 HEATING COILS

3.12 HEATING WATER ZONE CONTROL

- A. Flow proving switch in heating pump discharge provides on/off indication.
- B. Control heating water at maximum 180 degrees F at outdoor temperature of 10 degrees F, and minimum 130 degrees F at outdoor temperature of 65 degrees F, with straight line relationship between.
- C. Display:
 1. System graphic.
 2. System supply temperature.
 3. System supply control point adjustment.
 4. System return temperature.
 5. Pump on/off indication.
 6. Pump on/off switch and speed.
 7. Boiler lead lag switch.

3.13 HUMIDIFIERS

3.14 INDUCTION UNITS

3.15 PARKING GARAGE VENTILATION SYSTEMS

- A. Carbon Monoxide (CO) and NO2 detector maintains maximum ppm as dictated by local codes by cycling exhaust fan. signal alarm when outside of normal parameters.

3.16 RADIANT PANELS

- A. Radiant panels to be wired to the controller controlling the space temp. they shall be enabled and turned on when OA is below 40F adj and not driven by VAV box space temp sequence unless approved by facilities engineering.

3.17 RADIATION AND CONVECTORS

- A. Radiant panels to be wired to the controller controlling the space temp. they shall be enabled and turned on when OA is below 40F adj and not driven by VAV box space temp sequence unless approved by facilities engineering.

3.18 REFRIGERATION SYSTEMS

3.19 UNIT HEATERS

END OF SECTION 23 0993

**SECTION 23 1123
FACILITY NATURAL-GAS PIPING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pipe, pipe fittings, valves, and connections for natural gas piping systems.

1.02 RELATED REQUIREMENTS

- A. Section 07 8400 - Firestopping.
- B. Section 08 3100 - Access Doors and Panels.
- C. Section 09 9113 - Exterior Painting.
- D. Section 09 9123 - Interior Painting.
- E. Section 22 0516 - Expansion Fittings and Loops for Plumbing Piping.
- F. Section 22 0548 - Vibration and Seismic Controls for Plumbing Piping and Equipment.
- G. Section 22 0719 - Plumbing Piping Insulation.
- H. Section 23 0516 - Expansion Fittings and Loops for HVAC Piping.
- I. Section 23 0548 - Vibration and Seismic Controls for HVAC.
- J. Section 23 0553 - Identification for HVAC Piping and Equipment.
- K. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.
- L. Section 31 2316 - Excavation.
- M. Section 31 2316.13 - Trenching.
- N. Section 31 2323 - Fill.
- O. Section 33 5216 - Gas Hydrocarbon Piping.

1.03 REFERENCE STANDARDS

- A. ANSI Z21.18/CSA 6.3 - Gas Appliance Pressure Regulators; 2007 (Reaffirmed 2012).
- B. ANSI Z21.80/CSA 6.22 - Line Pressure Regulators; 2011 (Including Addendum 1).
- C. ANSI Z223.1 - National Fuel Gas Code; 2024.
- D. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Welding, Brazing, and Fusing Qualifications; 2015.
- E. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; 2011.
- F. ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes; 2013.
- G. ASME B31.1 - Power Piping; 2014.
- H. ASME B31.9 - Building Services Piping; 2014.
- I. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings; 1999 (Reapproved 2014).
- J. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2012.
- K. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.
- L. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2015.
- M. ASTM B68/B68M - Standard Specification for Seamless Copper Tube, Bright Annealed; 2011.
- N. ASTM B75/B75M - Standard Specification for Seamless Copper Tube; 2011.
- O. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2014.

- P. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric); 2013.
- Q. ASTM B813 - Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube; 2010.
- R. ASTM D2513 - Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings; 2014.
- S. ASTM D2683 - Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing; 2014.
- T. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers; 2024.
- U. AWWA C105/A21.5 - Polyethylene Encasement for Ductile-Iron Pipe Systems; 2010.
- V. AWWA C606 - Grooved and Shouldered Joints; 2011.
- W. ICC-ES AC01 - Acceptance Criteria for Expansion Anchors in Masonry Elements; 2012.
- X. ICC-ES AC106 - Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements; 2012.
- Y. ICC-ES AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements; 2013.
- Z. ICC-ES AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements; 2013.
- AA. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2009.
- BB. MSS SP-78 - Cast Iron Plug Valves, Flanged and Threaded Ends; 2011.
- CC. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends; 2010.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.
- C. Welder Certificate: Include welders certification of compliance with ASME BPVC-IX.
- D. Project Record Documents: Record actual locations of valves.
- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 6000 - Product Requirements, for additional provisions.
 - 2. Valve Repacking Kits: One for each type and size of valve.

1.05 QUALITY ASSURANCE

- A. Perform work in accordance with applicable codes.
- B. Valves: Manufacturer's name and pressure rating marked on valve body.
- C. Welding Materials and Procedures: Comply with ASME BPVC-IX and applicable state labor regulations.
- D. Welder Qualifications: Certified in accordance with ASME BPVC-IX.
- E. Identify pipe with marking including size, ASTM material classification, and ASTM specification.

1.06 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.

1.07 FIELD CONDITIONS

- A. Do not install underground piping when bedding is wet or frozen.

PART 2 PRODUCTS

2.01 NATURAL GAS PIPING, BURIED BEYOND 5 FEET OF BUILDING

- A. Steel Pipe: ASTM A53/A53M, Schedule 40 black.
 - 1. Fittings: ASTM A234/A234M, wrought steel welding type, with AWWA C105/A21.5 polyethylene jacket or double layer, half-lapped 10 mil polyethylene tape.
 - 2. Joints: ASME B31.1, welded.

2.02 NATURAL GAS PIPING, BURIED WITHIN 5 FEET OF BUILDING

- A. Steel Pipe: ASTM A53/A53M, Schedule 40 black.
 - 1. Fittings: ASTM A234/A234M, wrought steel welding type.
 - 2. Joints: ANSI Z223.1, welded.
 - 3. Jacket: AWWA C105/A21.5 polyethylene jacket or double layer, half-lapped 10 mil polyethylene tape.

2.03 NATURAL GAS PIPING, ABOVE GRADE

- A. Steel Pipe: ASTM A53/A53M, Schedule 40 black.
 - 1. Fittings: ASME B16.3, malleable iron, or ASTM A234/A234M, wrought steel welding type.
 - 2. Joints: Threaded or welded to ASME B31.1.
 - 3. Mechanical Press Sealed Fittings: Double pressed type and approved or certified, utilizing EPDM, non toxic synthetic rubber sealing elements.
 - a. Manufacturers:
 - 1) Apollo Valves; _____: www.apollovalves.com/#sle.
 - 2) Viega LLC; MegaPress: www.viega.us/#sle.

2.04 FLANGES, UNIONS, AND COUPLINGS

- A. Unions for Pipe Sizes 3 Inches and Under:
 - 1. Ferrous pipe: Class 150 malleable iron threaded unions.
- B. Flanges for Pipe Size Over 1 Inch:
 - 1. Ferrous Pipe: Class 150 malleable iron threaded or forged steel slip-on flanges; preformed neoprene gaskets.
- 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. Housing Material: Provide ASTM A47/A47M malleable iron, ductile iron, or _____, galvanized.
 - 3. Gasket Material: EPDM suitable for operating temperature range from minus 30 degrees F to 230 degrees F.
 - 4. Bolts and Nuts: Hot dipped galvanized or zinc-electroplated steel.
 - 5. When pipe is field grooved, provide coupling manufacturer's grooving tools.
 - 6. Manufacturers:
 - a. Apollo Valves; _____: www.apollovalves.com/#sle.
 - b. Grinnell Products; _____: www.grinnell.com/#sle.
 - c. Substitutions: See Section 01 6000 - Product Requirements.
- D. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

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.

2. Overhead Supports: Individual steel rod hangers attached to structure or to trapeze hangers.
 - a. Cold and Hot Pipe Sizes 6 Inches and Over: Double hangers.
3. Trapeze Hangers: Welded steel channel frames attached to structure.
4. Vertical Pipe Support: Steel riser clamp.
5. Floor Supports: Concrete pier or steel pedestal with floor flange; fixture attachment.
6. Rooftop Supports for Low-Slope Roofs: Steel pedestals with bases that rest on top of roofing membrane with slip sheet of same material as roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified; and as follows:
 - a. Bases: High density polypropylene.
 - b. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
 - c. Steel Components: Stainless steel, or carbon steel hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.
 - d. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports; corrosion resistant material.
 - e. Height: Provide minimum clearance of 6 inches under pipe to top of roofing.
- B. Hanger Fasteners: Attach hangers to structure using appropriate fasteners, as follows:
 1. Concrete Wedge Expansion Anchors: Complying with ICC-ES AC193.
 2. Masonry Wedge Expansion Anchors: Complying with ICC-ES AC01.
 3. Concrete Screw Type Anchors: Complying with ICC-ES AC193.
 4. Masonry Screw Type Anchors: Complying with ICC-ES AC106.

2.06 BALL VALVES

- A. Manufacturers:
 1. Apollo Valves; _____: www.apollovalves.com/#sle.
 2. Grinnell Products; _____: www.grinnell.com/#sle.
 3. Milwaukee Valve Company; _____: www.milwaukeevalve.com/#sle.
 4. Nibco, Inc; _____: www.nibco.com/#sle.
 5. Viega LLC; _____: www.viega.us/#sle.
 6. Uponor, Inc; _____: www.uponorpro.com/#sle.
 7. Substitutions: See Section 01 6000 - Product Requirements.
- B. Construction, 4 Inches and Smaller: MSS SP-110, Class 150, 400 psi CWP, bronze or ductile iron body, 304 stainless steel ball, regular port, Teflon seats and stuffing box ring, blow-out proof stem, lever handle with balancing stops, threaded or grooved ends with union.

2.07 PLUG VALVES

- A. Manufacturers:
 1. Apollo Valves; _____: www.apollovalves.com/#sle.
 2. Grinnell Products; _____: www.grinnell.com/#sle.
 3. Milwaukee Valve Company; _____: www.milwaukeevalve.com/#sle.
 4. Nibco, Inc; _____: www.nibco.com/#sle.

2.08 STRAINERS

- A. Manufacturers:
 1. Armstrong International, Inc; _____: www.armstronginternational.com/#sle.
 2. WEAMCO; _____: www.weamco.com/#sle.
- B. Size 2 inch and Under:
 1. Threaded brass body for 175 psi CWP, Y pattern with 1/32 inch stainless steel perforated screen.
 2. Class 150, threaded bronze body 300 psi CWP, Y pattern with 1/32 inch stainless steel perforated screen.

- C. Size 1-1/2 inch to 4 inch:
 - 1. Class 125, flanged iron body, Y pattern with 1/16 inch stainless steel perforated screen.
- D. Size 5 inch and Larger:
 - 1. Class 125, flanged iron body, basket pattern with 1/8 inch stainless steel perforated screen.

2.09 LINE PRESSURE REGULATORS AND APPLIANCE REGULATORS INDICATORS

- A. Manufacturers:
 - 1. Actaris Metering Systems (A brand of ITT Controls); _____: www.actaris-metering-systems.com/#sle.
 - 2. Maxitrol Company; _____: www.maxitrol.com/#sle.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Compliance Requirements:
 - 1. Appliance Regulator: ANSI Z21.18/CSA 6.3.
 - 2. Line Pressure Regulator: ANSI Z21.80/CSA 6.22.
- C. Materials in Contact With Gas:
 - 1. Housing: Aluminum, steel (free of non-ferrous metals).
 - 2. Seals and Diaphragms: NBR-based rubber.
- D. Maximum Inlet Operating Pressure: 10 psi.
 - 1. Appliance Regulator: 10 psi.
 - 2. Line Pressure Regulator: 10 psi.
- E. Maximum Body Pressure: 10 psi.
- F. Output Pressure Range: 1 inch wc to 80 inch wc.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide non-conducting dielectric connections wherever jointing dissimilar metals.
- C. Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.
- D. Group piping whenever practical at common elevations.
- E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to Section 22 0516.
- F. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
 - 1. Refer to Section 22 0719.
- G. Provide access where valves and fittings are not exposed.
 - 1. Coordinate size and location of access doors with Section 08 3100.
- H. Install vent piping penetrating roofed areas to maintain integrity of roof assembly; refer to Section 075323.
- I. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
- J. Provide support for utility meters in accordance with requirements of utility companies.
- K. Prepare exposed, unfinished pipe, fittings, supports, and accessories ready for finish painting.
 - 1. Painting of interior piping systems and components is specified in Section 09 9123.
 - 2. Painting of exterior piping systems and components is specified in Section 09 9113.
- L. Excavate in accordance with Section 31 2316.
- M. Backfill in accordance with Section 31 2323.

- N. Install valves with stems upright or horizontal, not inverted.
- O. Pipe vents from gas pressure reducing valves to outdoors and terminate in weather proof hood.
- P. Sleeve pipes passing through partitions, walls and floors.
- Q. Pipe Hangers and Supports:
 - 1. Install in accordance with ASME B31.9.
 - 2. Support horizontal piping as indicated.
 - 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 other 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. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
 - a. Painting of interior piping systems and components is specified in Section 09 9123.
 - b. Painting of exterior piping systems and components is specified in Section 09 9113.
 - 9. Provide hangers adjacent to motor driven equipment with vibration isolation; refer to Section 22 0548.

3.02 APPLICATION

- A. Install unions downstream of valves and at equipment or apparatus connections.
- B. Install brass male adapters each side of valves in copper piped system. Solder adapters to pipe.
- C. Install ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- D. Provide plug valves in natural gas systems for shut-off service.

3.03 SERVICE CONNECTIONS

- A. Provide new gas service complete with gas meter and regulators in accordance with Section 33 5216. Gas service distribution piping to have initial minimum pressure of to meet equipment manufacturer recommendations.

END OF SECTION 23 1123

SECTION 23 2113 HYDRONIC PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Hydronic system requirements.
- B. Heating water piping, above grade.
- C. Heating water and glycol piping, above grade.
- D. Chilled water piping, buried.
- E. Chilled water piping, above grade.
- F. Condenser water piping, buried.
- G. Condenser water piping, above grade.
- H. Radiant heating piping system.
- I. Equipment drains and overflows.
- J. Pipe hangers and supports.
- K. Unions, flanges and mechanical couplings.
- L. Valves:
 - 1. Ball valves.
 - 2. Butterfly valves.
 - 3. Check valves.
 - 4. Pressure independent temperature control valves (no pressure independent balancing valves).
- M. Flow controls.

1.02 RELATED REQUIREMENTS

- A. Section 07 8400 - Firestopping.
- B. Section 08 3100 - Access Doors and Panels.
- C. Section 09 9123 - Interior Painting.
- D. Section 22 0516 - Expansion Fittings and Loops for Plumbing Piping.
- E. Section 22 0548 - Vibration and Seismic Controls for Plumbing Piping and Equipment.
- F. Section 22 0553 - Identification for Plumbing Piping and Equipment.
- G. Section 22 0719 - Plumbing Piping Insulation.
- H. Section 23 0516 - Expansion Fittings and Loops for HVAC Piping.
- I. Section 23 0523 - General-Duty Valves for HVAC Piping.
- J. Section 23 0548 - Vibration and Seismic Controls for HVAC.
- K. Section 23 0553 - Identification for HVAC Piping and Equipment.
- L. Section 23 0719 - HVAC Piping Insulation.
- M. Section 23 2114 - Hydronic Specialties.
- N. Section 23 2500 - HVAC Water Treatment: Pipe cleaning.

1.03 REFERENCE STANDARDS

- A. ANSI/FCI 70-2 - Control Valve Seat Leakage; 2013.
- B. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Welding, Brazing, and Fusing Qualifications; 2015.
- C. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; 2011.

- D. ASME B16.15 - Cast Copper Alloy Threaded Fittings Classes 125 and 250; 2013.
- E. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings; 2012.
- F. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2013.
- G. ASME B16.34 - Valves - Flanged, Threaded and Welding End; 2013.
- H. ASME B31.9 - Building Services Piping; 2014.
- I. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2012.
- J. ASTM A106/A106M - Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service; 2014.
- K. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.
- L. ASTM A183 - Standard Specification for Carbon Steel Track Bolts and Nuts; 2003 (Reapproved 2009).
- M. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2015.
- N. ASTM A536 - Standard Specification for Ductile Iron Castings; 1984 (Reapproved 2014).
- O. ASTM B32 - Standard Specification for Solder Metal; 2008 (Reapproved 2014).
- P. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2014.
- Q. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric); 2013.
- R. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120; 2021.
- S. ASTM D2000 - Standard Classification System for Rubber Products in Automotive Applications; 2012.
- T. ASTM D2241 - Standard Specification for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series); 2015.
- U. ASTM D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40; 2013.
- V. ASTM D2467 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80; 2006.
- W. ASTM D2855 - Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings; 1996 (Reapproved 2010).
- X. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers; 2024.
- Y. ASTM F1476 - Standard Specification for Performance of Gasketed Mechanical Couplings for Use in Piping Applications; 2007 (Reapproved 2013).
- Z. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding; 2011-AMD 1.
- AA. AWS D1.1/D1.1M - Structural Welding Code - Steel; 2015.
- BB. AWWA C606 - Grooved and Shouldered Joints; 2011.
- CC. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2009.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Welders Certificate: Include welders certification of compliance with ASME BPVC-IX.
- C. Product Data:
 - 1. Include data on pipe materials, pipe fittings, valves, and accessories.
 - 2. Provide manufacturers catalogue information.

3. Show grooved joint couplings, fittings, valves, and specialties on drawings and product submittals, specifically identified with the manufacturer's style or series designation.
- D. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- E. Project Record Documents: Record actual locations of valves.
- F. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.
- G. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 1. See Section 01 6000 - Product Requirements, for additional provisions.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products of the type specified in this section, with minimum three years of documented experience.
- B. Installer Qualifications: Company specializing in performing work of the type specified in this section, with minimum 3 years of experience.
- C. Provide all grooved joint couplings, fittings, valves, specialties, and grooving tools from a single manufacturer.

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 FIELD CONDITIONS

- A. Do not install underground piping when bedding is wet or frozen.

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 brass fittings (union, valve, flange or coupling) or other non-conductive connections (final approval by owner) whenever jointing dissimilar metals. A valve shall be placed upstream of any connection involving a union or flange. Dielectric unions shall not be installed and shall be replaced with any of the before mentioned connections if encountered during repair or retrofit work.
 3. Grooved mechanical joints may be used in accessible locations only where visible or in mechanical rooms.
 - a. Accessible locations include those exposed on interior of building, and in mechanical rooms, aboveground outdoors, and as approved by Facilities Engineering.
 - b. Grooved mechanical connections and joints comply with AWWA C606.
 - 1) Ductile Iron: Comply with ASTM A536, Grade 65-45-12.
 - 2) Steel: Comply with ASTM A106/A106M, Grade B or ASTM A53/A53M.
 - c. Use rigid joints unless otherwise indicated.
 - d. Use gaskets of molded synthetic rubber with central cavity, pressure responsive configuration and complying with ASTM D2000, Grade 2CA615A15B44F17Z for circulating medium up to maximum 230 degrees F or Grade M3BA610A15B44Z for circulating medium up to maximum 200 degrees F.

- e. Provide steel coupling nuts and bolts complying with ASTM A183.
- 4. 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. On discharge of pumps, use spring loaded check valves.
 - 3. Isolate equipment using butterfly valves with lug end flanges or grooved mechanical couplings. Provide isolation valves at equipment whether shown or not.
 - 4. For throttling, bypass, or manual flow control services, use globe, ball, or butterfly valves.
 - 5. For throttling and isolation service in chilled and condenser water systems, use only butterfly valves.
 - 6. In heating water, chilled water, or condenser water systems, butterfly valves may be used interchangeably with gate and globe valves.
 - 7. For shut-off and to isolate parts of systems or vertical risers, use gate, ball, or butterfly valves.
 - 8. For throttling service, use plug cocks. Use non-lubricated plug cocks only when shut-off or isolating valves are also provided.

2.02 HEATING WATER AND GLYCOL 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. Steel Pipe Sizes 12 Inch and Greater: ASTM A53/A53M, 3/8 inch wall, 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. Grooved Joints: AWWA C606 grooved pipe, fittings of same material, and mechanical couplings.
- C. 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.
 - 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.
 - 2. Grooved Joints: AWWA C606 grooved tube, fittings of same material, and copper-tube-dimension mechanical couplings.
 - 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, nontoxic synthetic rubber sealing elements.
 - a. Manufacturers:
 - 1) Apollo Valves; _____: www.apollovalves.com/#sle.
 - 2) Grinnell Products; _____: www.grinnell.com/#sle.
 - 3) Viega LLC; _____: www.viega.us/#sle.

- 4) Substitutions: See Section 01 6000 - Product Requirements.

2.03 CHILLED WATER PIPING, BURIED

2.04 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. Steel Pipe Sizes 12 Inch and Greater: ASTM A53/A53M, 3/8 inch wall, 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. Grooved Joints: AWWA C606 grooved pipe, fittings of same material, and mechanical couplings.
- C. Copper Tube: ASTM B88 (ASTM B88M), Type L (B), hard 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.
 - 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.
 - 2. Grooved Joints: AWWA C606 grooved tube, fittings of same material, and copper-tube-dimension mechanical couplings.
 - 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, nontoxic synthetic rubber sealing elements.
 - a. Manufacturers:
 - 1) Apollo Valves; _____: www.apollovalves.com/#sle.
 - 2) Grinnell Products; _____: www.grinnell.com/#sle.
 - 3) Viega LLC; _____: www.viega.us/#sle.

2.05 CONDENSER WATER PIPING, BURIED

2.06 CONDENSER WATER PIPING, ABOVE GRADE

- A. Steel Pipe: ASTM A53/A53M, Schedule 40, black.
 - 1. Welded Joints: ASTM A234/A234M, wrought steel welding type fittings with finish matching piping; AWS D1.1/D1.1M welded.
 - 2. Threaded Joints: ASME B16.3, malleable iron fittings with finish matching piping.
 - 3. Grooved Joints: AWWA C606 grooved pipe, fittings of same material, and mechanical couplings.
- B. Steel Pipe Sizes 12 Inch and Greater: ASTM A53/A53M, 3/8 inch wall, 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. Grooved Joints: AWWA C606 grooved pipe, fittings of same material, and mechanical couplings.
- C. 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.
 - 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.

2. Grooved Joints: AWWA C606 grooved tube, fittings of same material, and copper-tube-dimension mechanical couplings.
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, nontoxic synthetic rubber sealing elements.
 - a. Manufacturers:
 - 1) Apollo Valves; _____: www.apollovalves.com/#sle.
 - 2) Grinnell Products; _____: www.grinnell.com/#sle.
 - 3) Viega LLC; _____: www.viega.us/#sle.
- D. PVC Pipe: ASTM D1785, Schedule 40, or ASTM D2241, SDR 21 or 26.
 1. Fittings: ASTM D2466 or ASTM D2467, PVC.
 2. Joints: Solvent welded in accordance with ASTM D2855.
- E. PVC Pipe Sizes 8 Inch and Greater: ASTM D1785, Schedule 80, or ASTM D2241, SDR 21 or 26.
 1. Fittings: ASTM D2466 or ASTM D2467, PVC.
 2. Joints: Solvent welded in accordance with ASTM D2855.

2.07 RADIANT HEATING PIPING

- A. Copper Tube: ASTM B88 (ASTM B88M), Type L (B) annealed.
 1. Fittings: ASME B16.22, wrought copper.
 2. Joints: Braze, AWS A5.8M/A5.8 BCuP copper/silver alloy.

2.08 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.
- C. PVC Pipe: ASTM D1785, Schedule 40, or ASTM D2241, SDR 21 or 26.
 1. Fittings: ASTM D2466 or D2467, PVC.
 2. Joints: Solvent welded in accordance with ASTM D2855.

2.09 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.
 2. Hangers for Pipe Sizes 1/2 to 1-1/2 Inch: Malleable iron, adjustable swivel, split ring.
 3. Hangers for Cold Pipe Sizes 2 Inches and Greater: Carbon steel, adjustable, clevis.
 4. Hangers for Hot Pipe Sizes 2 to 4 Inches: Carbon steel, adjustable, clevis.
 5. Hangers for Hot Pipe Sizes 6 Inches and Greater: Adjustable steel yoke, cast iron roll, double hanger.
 6. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
 7. Multiple or Trapeze Hangers for Hot Pipe Sizes 6 Inches and Greater: Steel channels with welded spacers and hanger rods, cast iron roll.
 8. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
 9. Wall Support for Pipe Sizes 4 Inches and Greater: Welded steel bracket and wrought steel clamp.

10. Wall Support for Hot Pipe Sizes 6 Inches and Greater: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast iron roll.
 11. Vertical Support: Steel riser clamp.
 12. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 13. 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.
 14. Floor Support for Hot Pipe Sizes 6 Inches and Greater: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
 15. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
 16. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
 17. 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.
- B. 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.
- C. Rooftop Supports for Low-Slope Roofs: Steel pedestals with bases that rest on top of roofing membrane, not requiring any attachment to the roof structure and not penetrating the roofing assembly, with support fixtures as specified; and as follows:
1. Bases: High density polypropylene.
 2. Base Sizes: As required to distribute load sufficiently to prevent indentation of roofing assembly.
 3. Steel Components: Stainless steel, or carbon steel hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.
 4. Attachment/Support Fixtures: As recommended by manufacturer, same type as indicated for equivalent indoor hangers and supports; corrosion resistant material.
 5. Height: Provide minimum clearance of 6 inches under pipe to top of roofing.

2.10 UNIONS, FLANGES, MECHANICAL COUPLINGS, AND DIELECTRIC CONNECTIONS

- A. Unions for Pipe less than 2 Inches:
1. Ferrous Piping: 150 psig malleable iron, threaded.
 2. Copper Pipe: Bronze, soldered joints. Install so coils can be removed.
- 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. 1/8 inch preformed stainless steel core with non-asbestos compressible graphite sealing element.
 4. Manufacturer:
 - a. Garlock; Graphonic 304 Stainless - www.garlock.com
 - b. Substitutions: See Section 01 6000 - Product Requirements.
- 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.
 7. Manufacturers:
 - a. Apollo Valves; _____: www.apollovalves.com/#sle.

- b. Grinnell Products; _____: www.grinnell.com/#sle.
 - c. Victaulic Company; _____: www.victaulic.com/#sle.
 - d. Substitutions: See Section 01 6000 - Product Requirements.
- 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.

2.11 BALL VALVES

- A. Manufacturers:
 - 1. Apollo Valves; _____: www.apollovalves.com/#sle.
 - 2. Grinnell Products; _____: www.grinnell.com/#sle.
 - 3. Victaulic Company; _____: www.victaulic.com/#sle.
 - 4. Viega LLC; _____: www.viega.us/#sle.
 - 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Up To and Including 2 Inches:
 - 1. Bronze one piece body, stainless steel ball, teflon seats and stuffing box ring, lever handle with balancing stops, solder or threaded ends.
- C. Over 2 Inches:
 - 1. Ductile iron body, stainless steel ball, teflon or Virgin TFE seat and stuffing box seals, lever handle, gear operated, or motorized actuator, flanged ends, rated to 800 psi.

2.12 BUTTERFLY VALVES

- A. Manufacturers:
 - 1. Apollo Valves; _____: www.apollovalves.com/#sle.
 - 2. Grinnell Products; _____: www.grinnell.com/#sle.
 - 3. Victaulic Company; _____: www.victaulic.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Body: Cast or ductile iron with resilient replaceable EPDM seat, wafer, lug, grooved, or flanged ends, extended neck.
- C. Disc: Construct of aluminum bronze, chrome plated ductile iron, stainless steel, ductile iron with EPDM encapsulation, or Buna-N encapsulation
- D. Stem: Stainless steel with stem offset from the centerline to provide full 360 degree circumferential setting.
- E. Operator: 10 position lever handle.

2.13 SWING CHECK VALVES

- A. Manufacturers:
 - 1. Apollo Valves; _____: www.apollovalves.com/#sle.
 - 2. Grinnell Products, a Tyco Business: www.grinnell.com.

3. Shurjoint Piping Products, Inc., a Tyco Business: www.shurjoint.com.
 4. Hammond Valve: www.hammondvalve.com.
 5. Milwaukee Valve Company: www.milwaukeevalve.com.
 6. Nibco, Inc: www.nibco.com.
 7. Victaulic Company: www.victaulic.com.
 8. Substitutions: See Section 01 6000 - Product Requirements.
- B. Up To and Including 2 Inches:
1. Bronze body, bronze trim, bronze rotating swing disc, with composition disc, solder or threaded ends.
- C. Over 2 Inches:
1. Iron body, bronze trim, stainless steel, bronze, or bronze faced rotating swing disc, renewable disc and seat, flanged or grooved ends.

2.14 SPRING LOADED CHECK VALVES

- A. Manufacturers:
1. Crane Co.: www.craneco.com.
 2. Victaulic Company; _____: www.victaulic.com/#sle.
 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Iron body, bronze trim, split plate, hinged with stainless steel spring, resilient seal bonded to body, wafer or threaded lug ends.

2.15 PRESSURE INDEPENDENT TEMPERATURE CONTROL VALVES (NO P.I. BALANCING VALVES)

- A. Manufacturers:
1. Danfoss; AB-QM Valve: www.danfoss.com/#sle.
 2. Substitutions: See Section 01 6000 - Product Requirements.
- B. Control Valves: Factory-fabricated pressure independent with internal differential pressure regulator (DPRV) which automatically adjusts to normal changes in system pressure and provides 100 percent control valve authority at all positions of the valve.
1. Maintain proportional and linear flow coil characteristics.
 2. PICV to accurately control the flow from 0 to 100 percent full rated flow with an operating pressure differential range of 3 to 60 psig.
 3. Provide ANSI/FCI 70-2 Class 4 shut-off on all sizes and field serviceable.
 4. Provide control valve to incorporate control, balancing and flow limiting. Hydronic system pressure independent control valve bodies to comply with ASME B16.34 or ASME B16.15 pressure and temperature class ratings based on the design operating temperature and 150 percent of the system design operating pressure and have the following characteristics:
 - a. 2 NPS and Smaller: Class 150 bronze or brass body with union connections, stainless steel trim, stainless steel rising stem, stainless steel disc or ball, and screwed ends with backseating capacity repackable under pressure.
 - b. 2-1/2 NPS and Larger: Class 125 iron or ductile iron body, stainless steel trim, stainless steel rising stem, stainless steel disc or ball, flanged ends with backseating capacity repackable under pressure.
 - c. Pressure Control Seat: Brass construction with vulcanized EPDM.
 - d. Sizing: Line-size.
 - e. Fittings and Components: All fittings and components to meet ANSI standards and be compatible with readily available components. 8 inch valves and above to be provided with proper companion flanges.
 - f. Close-Off (Differential) Pressure Rating: Combination of actuator, DPRV action, and trim to provide a minimum close-off pressure rating of 150 percent of total system (pump) head. Provide actuator from the same manufacturer as the pressure independent control valve. (Belimo is preferred).

- C. Electronic Actuators: Direct-mounted, self-calibrating type designed for minimum 60,000 full-stroke cycles at rated force.
- D. Provide actuator with visible position indication. Fail positions on power failure to include in-place, open or closed as indicated in the controls specifications.
 - 1. Valves: Sized for maximum circuit flow rate and nominally, line-sized.
 - 2. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 - 3. Fail-Safe Operation: Mechanical, spring-return mechanism or capacitance return.
 - 4. Power Requirements (Two-Position Spring Return): 24 VAC.
 - 5. Power Requirements (Modulating): Maximum 10 VA at 24 VAC or 8 watts at 24 VDC.
 - 6. Proportional Signal: 0 to 10 VDC or 2 to 10 VDC or 4 to 20 mA, and 2 to 10 VDC position feedback signal.
 - 7. Provide plenum-rated actuators for service above ceilings to possess UL listings and approvals.
 - 8. Temperature Rating: 0 to 200 degrees F.

2.16 FLOW CONTROLS

- A. Manufacturers:
 - 1. Griswold Controls; _____: www.griswoldcontrols.com/#sle.
 - 2. ITT Bell & Gossett; _____: www.bellgossett.com/#sle.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Construction: Class 125, Brass or bronze body with union on inlet and outlet, temperature and pressure test plug on inlet and outlet, blowdown/backflush drain.
- C. Calibration: Control flow within 10 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, minimum pressure 2 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 2500 for additional requirements.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. PVC Pipe: Make solvent-welded joints in accordance with ASTM D2855.
- 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. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified.
- H. Slope piping and arrange to drain at low points.
- I. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to Section 22 0516.
- J. 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.
- K. Inserts:
1. Provide inserts for placement in concrete formwork.
 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- L. 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.
 9. Prime coat exposed steel hangers and supports. Refer to Section 09 9123. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
- M. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. Refer to Section 22 0719.
- N. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. Refer to Section 23 0719.
- O. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section 08 3100 .
- P. Use eccentric reducers to maintain top of pipe level.
- Q. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.
- R. Prepare unfinished pipe, fittings, supports, and accessories, ready for finish painting. Refer to Section 09 9123.
- S. Install valves with stems upright or horizontal, not inverted.
- T. Install takeoffs on top of the pipe being connected to.

END OF SECTION 23 2113

SECTION 23 2114 HYDRONIC SPECIALTIES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Compression tanks.
- B. Expansion tanks.
- C. Air vents.
- D. Air separators.
- E. Strainers.
- F. Side Stream Filtration
- G. Pump connectors.
- H. Combination pump discharge valves.
- I. Pressure-temperature test plugs.
- J. Balancing valves.
- K. Combination flow controls.
- L. Radiator valves.
- M. Relief valves.
- N. Pressure reducing valves.
- O. Glycol system.

1.02 RELATED REQUIREMENTS

- A. Section 22 1006 - Plumbing Piping Specialties: Backflow preventers.
- B. Section 23 2113 - Hydronic Piping.
- C. Section 23 2500 - HVAC Water Treatment: Pipe cleaning.

1.03 REFERENCE STANDARDS

- A. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250; 2010.
- B. ASME B16.5 - Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard; 2013.
- C. ASME B16.11 - Forged Fittings, Socket-welding and Threaded; 2011.
- D. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1 - Rules for Construction of Pressure Vessels; 2015.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination: Coordinate the installation of equipment with size, location and installation of service utilities.
- B. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.
- C. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.05 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. 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.
- C. Certificates: Inspection certificates for pressure vessels from authority having jurisdiction.

- D. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- E. Project Record Documents: Record actual locations of flow controls.
- F. Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.
- G. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 6000 - Product Requirements, for additional provisions.
 - 2. Extra Glycol Solution: One container, 55 gallon size.

1.06 QUALITY ASSURANCE

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

1.07 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 COMPRESSION TANKS

- A. Manufacturers:
 - 1. Amtrol Inc; _____: www.amtrol.com/#sle.
 - 2. ITT Bell & Gossett; _____: www.bellgossett.com/#sle.
- B. Construction: Closed, welded steel, tested, and stamped in accordance with ASME BPVC-VIII-1; cleaned, prime coated, and supplied with steel support saddles; with tappings for installation of accessories.
 - 1. Pressure rating: 100 psi.
- C. Gauge Glass Set: Brass compression stops, guard, and 3/4 inch red line glass, maximum 24 inches length, long enough to cover tank for 2 inches above bottom to 2 inches below top.
- D. Quick Connect Air Inlet:
 - 1. Compressed Air: 75 inches of 1/4 inch diameter braided reinforced air hose, air chuck, check valve, and shut-off valve on supply from control air compressor.
 - 2. Expansion Tank: Inlet tire check valve, manual air vent, tank drain, and pressure relief valve.
- E. Automatic Cold Water Fill Assembly: Pressure reducing valve, reduced pressure, double check back flow preventer, test cocks, strainer, vacuum breaker, and valved by-pass. Refer to Section 22 1006.
- F. Hot Water Heating System:
 - 1. Select expansion tank pressure relief valve at _____ psi maximum.
 - 2. Set pressure reducing valve at 5 psi.
- G. Chilled Water System:
 - 1. Select expansion tank pressure relief valve at _____ psi maximum.
 - 2. Set pressure reducing valve at 5 psi.

2.02 EXPANSION TANKS

- A. Manufacturers:
 - 1. Amtrol Inc; _____: www.amtrol.com/#sle.
 - 2. ITT Bell & Gossett; _____: www.bellgossett.com/#sle.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.

- B. Construction: Welded steel, tested and stamped in accordance with ASME BPVC-VIII-1; supplied with National Board Form U-1, rated for working pressure of 125 psi, with flexible EPDM diaphragm or bladder sealed into tank, and steel support stand.
- C. Accessories: Pressure gauge and air-charging fitting, tank drain; precharge to design pressure. design air pressure to be clearly labeled on the tank
- D. Automatic Cold Water Fill Assembly: Pressure reducing valve, reduced pressure double check back flow preventer, test cocks, strainer, vacuum breaker, and valved by-pass. Provide resettable water meter inline.

2.03 AIR VENTS

- A. Manufacturers:
 - 1. Armstrong International, Inc; _____: www.armstronginternational.com/#sle.
 - 2. ITT Bell & Gossett; _____: www.bellgossett.com/#sle.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Air Vent to be installed in locations where potential trapped air could be located.

2.04 AIR SEPARATORS

- A. Dip Tube Fitting (Where Not Provided By Boiler Manufacturer):
 - 1. Manufacturers:
 - a. ITT Bell & Gossett; _____: www.bellgossett.com/#sle.
 - b. Spirotherm, Inc.
 - 2. For 125 psi operating pressure; to prevent free air collected in boiler from rising into system.
- B. In-line Air Separators:
 - 1. Manufacturers:
 - a. Armstrong International, Inc; _____: www.armstronginternational.com/#sle.
 - b. ITT Bell & Gossett; _____: www.bellgossett.com/#sle.
 - c. Spirotherm, Inc.
 - d. Substitutions: See Section 01 6000 - Product Requirements.
 - 2. Cast iron for sizes 1-1/2 inch and smaller, or steel for sizes 2 inch and larger; tested and stamped in accordance with ASME BPVC-VIII-1; for 125 psi operating pressure.
- C. Centrifugal Air Separators/Strainers:
 - 1. Manufacturers:
 - a. Armstrong International, Inc; _____: www.armstronginternational.com/#sle.
 - b. ITT Bell & Gossett; _____: www.bellgossett.com/#sle.
 - c. Spirotherm, Inc
 - d. Substitutions: See Section 01 6000 - Product Requirements.
 - 2. Steel, tested and stamped in accordance with ASME BPVC-VIII-1; for 125 psi operating pressure, with integral bronze strainer, tangential inlet and outlet connections, and internal stainless steel air collector tube.
- D. Coalescing Air/Dirt Separators:
 - 1. Manufacturers:
 - a. Armstrong International, Inc; _____: www.armstronginternational.com/#sle.
 - b. ITT Bell & Gossett; _____: www.bellgossett.com/#sle.
 - c. Spirotherm, Inc; _____: www.spirotherm.com/#sle.
 - d. Substitutions: See Section 01 6000 - Product Requirements.
 - 2. Tank: Fabricated steel tank; tested and stamped in accordance with ASME BPVC-VIII-1; for 150 psi operating pressure and 270 degrees F maximum operating temperature; subject to the requirements of the application and the manufacturer's standard maximum operating conditions.

3. Coalescing Medium: Provide structured copper, stainless steel, or _____ medium filling the entire vessel to suppress turbulence and provide air elimination efficiency of 100 percent free air, 100 percent entrained air, and 99.6 percent dissolved air at the installed location.
4. Air Vent: Integral float actuated air vent at top fitting of tank rated at 150 psi, threaded to the top of the separator.
5. Inlet and Outlet Connections: Threaded for 2 NPS and smaller; Class 150 flanged connections for 2-1/2 NPS and larger.
6. Blowdown Connection: Threaded.
7. Size: Match system flow capacity.

2.05 STRAINERS

- A. Manufacturers:
 1. Armstrong International, Inc: www.armstronginternational.com.
 2. Grinnell Products, a Tyco Business: www.grinnell.com.
 3. Substitutions: See Section 01 6000 - Product Requirements.
- 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 1/16 inch or 3/64 inch stainless steel perforated screen.
- D. Size 5 inch and Larger:
 1. Provide flanged or grooved iron body for 175 psi working pressure, basket pattern with 1/8 inch stainless steel perforated screen.

2.06 SIDE STREAM FILTRATION

- A. Manufacturers:
 1. Shelco.
 2. Axiom.
 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Sized for 15% percent design flow rate.
- C. configured to allow chemical shock feed.
- D. Accessories: Adjustable foot support to elevate, blowdown tapping in bottom, gauge tapping in side. pipe to nearest floor drain.

2.07 PUMP CONNECTORS

- A. Manufacturers:
 1. The Metraflex Company; Vane Flex: www.metroflex.com/#sle.
 2. Substitutions: See Section 01 6000 - Product Requirements.
- B. Flexible Connectors: Flanged, braided type with wetted components of stainless steel, sized to match piping.
 1. Maximum Allowable Working Pressure: 150 psig at 120 degrees F.
 2. Accommodate the Following:
 - a. Axial Deflection in Compression and Expansion: _____ inch.
 - b. Lateral Movement: _____ inch.
 - c. Angular Rotation: 15 degrees.
 - d. Force developed by 1.5 times specified maximum allowable operating pressure.
 3. End Connections: Same as specified for pipe jointing.
 4. Provide pump connector with integral vanes to reduce turbulent flow.
 5. Provide necessary accessories including, but not limited to, swivel joints.

2.08 COMBINATION PUMP DISCHARGE VALVES

- A. Manufacturers:
 - 1. Crane Co.; _____: www.craneco.com/#sle.
 - 2. ITT Bell & Gossett; _____: www.bellgossett.com/#sle
 - 3. Victaulic Company of America; _____: www.victaulic.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- 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.

2.09 PRESSURE-TEMPERATURE TEST PLUGS

- A. Manufacturers:
 - 1. Ferguson Enterprises Inc; _____: www.fnw.com/#sle.
 - 2. Peterson Equipment Company Inc; _____: www.petesplug.com/#sle.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Construction: Brass body designed to receive temperature or pressure probe with removable protective cap, and Neoprene rated for minimum 200 degrees F.
- C. Application: Use extended length plugs to clear insulated piping.

2.10 BALANCING VALVES

- A. Manufacturers:
 - 1. Armstrong International, Inc; _____: www.armstronginternational.com/#sle.
 - 2. ITT Bell & Gossett; _____: www.bellgossett.com/#sle.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. 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, soldered, or grooved connections.
 - 2. Metal construction materials consist of bronze or brass.
 - 3. Non-metal construction materials consist of Teflon, EPDM, or engineered resin.
- C. Size 2.5 inch and Larger:
 - 1. Provide ball, globe, or butterfly style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and flanged, grooved, or weld end connections.
 - 2. Valve body construction materials consist of cast iron, carbon steel, or ductile iron.
 - 3. Internal components construction materials consist of brass, aluminum bronze, bronze, Teflon, EPDM, NORYL, or engineered resin.

2.11 COMBINATION FLOW CONTROLS

- A. Manufacturers:
 - 1. Armstrong International; _____: www.armstronginternational.com/#sle.
 - 2. ITT Bell & Gossett; _____: www.bellgossett.com/#sle.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- 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 10 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, minimum pressure 2 psi.
- D. Control Mechanism: Provide stainless steel or nickel plated brass piston or regulator cup, operating against stainless steel helical or wave formed spring or elastomeric diaphragm and polyphenylsulfone orifice plate.
 - 1. Accessories: In-line strainer on inlet and ball valve on outlet.

2.12 FLOW METERS

- A. Manufacturers:
 - 1. Dwyer Instruments, Inc; _____: www.dwyer-inst.com/#sle.
 - 2. Belimo

2.13 RADIATOR VALVES

- A. Manufacturers:
 - 1. Belimo
 - 2. ITT Bell & Gossett; _____: www.bellgossett.com/#sle.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Angle or straight pattern, rising stem, inside screw globe valve for 125 psi working pressure, with bronze body and integral union for screwed connections, renewable composition disc, plastic wheel handle for shut-off service, and lockshield key cap and set screw memory bonnet for balancing service.

2.14 RELIEF VALVES

- A. Manufacturers:
 - 1. Armstrong International, Inc; _____: www.armstronginternational.com/#sle.
 - 2. ITT Bell & Gossett; _____: www.bellgossett.com/#sle.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labelled.

2.15 PRESSURE REDUCING VALVES

- A. Manufacturers:
 - 1. Armstrong International, Inc; _____: www.armstronginternational.com/#sle.
 - 2. ITT Bell & Gossett; _____: www.bellgossett.com/#sle.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Operation: Automatically feeds make-up water to the hydronic system whenever pressure in the system drops below the pressure setting of the valve. Refer to Section 23 2113.
- C. Materials of Construction:
 - 1. Valve Body: Constructed of bronze, cast iron, brass, iron, or _____.
 - 2. Internal Components: Construct of stainless steel, brass, or _____ and engineered plastics, composition material, or _____.
- D. Connections:
 - 1. NPT threaded: 0.50 inch, 0.75 inch, or ____ inch.
 - 2. Soldered: 0.50 inch or ____ inch.
- E. Provide integral check valve and strainer.
- F. Maximum Inlet Pressure: 100 psi.
- G. Maximum Fluid Temperature: 180 degrees F.
- H. Operating Pressure Range: Between 10 psi and 25 psi.

2.16 PRESSURE INDEPENDENT VALVES

- A. Manufacturers:
 - 1. Griswold Controls LLC; PIC-V: www.griswoldcontrols.com/#sle.
 - 2. Belimo.
- B. Size 2 inch and Smaller:
 - 1. Provide ball, globe, or _____ style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and NPT threaded, soldered, or _____ connections.
 - 2. Metal construction materials consist of bronze, brass, or _____.

3. Non-metal construction materials consist of Teflon, EPDM, engineered resin, or _____.
- C. Size 2.5 inch and Larger:
1. Provide ball, globe, butterfly, or _____ style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and flanged, grooved, weld end, or _____ connections.
 2. Valve body construction materials consist of cast iron, carbon steel, ductile iron, or _____.
 3. Internal components construction materials consist of brass, aluminum bronze, bronze, Teflon, EPDM, NORYL, engineered resin, or _____.

2.17 AUTOMATIC FLOW LIMITING VALVES

- A. Manufacturers:
1. Griswold Controls LLC; Isolator R Valve: www.griswoldcontrols.com/#sle.
 2. Hays Fluid Controls; _____: www.haysfluidcontrols.com/#sle.
 3. Belimo.
 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Size 0.50 inch to 14 inch:
1. Provide ball, globe, or _____ style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and NPT threaded, soldered, or _____ connections.
 2. Metal construction materials consist of bronze, brass, or _____.
 3. Non-metal construction materials consist of Teflon, EPDM, engineered resin, or _____.
- C. Size 2.5 inch to 24 inch:
1. Provide ball, globe, butterfly, wafer, or _____ style with flow balancing, flow measurement, and shut-off capabilities, memory stops, minimum of two metering ports and flanged, grooved, weld end, or _____ connections.
 2. Valve body construction materials consist of cast iron, carbon steel, ductile iron, gray iron, or _____.
 3. Internal components construction materials consist of brass, aluminum bronze, bronze, Teflon, EPDM, NORYL, engineered resin, or _____.

2.18 GLYCOL FILL SYSTEM

- A. Manufacturers:
1. Wessels Company
 2. Axiom.
- B. Mixing Tank: 55 gallon steel drum with fittings suitable for filling and hand pump for charging, rubber hose for connection of hand pump to system.
- C. Storage Tank: Closed type, welded steel constructed, tested and stamped in accordance with ASME BPVC-VIII-1; 100 psi rating; cleaned, prime coated, and supplied with steel support saddles. Construct with tappings for installation of accessories.
- D. Expansion Tank: Diaphragm type with vent fitting with air separator, and automatic air vent.
- E. Air Pressure Reducing Station: Pressure reducing valve with shut-off valves, strainer, check valve and needle valve bypass.
- F. Glycol Solution:
1. Inhibited propylene glycol and water solution mixed 50 percent glycol for snowmelt or 30 percent for all other.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install specialties in accordance with manufacturer's instructions.

- B. Where large air quantities can accumulate, provide enlarged air collection standpipes.
- C. Provide manual air vents at system high points and as indicated.
- D. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.
- E. Provide air separator on suction side of system circulation pump and connect to expansion tank.
- F. Provide valved drain and hose connection on strainer blow down connection.
- G. Provide pump suction fitting on suction side of base mounted centrifugal pumps where indicated. Remove temporary strainers after cleaning systems.
- H. Provide combination pump triple duty discharge valve on discharge side of base mounted centrifugal pumps where indicated.
- I. Support pump fittings with floor mounted pipe and flange supports.
- J. Provide radiator valves on water inlet to terminal heating units such as radiation, unit heaters, and fan coil units.
- K. Provide radiator balancing valves on water outlet from terminal heating units such as radiation, unit heaters, and fan coil units.
- L. Provide relief valves on pressure tanks, low pressure side of reducing valves, heat exchangers, and expansion tanks.
- M. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.
- N. Pipe relief valve outlet to nearest floor drain.
- O. Clean and flush glycol system before adding glycol solution. Refer to Section 23 2500.
- P. Feed glycol solution to system through make-up line with pressure regulator, venting system high points.
- Q. Perform tests determining strength of glycol and water solution and submit written test results.
- R. record and label system total volume capacity

END OF SECTION 23 2114

SECTION 23 2123 HYDRONIC PUMPS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. System lubricated circulators.
- B. In-line circulators.
- C. Vertical in-line pumps.
- D. Close-coupled pumps.
- E. Base-mounted pumps.
- F. Dual drive pumping system.

1.02 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete.
- B. Section 22 0513 - Common Motor Requirements for Plumbing Equipment.
- C. Section 22 0548 - Vibration and Seismic Controls for Plumbing Piping and Equipment.
- D. Section 22 0716 - Plumbing Equipment Insulation.
- E. Section 22 0719 - Plumbing Piping Insulation.
- F. Section 23 0513 - Common Motor Requirements for HVAC Equipment.
- G. Section 23 0548 - Vibration and Seismic Controls for HVAC.
- H. Section 23 0716 - HVAC Equipment Insulation.
- I. Section 23 0719 - HVAC Piping Insulation.
- J. Section 23 2113 - Hydronic Piping.
- K. Section 23 2114 - Hydronic Specialties.
- L. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. NEMA MG 00001 - Motors and Generators; 2024.
- B. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports; 2013.
- C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D. UL 778 - Standard for Motor-Operated Water Pumps; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 01 3000 - 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. startup procedure must include factory authorized tech verification of base mounted pumps alignment.
- D. Manufacturer's Installation Instructions: Indicate hanging and support requirements and recommendations.
- E. Operation and Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.
- F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 6000 - 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.
- B. Hospitals and critical applications shall be designed with 100% redundancy.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Armstrong Fluid Technology, Inc; _____: www.armstrongfluidtechnology.com/#sle.
- B. Bell & Gossett, a Xylem Inc. brand; _____: www.bellgossett.com/#sle.
- C. Wilo Pumps
- D. Substitutions: See Section 01 6000 - Product Requirements.

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. Provide TEFL type motors suitable to application and temperature ranges.
- B. Minimum Quality Standard: UL 778.
- C. Base Mounted Pumps: Aligned by qualified millwright.
- D. 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 SYSTEM LUBRICATED CIRCULATORS

- A. Type: Horizontal shaft, single stage, direct connected with multiple speed wet rotor motor for in-line mounting, for 140 psi maximum working pressure, 230 degrees F maximum water temperature.
- B. Casing: Cast iron with flanged pump connections.
- C. Impeller, Shaft, Rotor: Stainless Steel.
- D. Bearings: Metal Impregnated carbon (graphite) and ceramic.
- E. Motor: Impedance protected, multiple speed, with external speed selector.

2.04 IN-LINE CIRCULATORS

- A. Type: Horizontal shaft, single stage, direct connected, with resiliently mounted motor for in-line mounting, oil lubricated, for 125 psi maximum working pressure.
- B. Casing: Cast iron, with flanged pump connections.
- C. Impeller: premium suitable material keyed to shaft.
- D. Bearings: Oil-lubricated bronze sleeve.
- E. Shaft: Alloy steel with bronze sleeve, integral thrust collar.
- F. Seal: Mechanical seal, 225 degrees F maximum continuous operating temperature.
- G. Drive: Flexible coupling.

2.05 VERTICAL IN-LINE PUMPS

- A. Type: Vertical, single stage, close coupled, radially or horizontally split casing, for in-line mounting, for 175 psi working pressure.
- B. Casing: Cast iron, with suction and discharge gauge port, casing wear ring, seal flush connection, drain plug, flanged suction and discharge.
- C. Impeller: Bronze, fully enclosed, keyed directly to motor shaft or extension.
- D. Shaft: Carbon steel with stainless steel impeller cap screw or nut and bronze sleeve.

- E. Seal: Mechanical seal, 225 degrees F maximum continuous operating temperature.

2.06 CLOSE COUPLED PUMPS

- A. Type: Horizontal shaft, single stage, close coupled, radially split casing, for 125 psi maximum working pressure.
- B. Casing: Cast iron, with suction and discharge gauge ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.
- C. Impeller: Bronze, fully enclosed, keyed to motor shaft extension.
- D. Shaft: Stainless steel.
- E. Seal: Mechanical seal, 225 degrees F maximum continuous operating temperature.
- F. Seal: Packing gland with minimum four rings graphite impregnated packing and bronze lantern rings, 230 degrees F maximum continuous operating temperature.

2.07 BASE-MOUNTED PUMPS

- A. Type: Horizontal shaft, single stage, direct connected, radially or horizontally split casing, for 125 psi maximum working pressure.
- B. Casing: Cast iron, or ductile iron with suction and discharge gauge ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.
- C. Impeller: Bronze, fully enclosed, keyed to shaft.
- D. Bearings: Oil lubricated roller or ball bearings.
- E. Shaft: Alloy steel with copper, bronze, or stainless steel shaft sleeve.
- F. Seal: Mechanical seal, 225 degrees F maximum continuous operating temperature.
- G. Seal: Packing gland with minimum four rings graphite impregnated packing and bronze lantern rings, 250 degrees F maximum continuous operating temperature.
- H. Drive: Flexible coupling with coupling guard.
- I. Baseplate: Cast iron or fabricated steel with integral drain rim.
- J. Manufacturers:
 - 1. Armstrong Fluid Technology, Inc; Design Envelope 4200H: www.armstrongfluidtechnology.com/#sle.
 - 2. Bell & Gossett, a Xylem Inc. brand; []: www.bellgossett.com/#sle.
 - 3. Wilo.

2.08 IN-LINE WET ROTOR VARIABLE SPEED ECM CIRCULATORS

- A. Type: Factory-assembled and tested, self-regulating, in line wet rotor type circulator pump, with synchronous, permanent-magnet type motor and integrated variable speed electronically commutated motor.
- B. Construction Features:
 - 1. Single phase, 120 VAC or 208-230 VAC as scheduled, 60 Hz.
 - 2. Pump Shaft: Stainless steel.
 - 3. Bearings. Metal impregnated carbon sleeve or ball bearing type.
 - 4. Connection Style: Flanged
 - 5. Rating: 145 psig at 230 F
- C. Domestic Hot Water: Lead free bronze, glass-filled polypropylene engineered composite or stainless steel impeller; lead free bronze or stainless steel body.
- D. C. Hydronic Systems: cast iron, glass-filled polypropylene engineered composite, or stainless steel impeller. System-lubricated, cast iron body.

- E. D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application. UL 778 listed for motor-operated water pumps, including protection against over/under voltage, thermal over-load (motor and electronics), over current, and protection for locked rotor and dry run/no-load condition.
- F. E. Terminal Box to include gasketed cover, NPT power cable/conduit connection, with coded terminal strip indicating common/neutral/ground.
- G. Acceptable Manufacturers:
 - 1. ITT Bell & Gossett.
 - 2. Wilo.
 - 3. Grundfos.
- H.

PART 3 EXECUTION

3.01 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. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For close-coupled or base-mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4 inches and over.
- D. Provide line sized shut-off valve and strainer on pump suction, and line sized soft seat check valve and balancing valve on pump discharge.
- E. Provide air cock and drain connection on horizontal pump casings.
- F. Provide drains for bases and seals, piped to and discharging into floor drains.
- G. Check, align, and certify alignment of base-mounted pumps prior to start-up.
- H. Install close-coupled and base-mounted pumps on concrete housekeeping base, with anchor bolts, set and level, and grout in place. Refer to Section 03 3000.
- I. Lubricate pumps before start-up.
- J. Provide side-stream filtration system for closed loop systems. Install across pump with flow from pump discharge to pump suction from pump tapings.
- K. Inertia bases must be incorporated in design as required per ASHRAE Guidelines.
- L. Pump utilizing motor mounted LCD display must be installed with the display visible and electrical code service clearance met.
- M. When suction diffusers are used, shall include start up screen and general operation screen with appropriate mesh size for a
- N. 5 HP and above Pump controls must include Bacnet integration to BMS. consult with facilities engineering on application.
- O. All pumps performance must be verified through test and balance with a report.

END OF SECTION 23 2123

SECTION 23 2213
STEAM AND CONDENSATE HEATING PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pipe and pipe fittings.
- B. Pipe hangers and supports.
- C. Steam piping system.
- D. Steam condensate piping system.

1.02 RELATED REQUIREMENTS

- A. Section 07 8400 - Firestopping.
- B. Section 08 3100 - Access Doors and Panels.
- C. Section 09 9123 - Interior Painting.
- D. Section 22 0548 - Vibration and Seismic Controls for Plumbing Piping and Equipment.
- E. Section 22 0553 - Identification for Plumbing Piping and Equipment.
- F. Section 22 0719 - Plumbing Piping Insulation.
- G. Section 23 0523 - General-Duty Valves for HVAC Piping.
- H. Section 23 0548 - Vibration and Seismic Controls for HVAC.
- I. Section 23 0553 - Identification for HVAC Piping and Equipment.
- J. Section 23 0719 - HVAC Piping Insulation.
- K. Section 23 2214 - Steam and Condensate Heating Specialties.
- L. Section 23 2500 - HVAC Water Treatment: Pipe cleaning.

1.03 REFERENCE STANDARDS

- A. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300; 2011.
- 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 B31.1 - Power Piping; 2014.
- E. ASME B31.9 - Building Services Piping; 2014.
- F. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Welding, Brazing, and Fusing Qualifications; 2015.
- G. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2012.
- H. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.
- I. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2015.
- J. ASTM B32 - Standard Specification for Solder Metal; 2008 (Reapproved 2014).
- K. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2014.
- L. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric); 2013.
- M. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers; 2024.
- N. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding; 2011-AMD 1.
- O. AWS D1.1/D1.1M - Structural Welding Code - Steel; 2015.

- P. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2009.

1.04 SYSTEM DESCRIPTION

- A. When more than one piping system material is selected, ensure systems components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, unions, and couplings for servicing are consistently provided.
- B. Use unions and flanges downstream of valves and at equipment or apparatus connections. Use dielectric unions where joining dissimilar materials. Do not use direct welded or threaded connections.
- C. Provide pipe hangers and supports in accordance with ASME B31.9 or MSS SP-58 unless indicated otherwise.
- D. Use gate valves for shut-off and to isolate equipment, part of systems, or vertical risers.
- E. Use globe valves for throttling, bypass, or manual flow control services.

1.05 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Welders Certificate: Include welders certification of compliance with ASME BPVC-IX.
- C. Manufacturer's Installation Instructions: Indicate hanging and support methods, joining procedures.
- D. Project Record Documents: Record actual locations of valves.
- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 6000 - Product Requirements, for additional provisions.
 - 2. Valve Repacking Kits: One for each type and size of valve.

1.06 QUALITY ASSURANCE

- A. Welder Qualifications: Certified in accordance with ASME BPVC-IX.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. 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 REGULATORY REQUIREMENTS

- A. Comply with ASME B31.9 and ASME B31.1 code for installation of piping system.
- B. Welding Materials and Procedures: Comply with ASME BPVC-IX and applicable state labor regulations.

2.02 MEDIUM AND HIGH PRESSURE STEAM PIPING (150 PSIG MAXIMUM)

- A. Steel Pipe: ASTM A53/A53M, Schedule 80, black.
 - 1. Fittings: ASME B16.3 malleable iron Class 150, or ASTM A234/A234M wrought steel welding type.
 - 2. Joints: Threaded up to 2", or AWS D1.1/D1.1M welded for size 2" and above.
- B. Steel Pipe Sizes 16 Inch and Over: ASTM A53/A53M, black.
 - 1. Fittings: ASTM A234/A234M wrought steel welding type.
 - 2. Joints: Welded in accordance with AWS D1.1/D1.1M.

2.03 LOW PRESSURE STEAM PIPING (15 PSIG MAXIMUM)

- A. Steel Pipe: ASTM A53/A53M, Schedule 80, black.
 - 1. Fittings: ASME B16.3 malleable iron Class 150, or ASTM A234/A234M wrought steel.
 - 2. Joints: Threaded up to 2", or AWS D1.1/D1.1M welded for size 2" and above.
- B. Steel Pipe Sizes 12 Inch and Over: ASTM A53/A53M wall, black.

1. Fittings: ASTM A234/A234M wrought steel.
2. Joints: Welded in accordance with AWS D1.1/D1.1M.

2.04 MEDIUM AND HIGH PRESSURE STEAM CONDENSATE PIPING

- A. Steel Pipe: ASTM A53/A53M, Schedule 80, black.
 1. Fittings: ASME B16.3 malleable iron Class 150 or ASTM A234/A234M wrought steel.
 2. Joints: Threaded up to 2", or AWS D1.1/D1.1M welded for size 2" and above.
- B. Steel Pipe Sizes 12 Inch and Over: ASTM A53/A53M, wall, black.
 1. Fittings: ASTM A234/A234M wrought steel.
 2. Joints: Welded in accordance with AWS D1.1/D1.1M.

2.05 LOW PRESSURE STEAM CONDENSATE PIPING

- A. Steel Pipe: ASTM A53/A53M, Schedule 80, black.
 1. Fittings: ASME B16.3 malleable iron Class 150, or ASTM A234/A234M wrought steel.
 2. Joints: Threaded up to 2", or AWS D1.1/D1.1M welded for size 2" and above.
- B. Steel Pipe Sizes 12 Inch and Over: ASTM A53/A53M, wall, black.
 1. Fittings: ASTM A234/A234M wrought steel.
 2. Joints: Welded in accordance with AWS D1.1/D1.1M.

2.06 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 2 to 4 Inches: Carbon steel, adjustable, clevis.
- C. Hangers for Pipe Sizes 6 Inches and Over: Adjustable steel yoke, cast iron roll, double hanger.
- D. Multiple or Trapeze Hangers for Pipe Sizes to 4 inches: Steel channels with welded spacers and hanger rods.
- E. Multiple or Trapeze Hangers for Pipe Sizes 6 Inches and Over: Steel channels with welded spacers and hanger rods; cast iron roll and stand.
- F. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
- G. Wall Support for Pipe Sizes 4 to 5 Inches: Welded steel bracket and wrought steel clamp.
- H. Wall Support for Pipe Sizes 6 Inches and Over: Welded steel bracket and wrought steel clamp; adjustable steel yoke and cast iron roll.
- I. Vertical Support: Steel riser clamp.
- J. Floor Support for Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- K. Floor Support for Pipe Sizes 6 Inches and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
- L. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
- M. 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.

2.07 UNIONS, FLANGES, COUPLINGS AND GASKETS

- A. Unions for Pipe 1-1/4 Inches and Under:
 1. Ferrous Piping: 150 psig malleable iron, threaded.
- B. Flanges for Pipe Over 1-1/4 Inches
 1. Ferrous Piping: 150 psig forged steel, slip-on.

- C. Dielectric Connections: Shall be made with the use of brass fittings (union, valve, flange or coupling) or other non-conductive connections (final approval by owner) whenever joining dissimilar metals. A valve shall be placed upstream of any connection involving a union or flange. Dielectric unions shall not be used and shall be replaced with any of the before mentioned connections if encountered during repair or retrofit work..
- D. Gaskets: 1/8 inch thick preformed stainless steel core with non-asbestos compressible graphite sealing element:
 - 1. Manufacturer: Garlock; Graphonic 304 Stainless: www.garlock.com
 - 2. Substitutions: See Section 01 1600 - Product Requirements.

PART 3 EXECUTION

3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.
- D. Keep open ends of pipe free from scale and dirt. Whenever work is suspended during construction protect open ends with temporary plugs or caps.
- E. After completion, fill, clean, and treat systems. Refer to Section 23 2500.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Route piping in orderly manner, plumb and parallel to building structure, and maintain gradient.
- C. Install piping to conserve building space and avoid interference with use of space.
- D. Sleeve pipe passing through partitions, walls, and floors.
- E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- F. Inserts:
 - 1. Provide inserts for placement in concrete formwork.
 - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
 - 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 - 5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- G. Pipe Hangers and Supports:
 - 1. Install in accordance with ASME B31.9.
 - 2. Support horizontal piping as indicated.
 - 3. Place hangers within 12 inches of each horizontal elbow.
 - 4. Use hangers with 1-1/2 inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
 - 5. Support vertical piping at every floor. Support riser piping independently of connected horizontal piping.
 - 6. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 - 7. Provide copper plated hangers and supports for copper piping.
 - 8. Prime coat exposed steel hangers and supports. Refer to Section 09 9123. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
- H. Provide clearance for installation of insulation and access to valves and fittings.

- I. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Section 08 3100.
- J. Slope steam piping one inch in 40 feet in direction of flow. Use eccentric reducers to maintain bottom of pipe level.
- K. Slope steam condensate piping one inch in 40 feet. Provide drip trap assembly at low points and before control valves. Run condensate lines from trap to nearest condensate receiver. Provide loop vents over trapped sections.
- L. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.
- M. Prepare unfinished pipe, fittings, supports, and accessories ready for finish painting. Refer to Section 09 9123.
- N. Install valves with stems upright or horizontal, not inverted.

3.03 SCHEDULES

- A. Hanger Spacing for Steel Steam Piping per local and state codes
- B. Hanger Spacing for Steel Steam Condensate Piping per local and state codes

END OF SECTION 23 2213

SECTION 23 2214
STEAM AND CONDENSATE HEATING SPECIALTIES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Steam traps.
- B. Steam air vents.
- C. Flash tanks.
- D. Deaerators.
- E. Boiler feed units.
- F. Condensate return units.
- G. Receivers.
- H. Condensate pumps.
- I. Pressure reducing valves.
- J. Steam safety valves.

1.02 RELATED REQUIREMENTS

- A. Section 22 0513 - Common Motor Requirements for Plumbing Equipment: Pump motors.
- B. Section 22 0716 - Plumbing Equipment Insulation.
- C. Section 22 0719 - Plumbing Piping Insulation.
- D. Section 23 0513 - Common Motor Requirements for HVAC Equipment: Pump motors.
- E. Section 23 0716 - HVAC Equipment Insulation.
- F. Section 23 0719 - HVAC Piping Insulation.
- G. Section 23 2213 - Steam and Condensate Heating Piping.
- H. Section 23 5213 - Electric Boilers.
- I. Section 23 5223 - Cast-Iron Boilers.
- J. Section 23 5233.16 - Steel Water-Tube Boilers.
- K. Section 23 5239.13 - Scotch Marine Boilers.
- L. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1 - Rules for Construction of Pressure Vessels; 2015.
- B. ASME B31.9 - Building Services Piping; 2014.
- C. ASTM A105/A105M - Standard Specification for Carbon Steel Forgings for Piping Applications; 2013.
- D. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings; 2004 (Reapproved 2014).
- E. ASTM A216/A216M - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service; 2012.
- F. ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures; 1999 (Reapproved 2014).
- G. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.

- B. Product Data:
 1. Provide for manufactured products and assemblies required for this project.
 2. Include product description, model, dimensions, component sizes, rough-in requirements, service sizes, and finishes.
 3. Submit schedule indicating manufacturer, model number, size, location, rated capacity, load served, and features for each specialty.
 4. Include electrical characteristics and connection requirements.
- C. Manufacturer's Installation Instructions: Indicate application, selection, and hookup configuration. Include pipe and accessory elevations.
- D. Operation and Maintenance Data: Include installation instructions, servicing requirements, and recommended spare parts lists.

1.05 QUALITY ASSURANCE

- A. Perform Work in accordance with State of Michigan standard for installation of boilers and pressure vessels.
- B. Manufacturer Qualifications: Company specializing in manufacturing the types of products specified in this section, with minimum three years of documented experience.
- C. Products Requiring Electrical Connection: Listed and classified by UL as suitable for the purpose indicated.

1.06 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 STEAM TRAPS

- A. Manufacturers:
 1. Armstrong International, Inc; _____: www.armstronginternational.com/#sle.
 2. Spirax-Sarco; _____: www.spiraxsarco.com/us/#sle.
- B. Steam Trap Applications:
 1. Use Thermostatic Steam Traps for:
 - a. Steam radiation units.
 - b. Convectors.
 - c. Unit ventilators.
 - d. Other similar terminal heating units.
 2. Use Float and Thermostatic Traps for:
 - a. Unit heaters.
 - b. Converters.
 - c. Heating coils
 - d. Steam separators.
 - e. Flash tanks.
 - f. Process equipment.
 3. Use Inverted Bucket Steam Traps for:
 - a. Main headers.
 - b. Branch lines.
 - c. Steam jacketed equipment.
 - d. Direct steam injected equipment.
 - e. Deaerators.
- C. Steam Trap Performance:

1. Select to handle minimum of two times maximum condensate load of apparatus served.
2. Pressure Differentials:
 - a. Low Pressure Systems (15 psi maximum): 2 psi.
 - b. Medium Pressure Steam (60 psi maximum): 15 psi.
 - c. High Pressure Steam (150 psi maximum): 40 psi.
- D. Inverted Bucket Traps: ASTM A126 cast iron or semi-steel body with bolted cover, brass bucket, stainless steel seats and plungers, and stainless steel lever mechanism with knife edge operating surfaces.
 1. Rating: 60 psi WSP.
 2. Features: Access to internal parts without disturbing piping, top test plug, bottom drain plugs.
 3. Accessories:
 - a. Integral inlet strainer of brass.
 - b. Integral inlet check valve.
 - c. Integral bimetal air vent.
- E. Float and Thermostatic Traps: ASTM A126 cast iron or semi-steel body and bolted cover, stainless steel or bronze bellows type air vent, stainless steel or copper float, stainless steel lever and valve assembly.
 1. Rating: 15 psi WSP.
 2. Features: Access to internal parts without disturbing piping, bottom drain plug.
 3. Accessories: Gauge glass with shut-off cocks.
- F. Thermodynamic Traps: Stainless steel body, disc, and cap.
 1. Rating: 300 psi WSP.
 2. Features:
 - a. Stainless steel insulating cap.
 - b. 1/4 inch steel blow down valve.
 - c. Integral strainer.
- G. Pressure Balanced Thermostatic Traps: ASTM A395/A395M cast iron body and bolted or screwed cover and integral ball joint union for 125 psi WSP; phosphor bronze bellows, stainless steel valve and seat, integral stainless steel strainer.

2.02 STEAM AIR VENTS

- A. Manufacturers:
 1. Armstrong International, Inc; _____: www.armstronginternational.com/#sle.
 2. Bell and Gossett, a xylem brand; _____: www.bellgossett.com/#sle.
 3. Spirax-Sarco; _____: www.spiraxsarco.com/us/#sle.
 4. Substitutions: See Section 01 6000 - Product Requirements.

2.03 FLASH TANKS

- A. Manufacturers:
 1. Armstrong International Inc; _____: www.armstronginternational.com/#sle.
 2. Penn Separator Corporation; _____: www.pennseparator.com/#sle.
 3. Wessels Company; _____: www.westank.com/#sle.
 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Tank: Closed type, welded steel construction, cleaned, prime coated, and supplied with steel support legs.
 1. Tested and stamped in accordance with ASME BPVC-VIII-1.
 2. Working Pressure: 100 psi.
 3. Construct with nozzles and tapings for installation of accessories and piping connections.

2.04 DEAERATORS

- A. Manufacturers:
 1. Bryan Steam Corporation; _____: www.bryanboilers.com/#sle.

2. Cleaver-Brooks; _____: www.cleaver-brooks.com/#sle.
 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Deaerator System: Consists of storage tank, surge tank, boiler feed pumps, transfer pumps, float switches, control panel and accessories.
- C. Deaerator Storage Tank:
1. Horizontal welded steel, ASME BPVC-VIII-1 stamped construction.
 2. Working Pressure: 50 psi.
 3. Manhole: 11 by 15 inch.
 4. Base: Elevated, fabricated steel.
- D. Storage Tank Accessories:
1. Steam pressure reducing valve.
 2. Water level gauge glass.
 3. Manual and automatic vent valves.
 4. Pressure relief valve.
 5. Thermometer.
 6. Pressure gauge.
 7. Overflow drain.
 8. Manual drain valve.
 9. Pressure gauges on pump discharge.
 10. Bronze isolation valves and strainers between boiler feed pumps and tanks.
 11. Double pole high and low level alarm float switches.
- E. Surge Tank: Horizontal welded steel.
1. ASME BPVC-VIII-1 stamped construction.
 2. Working Pressure: 50 psi.
 3. Manhole: 11 by 15 inch.
 4. Base: Elevated, fabricated steel.
- F. Surge Tank Accessories:
1. Water level gauge glass.
 2. Pressure relief valve.
 3. Thermometer.
 4. Pressure gauge.
 5. Inlet diffuser.
 6. Overflow drain.
 7. Manual drain valve.
 8. Pressure gauges on pump discharge.
 9. Bronze isolation valves and strainers between transfer pumps and tank.
 10. Double pole low level alarm float switch.
- G. Boiler Feed Pumps: One stage, vertical design, bronze fitted with stainless steel shaft, bronze impeller, renewable bronze case ring, mechanical shaft seal, close coupled to 3500 rpm motor.
- H. Transfer Pumps: Vertical design, bronze fitted with stainless steel shaft, enclosed bronze impeller, renewable bronze case ring, mechanical shaft seal, close coupled to motor.
- I. Control Cabinet:
1. NEMA EN 10250 enclosure, UL listed, with piano hinged door, grounding lug terminal strip and fusible control circuit transformer.
 2. Combination magnetic starters with overload relays, circuit breakers and cover interlock.
 3. Electric alternator, 'Auto-Off' switch.
 4. Selector 'lead-off-lag' switches.
 5. Alarm lights, acknowledge button, test buttons, alarm horn.
 6. All controls to be integrated to the corporate building automation with
- J. Control Sequence:

2.05 LOW PRESSURE BOILER FEED UNITS

- A. Manufacturers:
 - 1. Bryan Steam Corporation; _____: www.bryanboilers.com/#sle.
 - 2. Cleaver-Brooks; _____: www.cleaver-brooks.com/#sle.
 - 3. Marshall Engineered Products Company; _____: www.mepcollc.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Boiler Feed Units: Consist of receiver, inlet strainer, pumps, water make-up assembly, electric control components and accessories.
- C. Condensate Receiver: Cast iron, equipped with water level gauge, dial thermometer, pressure gauges on pump discharge, bronze isolation valves and strainer between pumps and receiver, and lifter eye bolts.
- D. Inlet Strainer: Cast iron, with vertical self-cleaning easily removable bronze screen and large dirt pocket, mounted on receiver.
- E. Water Make-Up Assembly: Level control switch and solenoid valve mounted on receiver.
 - 1. Valve: Packless, piston pilot operated type with cushioned closing and epoxy resin molded waterproof coil.
 - 2. Capacity: Equal to one boiler feed pump.
 - 3. With strainer, and manual bypass.
- F. Pumps: Vertical design, bronze fitted with stainless steel shaft, enclosed bronze impeller, renewable bronze case ring, mechanical shaft seal, close coupled to motor.

2.06 HIGH PRESSURE BOILER FEED UNITS

- A. Manufacturers:
 - 1. Bryan Steam Corporation; _____: www.bryanboilers.com/#sle.
 - 2. Cleaver-Brooks; _____: www.cleaver-brooks.com/#sle.
 - 3. Marshall Engineered Products Company; _____: www.mepcollc.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Boiler Feed Units: Consist of receiver, inlet strainer, pumps, water make-up assembly, electric controls and NEMA EN 10250 control cabinet, and accessories.
- C. Condensate Receiver: Horizontal welded steel construction with cradles, inlet cascade baffle and dished heads.
- D. Inlet Strainer: With self-cleaning bronze screen and large dirt pocket on receiver. Screen shall be vertically removable for cleaning.
- E. Water Make-up Assembly: Level control switch and solenoid valve mounted on receiver.
 - 1. Valve: Packless, piston pilot operated type with cushioned closing and epoxy resin molded waterproof coil.
 - 2. Capacity: Equal to one boiler feed pump.
 - 3. Provide with strainer and manual bypass.
- F. Accessories:
 - 1. Water level gauge.
 - 2. Dial thermometer.
 - 3. Low water cut-off switch.
 - 4. Pressure gauges on pump discharge.
 - 5. Bronze isolation valves and strainer between pumps and receiver.
 - 6. chemical injection Quils
- G. Pumps: One stage, vertical design, bronze fitted with stainless steel shaft, bronze impeller, renewable bronze case ring, mechanical shaft seal, close coupled to 3500 rpm motor.

2.07 LOW PRESSURE CONDENSATE RETURN UNITS

- A. Manufacturers:

1. Bell and Gossett
 2. Hoffman
 3. Spirax-Sarco; _____: www.spiraxsarco.com/us/#sle.
 4. Armstrong.
 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Condensate Return Units: Consist of receiver, inlet strainer, pumps, float switches, control panel and accessories.
- C. Condensate Receiver: Cast iron, equipped with externally adjustable float switches, water level gauge, dial thermometer, pressure gauges on pump discharge, bronze isolation valves between pumps and receiver, and lifting eye bolts.
- D. Inlet Strainer: Cast iron with vertical self-cleaning bronze screen and large dirt pocket, mounted on receiver. Screen shall be easily removable for cleaning.
- E. Pumps: One stage, vertical design, bronze fitted with stainless steel shaft, bronze impeller, renewable bronze case ring, mechanical shaft seal, close coupled to 1750 rpm motor.
- F. Control Cabinet:
1. NEMA EN 10250 enclosure, UL listed, with piano hinged door, grounding lug, terminal strip, and fusible control circuit transformer.
 2. Combination magnetic starters with overload relays, circuit breakers and cover interlock.
 3. Electric alternator.
 - a. Operate pumps on high level, alternating after each cycle.
 - b. Operate second pump upon failure of first pump and alarm.
 4. 'Auto-Off' switch.
 5. Test button, high level alarm light, acknowledge button, alarm horn.

2.08 HIGH PRESSURE CONDENSATE RETURN UNITS

- A. Manufacturers:
1. Bell and Gossett
 2. Hoffman
 3. Spirax-Sarco; _____: www.spiraxsarco.com/us/#sle.
 4. Armstrong.
 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Condensate Return Units: Consist of receiver, pumps, float switches, control panel and accessories.
- C. Condensate Receiver: Horizontal welded steel.
1. ASME BPVC-VIII-1 stamped construction.
 2. Working Pressure: 125 psi.
 3. Base: Elevated, fabricated steel.
- D. Accessories:
1. Air vent valve.
 2. Water level gauge glass.
 3. Pressure relief valve.
 4. Dial thermometer.
 5. Pressure gauge.
 6. Corrosion inhibitor anode.
 7. Inlet baffle.
 8. Drain valve.
 9. Pressure gauges on pump discharge.
 10. Bronze isolation valves between pumps and receiver.
 11. Double pole float switches.
- E. Pumps: One stage, vertical design, bronze fitted with stainless steel shaft, bronze impeller, renewable bronze case ring, mechanical shaft seal, close coupled to 3500 rpm motor.

- F. Control Cabinet:
1. NEMA EN 10250 enclosure, UL listed, with piano hinged door, grounding lug, terminal strip, and fusible control circuit transformer.
 2. Combination magnetic starters with overload relays, circuit breakers and cover interlock.
 3. Electric alternator, 'Auto-Off' switch.
 - a. Operate pump on high level, alternating after each cycle.
 - b. Operate second pump upon failure of first pump and alarm.
 4. Selector 'lead-off-lag' switches.
 5. Test buttons, high level alarm light, acknowledge button, alarm horn.

2.09 RECEIVERS

- A. Manufacturers:
1. Bell and Gossett
 2. Hoffman
 3. Spirax-Sarco; _____: www.spiraxsarco.com/us/#sle.
 4. Armstrong.
 5. Substitutions: See Section 01 6000 - Product Requirements.

2.10 CONDENSATE PUMPS

- A. Manufacturers:
1. Bell and Gossett
 2. Hoffman
 3. Spirax-Sarco; _____: www.spiraxsarco.com/us/#sle.
 4. Armstrong.
 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Pumps: Vertical design, bronze fitted with stainless steel shaft, enclosed bronze impeller, renewable bronze case ring, mechanical shaft seal, close coupled to motor.

2.11 PRESSURE REDUCING VALVES

- A. Manufacturers:
1. Armstrong International, Inc; GP 2000 PRV: www.armstronginternational.com/#sle.
 2. SPENCE
 3. McDonnell & Miller, a xylem brand; _____: www.mcdonnellmiller.com/#sle.
 4. Spirax-Sarco; _____: www.spiraxsarco.com/us/#sle.
 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Bronze or cast iron body, stainless or chrome steel valve spring, stem, and trim, phosphor bronze diaphragm, direct acting, threaded up to 2 inches, flanged over 2 inches.

2.12 SAFETY RELIEF VALVES

- A. Manufacturers:
1. Armstrong International, Inc; _____: www.armstronginternational.com/#sle.
 2. ITT McDonnell & Miller, a xylem brand; _____: www.mcdonnellmiller.com/#sle.
 3. Spirax-Sarco; _____: www.spiraxsarco.com/us/#sle.
- B. Valve: Bronze body, stainless steel valve spring, stem, and trim, direct pressure actuated, capacities ASME certified and labelled.
- C. Accessories: Drip pan elbow.

2.13 CONTROL VALVES

- A. Manufacturers:
1. Belimo

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install steam and steam condensate piping and specialties in accordance with ASME B31.9.

- B. Install specialties in accordance with manufacturer's instructions.
- C. Steam Traps:
 - 1. Provide minimum 3/4 inch size on steam mains and branches.
 - 2. Install with union or flanged connections at both ends.
 - 3. Provide gate valve and strainer at inlet, and gate valve and check valve at discharge.
 - 4. Provide minimum 10 inch long, line size dirt pocket between apparatus and trap.
- D. Remove thermostatic elements from steam traps during temporary and trial usage, and until system has been operated and dirt pockets cleaned of sediment and scale.
- E. Provide pressure reducing stations with pressure reducing valve, valved bypass, strainer and pressure gauge on upstream side, relief valve and pressure gauge on downstream side of pressure reducing valve.
 - 1. Pressure reducing station shall be one or two stages as required, to produce flat reduced pressure curve over range of capacity.
 - 2. Locate pilot operator control minimum 6 feet downstream of valve.
- F. Rate relief valves for pressure upstream of pressure reducing station, for full operating capacity. Set relief at maximum 20 percent above reduced pressure.
- G. Terminate relief valves to outdoors. Provide drip pan elbow with drain connection to nearest floor drain.
- H. Terminate relief valves to outdoors 6 feet minimum above roof. Provide drip pan elbow with drain connection to nearest floor drain.
- I. When several relief valve vents are connected to a common header, header cross section area shall equal sum of individual vent outlet areas.

END OF SECTION 23 2214

**SECTION 23 2300
REFRIGERANT PIPING**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Piping.
- B. Refrigerant.
- C. Moisture and liquid indicators.
- D. Valves.
- E. Strainers.
- F. Check valves.
- G. Pressure regulators.
- H. Pressure relief valves.
- I. Filter-driers.
- J. Solenoid valves.
- K. Expansion valves.
- L. Receivers.
- M. Flexible connections.
- N. Engineered wall seals and insulation protection.
- O. Exterior penetration accessories.

1.02 RELATED REQUIREMENTS

- A. Section 07 8400 - Firestopping.
- B. Section 08 3100 - Access Doors and Panels.
- C. Section 09 9123 - Interior Painting.
- D. Section 22 0716 - Plumbing Equipment Insulation.
- E. Section 22 0719 - Plumbing Piping Insulation.
- F. Section 23 0716 - HVAC Equipment Insulation.
- G. Section 23 0719 - HVAC Piping Insulation.
- H. Section 23 0993 - Sequence of Operations for HVAC Controls.
- I. Section 23 5400 - Furnaces.
- J. Section 23 6100 - Refrigerant Compressors.
- K. Section 23 6213 - Packaged Air-Cooled Refrigerant Compressor and Condenser Units.
- L. Section 23 6313 - Air Cooled Refrigerant Condensers.
- M. Section 23 8124 - Computer Room Air Conditioners - Floor Mounted.
- N. Section 23 8200 - Convection Heating and Cooling Units: Air coils.
- O. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. AHRI 495 - Performance Rating of Refrigerant Liquid Receivers; 2005.
- B. AHRI 710 - Performance Rating of Liquid-Line Driers; 2009.
- C. AHRI 730 (I-P) - Flow Capacity Rating of Suction Line Filters and Suction Line Filter Driers; 2013 (Reapproved 2014).
- D. AHRI 750 - Standard for Thermostatic Refrigerant Expansion Valves; 2007.

- E. AHRI 760 - Standard for Performance Rating of Solenoid Valves for Use With Volatile Refrigerants; 2007.
- F. ASHRAE Std 15 - Safety Standard for Refrigeration Systems; 2013.
- G. ASHRAE Std 34 - Designation and Safety Classification of Refrigerants; 2013.
- H. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1 - Rules for Construction of Pressure Vessels; 2015.
- I. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Welding, Brazing, and Fusing Qualifications; 2015.
- J. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings; 2013.
- K. ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes; 2013.
- L. ASME B31.5 - Refrigeration Piping and Heat Transfer Components; 2013.
- M. ASME B31.9 - Building Services Piping; 2014.
- N. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2012.
- O. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2017.
- P. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2015.
- Q. ASTM B88 - Standard Specification for Seamless Copper Water Tube; 2014.
- R. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric); 2013.
- S. ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service; 2013.
- T. ASTM E331 - Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference; 2000 (Reapproved 2023).
- U. ASTM E283 - Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen; 2004 (Reapproved 2012).
- V. ASTM E2178 - Standard Test Method for Air Permeance of Building Materials; 2013.
- W. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2023d.
- X. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials; 2014.
- Y. ASTM F708 - Standard Practice for Design and Installation of Rigid Pipe Hangers; 2024.
- Z. ASTM G153 - Standard Practice for Operating Enclosed Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials; 2013.
- AA. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi; 2015, with Editorial Revision (2021).
- BB. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding; 2011-AMD 1.
- CC. AWS D1.1/D1.1M - Structural Welding Code - Steel; 2015.
- DD. ICC (IMC)-2018 - International Mechanical Code; 2018.
- EE. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2009.

1.04 SYSTEM DESCRIPTION

- A. Where more than one piping system material is specified ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
- B. Liquid Indicators:
 - 1. Use line size liquid indicators in main liquid line leaving condenser.
 - 2. If receiver is provided, install in liquid line leaving receiver.
 - 3. Use line size on leaving side of liquid solenoid valves.
- C. Valves:
 - 1. Use service valves on suction and discharge of compressors.
 - 2. Use gauge taps at compressor inlet and outlet.
 - 3. Use gauge taps at hot gas bypass regulators, inlet and outlet.
 - 4. Use check valves on compressor discharge.
 - 5. Use check valves on condenser liquid lines on multiple condenser systems.
- D. Refrigerant Charging (Packed Angle) Valve: Use in liquid line between receiver shut-off valve and expansion valve.
- E. Filter-Driers:
 - 1. Use a filter-drier immediately ahead of liquid-line controls, such as thermostatic expansion valves, solenoid valves, and moisture indicators.
 - 2. Use sealed filter-driers in lines smaller than 1/2 inch outside diameter.
 - 3. Use sealed filter-driers in low temperature systems.
 - 4. Use sealed filter-driers in systems utilizing hermetic compressors.
 - 5. Use replaceable core filter-driers in lines of 1/2 inch outside diameter or greater.
 - 6. Use replaceable core liquid-line filter-driers in systems utilizing receivers.
- F. Solenoid Valves:
 - 1. Use in liquid line of systems operating with single pump-out or pump-down compressor control.
 - 2. Use in liquid line of single or multiple evaporator systems.
- G. Receivers:
- H. Flexible Connectors: Utilize at or near compressors where piping configuration does not absorb vibration.

1.05 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide general assembly of specialties, including manufacturers catalogue information. Provide manufacturers catalog data including load capacity.
- C. Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.
- D. Shop Drawings: Indicate schematic layout of system, including equipment, critical dimensions, and sizes.
- E. Design Data: Submit design data indicating pipe sizing. Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.
- F. Test Reports: Indicate results of leak test, acid test.
- G. Manufacturer's Installation Instructions: Indicate support, connection requirements, and isolation for servicing.
- H. Project Record Documents: Record exact locations of equipment and refrigeration accessories on record drawings.

- I. Maintenance Data: Include instructions for changing cartridges, assembly views, spare parts lists.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store piping and specialties in shipping containers with labeling in place.
- B. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.
- C. Dehydrate and charge components such as piping and receivers, seal prior to shipment, until connected into system.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

- A. Comply with ASME B31.9 for installation of piping system.

2.02 PIPING

- A. Copper Tube: ASTM B280, H58 hard drawn or O60 soft annealed.
 - 1. Fittings: ASME B16.22 wrought copper.
 - 2. Joints: Braze, AWS A5.8M/A5.8 BCuP silver/phosphorus/copper alloy.

2.03 REFRIGERANT

- A. Refrigerant: Use only refrigerants that have ozone depletion potential (ODP) of zero and global warming potential (GWP) of less than 50.
- B. Refrigerant: R-454B & R-32 as defined in ASHRAE Std 34.

2.04 MOISTURE AND LIQUID INDICATORS

- A. Manufacturers:
 - 1. Henry Technologies; _____: www.henrytech.com/#sle.
 - 2. Parker Hannifin/Refrigeration and Air Conditioning; _____: www.parker.com/#sle.
 - 3. Sporlan, a Division of Parker Hannifin; _____: www.parker.com/#sle.

2.05 VALVES

- A. Manufacturers:
 - 1. Hansen Technologies Corporation; _____: www.hantech.com/#sle.
 - 2. Henry Technologies; _____: www.henrytech.com/#sle.
 - 3. Flomatic Valves; _____: www.flomatic.com/#sle.

2.06 STRAINERS

- A. Manufacturers:
 - 1. Hansen Technologies Corporation; _____: www.hantech.com/#sle.
 - 2. Parker Hannifin/Refrigeration and Air Conditioning; _____: www.parker.com/#sle.
 - 3. Sporlan, a Division of Parker Hannifin; _____: www.parker.com/#sle.

2.07 CHECK VALVES

- A. Manufacturers:
 - 1. Hansen Technologies Corporation; _____: www.hantech.com/#sle.
 - 2. Parker Hannifin/Refrigeration and Air Conditioning; _____: www.parker.com/#sle.
 - 3. Sporlan, a Division of Parker Hannifin; _____: www.parker.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.

2.08 PRESSURE RELIEF VALVES

- A. Manufacturers:
 - 1. Hansen Technologies Corporation; _____: www.hantech.com/#sle.
 - 2. Henry Technologies; _____: www.henrytech.com/#sle.
 - 3. Sherwood Valve/Harsco Corporation; _____: www.sherwoodvalve.com/#sle.

2.09 FILTER-DRIERS

A. Manufacturers:

1. Flow Controls Division of Emerson Electric; _____: www.emersonflowcontrols.com/#sle.
2. Parker Hannifin/Refrigeration and Air Conditioning; _____: www.parker.com/#sle.
3. Sporlan, a Division of Parker Hannifin; _____: www.parker.com/#sle.

2.10 SOLENOID VALVES

A. Manufacturers:

1. Flow Controls Division of Emerson Electric; _____: www.emersonflowcontrols.com/#sle.
2. Parker Hannifin/Refrigeration and Air Conditioning; _____: www.parker.com/#sle.
3. Sporlan, a Division of Parker Hannifin; _____: www.parker.com/#sle.

2.11 EXPANSION VALVES

A. Manufacturers:

1. Flow Controls Division of Emerson Electric; _____: www.emersonflowcontrols.com/#sle.
2. Parker Hannifin/Refrigeration and Air Conditioning; _____: www.parker.com/#sle.

2.12 FLEXIBLE CONNECTORS

A. Manufacturers:

1. Circuit Hydraulics, Ltd; _____: www.circuit-hydraulics.co.uk/#sle.
2. Flexicraft Industries; _____: www.flexicraft.com/#sle.
3. Penflex; _____: www.penflex.com/#sle.

PART 3 EXECUTION

3.01 PREPARATION

- A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare piping connections to equipment with flanges or unions.

3.02 INSTALLATION

- A. Install refrigeration specialties in accordance with manufacturer's instructions.
- B. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.
- C. Install piping to conserve building space and avoid interference with use of space.
- D. Group piping whenever practical at common elevations and locations. Slope piping one percent in direction of oil return.
- E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- F. Pipe Hangers and Supports:
 1. Install in accordance with ASME B31.5.
 2. Support horizontal piping as indicated.
 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. Support vertical piping at every floor. Support riser piping independently of connected horizontal piping.
 6. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
 7. Provide copper plated hangers and supports for copper piping.
- G. Arrange piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required. Slope horizontal piping 0.40 percent in direction of flow.
- H. Provide clearance for installation of insulation and access to valves and fittings.

- I. Provide access to concealed valves and fittings. Coordinate size and location of access doors with Section 08 3100.
- J. Flood piping system with nitrogen when brazing.
- K. Insulate piping and equipment; refer to Section and Section 22 0716.
- L. Insulate piping and equipment; refer to Section and Section 23 0716.
- M. Follow ASHRAE Std 15 procedures for charging and purging of systems and for disposal of refrigerant.
- N. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.
- O. Provide external equalizer piping on expansion valves with refrigerant distributor connected to evaporator.

3.03 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Test refrigeration system in accordance with ASME B31.5.
- C. Pressure test system with dry nitrogen to 200 psi. Perform final tests at 27 inches vacuum and 200 psi using halide torch. Test to no leakage.

END OF SECTION 23 2300

**SECTION 23 2500
HVAC WATER TREATMENT**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Materials.
 - 1. Closed system treatment (water).
 - 2. Steam system treatment.
 - 3. Condenser water system treatment (cooling towers).
 - 4. Open system treatment (humidifiers, air washers, evaporative condensers, small cooling towers, liquid coolers).
- B. By-pass (pot) feeder.
- C. Solution metering pump.
- D. Solution tanks.
- E. Agitator.
- F. Liquid level switch.
- G. Conductivity controller.
- H. Water meter.
- I. Solenoid valves.
- J. Timers.
- K. Water softeners.
- L. Test equipment.
- M. Side-stream filtration equipment.

1.02 RELATED REQUIREMENTS

- A. Section 01 1000 - Summary: Owner furnished treatment equipment.
- B. Section 01 6000 - Product Requirements: Owner furnished treatment equipment.
- C. Section 23 0913 - Instrumentation and Control Devices for HVAC.
- D. Section 23 2113 - Hydronic Piping.
- E. Section 23 2114 - Hydronic Specialties.
- F. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. UL (DIR) - Online Certifications Directory; current listings at database.ul.com.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide chemical treatment materials, chemicals, and equipment including electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate system schematic, equipment locations, and controls schematics, electrical characteristics and connection requirements.
- D. Manufacturer's Installation Instructions: Indicate placement of equipment in systems, piping configuration, and connection requirements.
- E. Manufacturer's Field Reports: Indicate start-up of treatment systems when completed and operating properly. Indicate analysis of system water after cleaning and after treatment.
- F. Certificate: Submit certificate of compliance from Authority Having Jurisdiction indicating approval of chemicals and their proposed disposal.

- G. Project Record Documents: Record actual locations of equipment and piping, including sampling points and location of chemical injectors.
- H. Operation and Maintenance Data: Include data on chemical feed pumps, agitators, and other equipment including spare parts lists, procedures, and treatment programs. Include step by step instructions on test procedures including target concentrations.

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. Company shall have local representatives with water analysis laboratories and full time service personnel.
- B. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum 3 years of experience and approved by manufacturer.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. AmSolv-Amrep, Inc; _____: www.amsolv.com/#sle.
- B. GE Water & Process Technologies; _____: www.gewater.com/#sle.
- C. Nalco, an Ecolab Company; _____: www.nalco.com/#sle.
- D. Substitutions: See Section 01 6000 - Product Requirements.

2.02 REGULATORY REQUIREMENTS

- A. Comply with applicable codes for addition of non-potable chemicals to building mechanical systems and to public sewage systems.
- B. Comply with UL (DIR) requirements.
- C. Perform work in accordance with local health department regulations.
- D. Provide certificate of compliance from Authority Having Jurisdiction indicating approval of installation.

2.03 MATERIALS

- A. Closed System Treatment (Water):
 - 1. Manufacturers:
 - a. AmSolv-Amrep, Inc; _____: www.amsolv.com/#sle.
 - b. GE Water & Process Technologies; _____: www.gewater.com/#sle.
 - c. Nalco, an Ecolab Company; _____: www.nalco.com/#sle.
 - d. Substitutions: See Section 01 6000 - Product Requirements.
- B. Steam System Treatment:
 - 1. Manufacturers:
 - a. AmSolv-Amrep, Inc; _____: www.amsolv.com/#sle.
 - b. GE Water & Process Technologies; _____: www.gewater.com/#sle.
 - c. Nalco, an Ecolab Company; _____: www.nalco.com/#sle.
 - d. Substitutions: See Section 01 6000 - Product Requirements.
- C. Condenser Water System Treatment (Cooling Towers):
 - 1. Manufacturers:
 - a. AmSolv-Amrep, Inc; _____: www.amsolv.com/#sle.
 - b. GE Water & Process Technologies; _____: www.gewater.com/#sle.
 - c. Nalco, an Ecolab Company; _____: www.nalco.com/#sle.
 - d. Substitutions: See Section 01 6000 - Product Requirements.
- D. Open System Treatment (Humidifiers, Air Washers, Evaporative Condensers, Small Cooling Towers, Liquid Coolers):
 - 1. Manufacturers:
 - a. AmSolv-Amrep, Inc; _____: www.amsolv.com/#sle.

- b. GE Water & Process Technologies; _____: www.gewater.com/#sle.
- c. Nalco, an Ecolab Company; _____: www.nalco.com/#sle.
- d. Substitutions: See Section 01 6000 - Product Requirements.

2.04 BY-PASS (POT) FEEDER

- A. Manufacturers:
 - 1. Griswold Controls; _____: www.griswoldcontrols.com/#sle.
 - 2. J. L. Wingert Company; _____: www.jlwingert.com/#sle.
 - 3. Neptune, a brand of the Dover Company; _____: www.neptune1.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.

2.05 SOLUTION METERING PUMP

- A. Manufacturers:
 - 1. Dover Corporation; _____: www.neptune1.com/#sle.
 - 2. Pulsafeeder Engineered Products; _____: www.pulsa.com/#sle.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Positive displacement, diaphragm pump with adjustable flow rate, thermoplastic construction, continuous-duty fully enclosed electric motor and drive, and built-in relief valve.

2.06 LIQUID LEVEL SWITCH

- A. Polypropylene housing with integrally mounted PVC air trap, receptacles for connection to metering pump, and low level alarm.

2.07 CONDUCTIVITY CONTROLLER

- A. Manufacturers:
 - 1. Envirocare International; _____: www.envirocare.com/#sle.
 - 2. JENCO Instruments Incorporated; _____: www.jencoi.com/#sle.
 - 3. Omega Engineering, Inc; _____: www.omega.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Packaged monitor controller with solid state circuiting, five percent accuracy, linear dial adjustment, built-in calibration switch, on-off switch and light, control function light, output to control circuit and recorder.

2.08 WATER METER

- A. Displacement type cold water meter with sealed, tamper-proof magnetic drive, impulse contact register, single pole, double throw dry contact switch.

2.09 SOLENOID VALVES

- A. Forged brass body globe pattern, normally open or closed as required, explosion-proof and watertight solenoid enclosure, and continuous duty coil.

2.10 TIMERS

- A. Electronic timers, infinitely adjustable over full range, 150 second and five minute range, mounted together in cabinet with hands-off-automatic switches and status lights.

2.11 WATER SOFTENERS

- A. Manufacturers:
 - 1. Culligan International Company; _____: www.culligan.com/#sle.
 - 2. Sterling Water Treatment; _____: www.sterlingwatertreatment.com/#sle.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Performance:
 - 1. See schedules on drawings

2.12 TEST EQUIPMENT

- A. Provide white enamel test cabinet with local and fluorescent light, capable of accommodating 4 - 10 ml zeroing titrating burettes and associated reagents.

2.13 SIDE-STREAM FILTRATION SYSTEM

- A. Manufacturers:
 - 1. Shelco - Multi-Cartridge/Bag .
 - 2. Axiom Filters.
- B. System: Differential pressure indicator, filter housing with cartridge filter, shut-off valves, and flow control valve.
- C. Hot Water and Glycol Filter Housing: Stainless Steel suitable for 220 degrees F and 200 psi operating conditions.
- D. Chilled Water Filter Housing: Stainless Steel housing suitable for 125 degrees F and 125 psi operating conditions.
- E. Cartridges: 30 micron for start-up and 5 micron for system operation. Review application with Facilities Engineering.

PART 3 EXECUTION

3.01 PREPARATION

- A. Systems shall be operational, filled, started, and vented prior to cleaning.
- B. Use water meter to record capacity in each system. Indicate on As-Built drawings,
- C. Place terminal control valves in open position during cleaning.
- D. Verify that electric power is available and of the correct characteristics.

3.02 CLEANING SEQUENCE

3.03 INSTALLATION

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

3.04 CLOSED SYSTEM TREATMENT

- A. Provide one bypass feeder on each system. Install isolating and drain valves and necessary piping. Install around balancing valve downstream of circulating pumps unless indicated otherwise.
- B. Introduce closed system treatment through bypass feeder when required or indicated by test.
- C. Provide 3/4 inch water coupon rack around circulating pumps with space for 4 test specimens.

3.05 STEAM SYSTEM TREATMENT

- A. Provide bypass feeder on feed water line to each boiler.
- B. Activate solution pumps when feed water pumps are running.
- C. Provide conductivity controller to sample boiler water and operate solenoid blowdown valve. Provide timer activated sampling with solenoid valve, balancing valve, and conductivity probe. Pipe to blowdown tank.
- D. Provide 3/4 inch water coupon rack on each feed water pump with space for 4 test specimens.
- E. Provide liquid level switch in each solution tank to deactivate solution pump and agitator and sound local alarm bell.

3.06 OPEN SYSTEM TREATMENT (HUMIDIFIERS)

3.07 CONDENSER WATER SYSTEMS (COOLING TOWERS)

- A. Provide solution pumps to feed sequestering agent and corrosion inhibitor from solution tank into condenser water supply to tower. Provide agitator as required.
- B. Provide conductivity controller to sample condenser water and operate 1 inch solenoid bleed valve and solution pumps. Provide 1/4 inch solenoid valve and piping to blowdown controller sampler wired to open when condensing water pump is operating.
- C. Provide solution pump to feed diluted acid from solution tank into condenser water supply to tower.

- D. Introduce algicide to tower by intermittent slug feed.
- E. Provide water meter in make-up water line to tower, to activate solution pumps for preset time when condenser water pumps are running.
- F. Provide liquid level switch in each solution tank to deactivate solution pump and agitator and sound local alarm bell.

3.08 CLOSEOUT ACTIVITIES

- A. Training: Train Owner's personnel on operation and maintenance of chemical treatment system on owner's actual equipment.
 - 1. Provide minimum of two hours of instruction for two people on Owner's installed equipment.
 - 2. Have operation and maintenance data prepared and available for review during training.
 - 3. Conduct training using actual equipment after treated system has been put into full operation.

END OF SECTION 23 2500

**SECTION 23 3100
HVAC DUCTS AND CASINGS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Metal ductwork.
- B. Nonmetal ductwork.
- C. Casing and plenums.
- D. Kitchen hood ductwork.
- E. Duct cleaning.

1.02 RELATED REQUIREMENTS

- A. Section 07 8400 - Firestopping.
- B. Section 09 9123 - Interior Painting: Weld priming, paint or coating.
- C. Section 11 4000 - Foodservice Equipment: Supply of kitchen range hoods for placement by this Section.
- D. Section 23 0130.51 - HVAC Air-Distribution System Cleaning: Cleaning ducts after completion of installation.
- E. Section 23 0593 - Testing, Adjusting, and Balancing for HVAC.
- F. Section 23 0713 - Duct Insulation: External insulation and duct liner.
- G. Section 23 3300 - Air Duct Accessories.
- H. Section 23 3600 - Air Terminal Units.
- I. Section 23 3700 - Air Outlets and Inlets.

1.03 REFERENCE STANDARDS

- A. ASHRAE (FUND) - ASHRAE Handbook - Fundamentals; 2013.
- B. ASTM A36/A36M - Standard Specification for Carbon Structural Steel; 2019.
- C. ASTM A240/A240M - Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications; 2015b.
- D. ASTM A276/A276M - Standard Specification for Stainless Steel Bars and Shapes; 2016.
- E. ASTM A480/A480M - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip; 2023b.
- F. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2023.
- G. ASTM A666/A666M - Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar; 2024.
- H. ASTM A1008/A1008M - Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Required Hardness, Solution Hardened, and Bake Hardenable; 2023, with Editorial Revision.
- I. ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength; 2023.
- J. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate; 2014.
- K. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric); 2014.
- L. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2023d.

- M. ICC-ES AC01 - Acceptance Criteria for Expansion Anchors in Masonry Elements; 2012.
- N. ICC-ES AC106 - Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements; 2012.
- O. ICC-ES AC193 - Acceptance Criteria for Mechanical Anchors in Concrete Elements; 2013.
- P. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2015.
- Q. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems; 2015.
- R. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations; 2014.
- S. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- T. SMACNA (FGD) - Fibrous Glass Duct Construction Standards; 2003.
- U. SMACNA (KVS) - Kitchen Ventilation Systems and Food Service Equipment Fabrication and Installation Guidelines; 2001.
- V. SMACNA (LEAK) - HVAC Air Duct Leakage Test Manual; 2012, 2nd Edition.
- W. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; current edition, including all revisions.
- X. UL 1978 - Grease Ducts; Current Edition, Including All Revisions.
- Y. UL 2221 - Tests of Fire Resistive Grease Duct Enclosure Assemblies; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate duct fittings, particulars such as gages, sizes, welds, and configuration prior to start of work for _____ pressure class and higher systems.
- C. Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA (LEAK).
- D. Project Record Documents: Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

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, and approved by manufacturer.
- B. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum 3 years of documented experience.

1.06 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 DUCT ASSEMBLIES

- A. Regulatory Requirements: Construct ductwork to comply with NFPA 90A standards.
- B. Ducts: Galvanized steel, unless otherwise indicated.
- C. Low Pressure Supply (Heating Systems): 1/2 inch w.g. pressure class, galvanized steel.
- D. Low Pressure Supply (System with Cooling Coils): 1/2 inch w.g. pressure class, galvanized steel.
- E. Medium and High Pressure Supply pressure class, galvanized steel.

- F. Return and Relief: , galvanized steel.
- G. General Exhaust:, galvanized steel.
- H. Kitchen Cooking Hood Exhaust:, galvanized steel.
 - 1. Construct of 16 gage, 0.0598 inch sheet steel using continuous external welded joints in rectangular sections.
 - 2. Construct of 18 gage, 0.0500 inch stainless steel using continuous external welded joints in rectangular sections.
- I. Dishwasher Exhaust: , galvanized steel.
 - 1. Construct of 16 gage, 0.0598 inch sheet steel using continuous external welded joints in rectangular sections.
 - 2. Construct of 18 gage, 0.0500 inch stainless steel using continuous external welded joints in rectangular sections.
- J. Grease Exhaust:, stainless steel.
 - 1. Construct of 18 gage, 0.0500 inch stainless steel.
 - 2. Construction:
 - a. Liquid tight with continuous external weld for all seams and joints.
 - b. Where ducts are not self draining back to equipment, provide low point drain pocket with copper drain pipe to sanitary sewer.
 - 3. Access Doors:
 - a. Provide for duct cleaning inside horizontal duct at drain pockets, every 20 feet and at each change of direction.
 - b. Use same material and thickness as duct with gaskets and sealants rated 1500 degrees F for grease tight construction.
- K. Fume Hood Exhaust, galvanized steel.
- L. Outside Air Intake: , galvanized steel.
- M. Combustion Air: , galvanized steel.
- N. Emergency Generation Ventilation: , galvanized steel.

2.02 MATERIALS

- A. Galvanized Steel for Ducts: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G60/Z180 coating.
- B. Stainless Steel for Ducts: ASTM A666, Type 304.
- C. 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.
 - 4. For Use With Flexible Ducts: UL labeled.
 - 5. Manufacturers:
 - a. Carlisle HVAC Products; Hardcast Iron-Grip 601 Water Based Duct Sealant: www.carlislehvac.com/#sle.
 - b. Substitutions: See Section 01 6000 - Product Requirements.
- D. Hanger Rod: ASTM A36/A36M; steel, galvanized; threaded both ends, threaded one end, or continuously threaded.
- E. Hanger Fasteners: Attach hangers to structure using appropriate fasteners, as follows:
 - 1. Concrete Wedge Expansion Anchors: Complying with ICC-ES AC193.
 - 2. Masonry Wedge Expansion Anchors: Complying with ICC-ES AC01.
 - 3. Concrete Screw Type Anchors: Complying with ICC-ES AC193.

4. Masonry Screw Type Anchors: Complying with ICC-ES AC106.

2.03 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. Provide turning vanes of perforated metal with glass fiber insulation when acoustical lining is indicated.
- F. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- G. Fabricate continuously welded round and oval duct fittings in accordance with SMACNA (DCS).
- H. 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.

2.04 MANUFACTURED DUCTWORK AND FITTINGS

- A. Flat Oval Ducts: Machine made from round spiral lockseam duct.
 - 1. Manufacture in accordance with SMACNA (DCS).
 - 2. Fittings: Manufacture at least two gages heavier metal than duct.
 - 3. Provide duct material, gages, reinforcing, and sealing for operating pressures indicated.
- B. Flexible Ducts: Black polymer film supported by helically wound spring steel wire.
 - 1. UL labeled.
 - 2. Insulation: Fiberglass insulation with polyethylene vapor barrier film.
 - 3. Pressure Rating: 4 inches WG positive and 0.5 inches WG negative.
 - 4. Maximum Velocity: 4000 fpm.
 - 5. Temperature Range: Minus 20 degrees F to 175 degrees F.
- C. Kitchen Cooking Hood and Grease Exhaust: Nominal 3 inches thick ceramic fiber insulation between 20 gage, 0.0375 inch, Type 304 stainless steel liner and 24 gage, 0.0239 inch aluminized steel sheet outer jacket.
 - 1. Tested and UL listed for use with commercial cooking equipment in accordance with NFPA 96.
 - 2. Certified for zero clearance to combustible material in accordance with:
 - a. UL 2221 with a 2 hour rating.
 - 3. Materials and construction of the modular sections and accessories to be in accordance with the terms of the following listings:
 - a. UL 1978.
 - b. UL 2221.
- D. Dishwasher Exhaust: Minimum 21 gage, 0.0344 inch thick, single wall, Type 304 stainless steel.
 - 1. Single wall, factory built chimney liner system.
 - 2. Designed, fabricated, and installed to be liquid tight preventing exhaust leakage into the building.
 - 3. Joints to be sealed during installation with factory supplied overlapping V-bands and sealant.

- E. Fume Hood Exhaust: Minimum 21 gage, 0.0344 inch thick, single wall, Type 304 stainless steel.
 - 1. Single wall, factory built chimney liner system.
 - 2. Designed, fabricated, and installed to be liquid tight preventing exhaust leakage into the building.
 - 3. Joints to be sealed during installation with factory supplied overlapping V-bands and sealant.

2.05 CASINGS

- A. Fabricate casings in accordance with SMACNA (DCS) and construct for operating pressures indicated.
- B. Mount floor mounted casings on 4 inch high concrete curbs. At floor, rivet panels on 8 inch centers to angles. Where floors are acoustically insulated, provide liner of galvanized 18 gage, 0.0478 inch expanded metal mesh supported at 12 inch centers, turned up 12 inches at sides with sheet metal shields.
- C. Reinforce door frames with steel angles tied to horizontal and vertical plenum supporting angles. Install hinged access doors where indicated or required for access to equipment for cleaning and inspection.

2.06 KITCHEN HOOD EXHAUST DUCTWORK

- A. Fabricate in accordance with ductwork manufacturer's installation instructions, SMACNA (DCS), SMACNA (KVS), and NFPA 96.

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. Flexible Ducts: Connect to metal ducts with adhesive. Limit length to 5 feet maximum and only in the vertical from the rigid duct turndown to the diffuser.
- E. Kitchen Hood Exhaust: Provide residue traps at base of vertical risers with provisions for clean out.
- F. Duct sizes indicated are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- 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 directly or with one foot maximum length of flexible duct. Do not use flexible duct to change direction.
- J. Connect diffusers or light troffer boots to low pressure ducts directly or with 5 feet maximum length of flexible duct held in place with strap or clamp.
- K. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.
- L. At exterior wall louvers, seal duct to louver frame and install blank-out panels.

3.02 CLEANING

- A. See Section 01 7419 - Construction Waste Management and Disposal, for additional requirements.

- B. Clean duct systems with high power vacuum machines. Protect equipment that could be harmed by excessive dirt with filters, or bypass during cleaning. Provide adequate access into ductwork for cleaning purposes.

END OF SECTION 23 3100

**SECTION 23 3300
AIR DUCT ACCESSORIES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Air turning devices/extractors.
- B. Backdraft dampers - metal.
- C. Backdraft dampers - fabric.
- D. Combination fire and smoke dampers.
- E. Combination fire and smoke dampers - corridor dampers.
- F. Duct access doors.
- G. Duct test holes.
- H. Fire dampers.
- I. Flexible duct connections.
- J. Smoke dampers.
- K. Volume control dampers.
- L. Miscellaneous products:

1.02 RELATED REQUIREMENTS

- A. Section 07 8400 - Firestopping.
- B. Section 22 0548 - Vibration and Seismic Controls for Plumbing Piping and Equipment.
- C. Section 23 0548 - Vibration and Seismic Controls for HVAC.
- D. Section 23 3100 - HVAC Ducts and Casings.
- E. Section 23 3600 - Air Terminal Units: Pressure regulating damper assemblies.

1.03 REFERENCE STANDARDS

- A. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2015.
- B. NFPA 92 - Standard for Smoke Control Systems; 2015.
- C. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations; 2014.
- D. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- E. UL 33 - Safety Heat Responsive Links for Fire-Protection Service; Current Edition, Including All Revisions.
- F. UL 555 - Standard for Fire Dampers; Current Edition, Including All Revisions.
- G. UL 555S - Standard for Smoke Dampers; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Manufacturer's Installation Instructions: Provide instructions for fire dampers.
- C. Project Record Drawings: Record actual locations of access doors and test holes.

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

1.06 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 AIR TURNING DEVICES/EXTRACTORS

- A. Manufacturers:
 - 1. Carlisle HVAC Products; Dynair Hollow Vane and Rail (Double Wall Vane): www.carlislehvac.com/#sle.
 - 2. Elgen Manufacturing, Inc; _____: www.elgenmfg.com/#sle.
 - 3. Ruskin Company; _____: www.ruskin.com/#sle.
 - 4. Titus HVAC, a brand of Johnson Controls; _____: www.titus-hvac.com/#sle.
 - 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Multi-blade device with blades aligned in short dimension; steel construction; with individually adjustable blades, mounting straps.

2.02 BACKDRAFT DAMPERS - METAL

- A. Manufacturers:
 - 1. Louvers & Dampers, Inc, a brand of Mestek, Inc; _____: www.louvers-dampers.com/#sle.
 - 2. Nailor Industries, Inc; _____: www.nailor.com/#sle.
 - 3. Ruskin Company; _____: www.ruskin.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. 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.

2.03 BACKDRAFT DAMPERS - FABRIC

- A. Fabric Backdraft Dampers: Factory-fabricated.
 - 1. Blades: Neoprene coated fabric material.
 - 2. Birdscreen: 1/2 inch nominal mesh of galvanized steel or aluminum.
 - 3. Maximum Velocity: 1000 fpm (5 mps) face velocity.

2.04 COMBINATION FIRE AND SMOKE DAMPERS

- A. Manufacturers:
 - 1. Lloyd Industries, Inc.; _____: www.firedamper.com/#sle.
 - 2. Louvers & Dampers, Inc, a brand of Mestek, Inc; _____: www.louvers-dampers.com/#sle.
 - 3. Nailor Industries, Inc; _____: www.nailor.com/#sle.
 - 4. Ruskin Company; _____: www.ruskin.com/#sle.
 - 5. Substitutions: See Section 01 6000 - Product Requirements.
- B. Fabricate in accordance with NFPA 90A, UL 555, UL 555S, and as indicated.
- C. Provide factory sleeve and collar for each damper.
- D. Multiple Blade Dampers: Fabricate with 16 gage, 0.0598 inch galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, stainless steel jamb seals, 1/8 by 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock, and 1/2 inch actuator shaft.
- E. Operators: UL listed and labelled spring return electric type suitable for 120 volts, single phase, 60 Hz. Provide end switches to indicate damper position. Locate damper operator on exterior of duct and link to damper operating shaft.

- F. Normally Open Smoke Responsive Fire Dampers: Curtain type, closing upon actuation of electro thermal link, flexible stainless steel blade edge seals to provide constant sealing pressure, stainless steel springs with locking devices to ensure positive closure for units mounted horizontally.
- G. Electro Thermal Link: Fusible link melting at 165 degrees F; 120 volts, single phase, 60 Hz; UL listed and labeled.

2.05 COMBINATION FIRE AND SMOKE DAMPERS - CORRIDOR DAMPERS

- A. Manufacturers:
 - 1. Ruskin Company; _____: www.ruskin.com/#sle.
 - 2. Substitutions: See Section 01 6000 - Product Requirements.
- B. Fabricate in accordance with NFPA 90A, UL 555, UL 555S, and as indicated.
- C. Provide factory sleeve and collar for each damper.
- D. Multiple Blade Dampers: Fabricate with 16 gage, 0.0598 inch galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, stainless steel jamb seals, 1/8 by 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock, and 1/2 inch actuator shaft.
- E. Operators: UL listed and labelled spring return electric type suitable for 120 volts, single phase, 60 Hz. Provide end switches to indicate damper position. Locate damper operator on interior of duct and link to damper operating shaft.
- F. Normally Open Smoke Responsive Fire Dampers: Curtain type, closing upon actuation of electro thermal link, flexible stainless steel blade edge seals to provide constant sealing pressure, stainless steel springs with locking devices to ensure positive closure for units mounted horizontally.
- G. Electro Thermal Link: Fusible link melting at 165 degrees F; 120 volts, single phase, 60 Hz; UL listed and labeled.

2.06 DUCT ACCESS DOORS

- A. Manufacturers:
 - 1. Elgen Manufacturing, Inc; _____: www.elgenmfg.com/#sle.
 - 2. Nailor Industries, Inc; _____: www.nailor.com/#sle.
 - 3. Ruskin Company; _____: www.ruskin.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- 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. Less Than 12 inches Square: Secure with sash locks.
 - 2. Up to 18 inches Square: Provide two hinges and two sash locks.
 - 3. Up to 24 by 48 inches: Three hinges and two compression latches with outside and inside handles.

2.07 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.

2.08 FIRE DAMPERS

- A. Manufacturers:
 - 1. Louvers & Dampers, Inc, a brand of Mestek, Inc; _____: www.louvers-dampers.com/#sle.
 - 2. Nailor Industries, Inc; _____: www.nailor.com/#sle.
 - 3. Ruskin Company; _____: www.ruskin.com/#sle.

- 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Fabricate in accordance with NFPA 90A and UL 555, and as indicated.
- C. Horizontal Dampers: Galvanized steel, 22 gage, 0.0299 inch frame, stainless steel closure spring, and lightweight, heat retardant non-asbestos fabric blanket.
- D. Curtain Type Dampers: Galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations. Configure with blades out of air stream except for 1.0 inch pressure class ducts up to 12 inches in height.
- E. Multiple Blade Dampers: 16 gage, 0.0598 inch galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, 1/8 by 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock.
- F. Fusible Links: UL 33, separate at 160 degrees F with adjustable link straps for combination fire/balancing dampers.

2.09 FLEXIBLE DUCT CONNECTIONS

- A. Manufacturers:
 - 1. Carlisle HVAC Products; Dynair Connector Plus G90 Steel Offset Seam Neoprene Fabric: www.carlislehvac.com/#sle.
 - 2. Elgen Manufacturing, Inc; _____: www.elgenmfg.com/#sle.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Fabricate in accordance with SMACNA (DCS) and as indicated.
- C. 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.
 - a. Net Fabric Width: Approximately 2 inches wide.

2.10 SMOKE DAMPERS

- A. Manufacturers:
 - 1. Louvers & Dampers, Inc, a brand of Mestek, Inc; _____: www.louvers-dampers.com/#sle.
 - 2. Nailor Industries, Inc; _____: www.nailor.com/#sle.
 - 3. Ruskin Company; _____: www.ruskin.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Fabricate in accordance with NFPA 90A and UL 555S, and as indicated.
- C. Dampers: UL Class 1 airfoil blade type smoke damper, normally open automatically operated by pneumatic actuator.
- D. Electro Thermal Link: Fusible link melting at 165 degrees F; 120 volts, single phase, 60 Hz; UL listed and labeled.

2.11 VOLUME CONTROL DAMPERS

- A. Manufacturers:
 - 1. Louvers & Dampers, Inc, a brand of Mestek, Inc; _____: www.louvers-dampers.com/#sle.
 - 2. Nailor Industries, Inc; _____: www.nailor.com/#sle.
 - 3. Ruskin Company; _____: www.ruskin.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Fabricate in accordance with SMACNA (DCS) and as indicated.
- C. Splitter Dampers:
- D. Single Blade Dampers:
 - 1. Fabricate for duct sizes up to 6 by 30 inch.
 - 2. Blade: 24 gage, 0.0239 inch, minimum.
 - 3. Manufacturers:

- a. Ruskin.
 - b. Nailor.
 - c. Louvers & Dampers Inc..
 - d. Contractor Manufactured - with Facilities Engineering approval
 - e. Substitutions: See Section 01 6000 - Product Requirements.
- E. 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.
 - 2. Manufacturers:
 - a. Ruskin.
 - b. Nailor.
 - c. Louvers & Dampers inc.
 - d. Substitutions: See Section 01 6000 - Product Requirements.
- F. 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 INSTALLATION

- A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA (DCS). Refer to Section 23 3100 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 access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, combination fire and smoke dampers, and elsewhere as indicated. Provide for cleaning kitchen exhaust ducts in accordance with NFPA 96 Provide minimum 8 by 8 inch size for hand access, size for shoulder access, and as indicated. Provide 4 by 4 inch for balancing dampers only. Review locations prior to fabrication.
- D. Provide duct test holes where indicated and required for testing and balancing purposes.
- E. Provide fire dampers, combination fire and smoke dampers, and smoke dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by Authorities Having Jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
- F. Install smoke dampers and combination smoke and fire dampers in accordance with NFPA 92.
- G. Demonstrate re-setting of fire dampers to Owner's representative.
- H. At fans and motorized equipment associated with ducts, provide flexible duct connections immediately adjacent to the equipment.
- I. At equipment supported by vibration isolators, provide flexible duct connections immediately adjacent to the equipment.
- J. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum 2 duct widths from duct take-off.
- K. Use splitter dampers only where indicated.
- L. Provide balancing dampers on high velocity systems where indicated. Refer to Section 23 3600 - Air Terminal Units.

- M. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.

END OF SECTION 23 3300

SECTION 23 3413 AXIAL HVAC FANS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Vaneaxial fans.
- B. Tubeaxial fans.
- C. Propeller fans.

1.02 RELATED REQUIREMENTS

- A. Section 22 0513 - Common Motor Requirements for Plumbing Equipment.
- B. Section 23 0513 - Common Motor Requirements for HVAC Equipment.
- C. Section 23 0548 - Vibration and Seismic Controls for HVAC.
- D. Section 23 0913 - Instrumentation and Control Devices for HVAC.
- E. Section 23 3300 - Air Duct Accessories: Backdraft dampers.
- F. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. 29 CFR 1910 - Occupational Safety and Health Standards; current edition.
- B. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings; 2015.
- C. ABMA STD 11 - Load Ratings and Fatigue Life for Roller Bearings; 1990 (Reapproved 2008).
- D. AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program; 2015.
- E. AMCA 99 - Standards Handbook; 2010.
- F. AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating; 2007.
- G. NEMA MG 00001 - Motors and Generators; 2024.
- H. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on axial fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate assembly of axial fans and accessories including fan curves with specified operating point clearly plotted, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.
- D. Test Reports: Indicate performance data for adjustable axial fan blades for at least five blade settings, including maximum.
- E. Manufacturer's Instructions: Indicate installation instructions.
- F. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.
- G. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Fan Belts: One set for each individual fan.

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.

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

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Protect motors, shafts, and bearings from weather and construction dust.

1.07 FIELD CONDITIONS

- A. Permanent fans may be used for ventilation during construction only after ductwork is clean, filters are in place, bearings have been lubricated, and fan has been test run under observation. Review with Facilities Engineering on each application.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Loren Cook Company: www.lorencook.com/#sle.
- B. Greenheck; www.greenheck.com_____.
- C. Substitutions: See Section 01 6000 - Product Requirements.

2.02 AXIAL FANS

- A. Manufacturers:
 - 1. Loren Cook Company; _____: www.lorencook.com/#sle.
 - 2. Twin City Fan & Blower; TCVX: www.tcf.com/#sle.
 - 3. Greenheck.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Performance Requirements:
 - 1. Performance Ratings: Determined in accordance with AMCA 210 and bearing the AMCA Certified Rating Seal.
 - 2. Sound Ratings: AMCA 301, tested to AMCA 300, and bearing the AMCA Certified Sound Rating Seal.
 - 3. Fabrication: Comply with AMCA 99.
 - 4. Performance Base: Sea level conditions.
 - 5. Temperature Limit: Maximum 300 degrees F.
- C. Hub and Impeller:
 - 1. Airfoil Impeller Blades: Adjustable die cast aluminum alloy welded steel die formed blades with belt drive.
 - 2. Hub: Die cast aluminum alloy or cast iron hub or with belt drive of spun, welded steel, bored and keyed to shaft; to facilitate indexing of blade angle with automatic adjustment stops.
 - 3. Controllable Pitch Assemblies: Incorporate ball bearing counterbalanced blade and variable pitch assembly into hub with mechanical link to casing exterior mounted actuator, or pneumatic or electric actuator incorporated within hub.
 - 4. Cast Components: X-ray components after fabrication and statically and dynamically balance assembly before attachment to motor or shaft.
- D. Casing:
 - 1. Fabricate casing of 1/4 inch steel for fans 40 inch in diameter and smaller and 3/8 inch steel for larger fans.
 - 2. Continuously weld, with inlet and outlet flange connections, and motor or shaft supports. Incorporate flow straightening guide vanes for fans specified for static pressures greater than 1 inch wg.
 - 3. Finish with one coat enamel applied to interior and exterior.
- E. Bearings and Drives:
 - 1. Bearings: Heavy duty pillow block type, self-aligning, grease-lubricated ball bearings, with ABMA STD 9 L-10 life at 50,000 hours.

2. Shafts: Hot rolled steel, ground and polished, with keyway; protectively coated with lubricating oil.
 3. V-Belt Drive: Cast iron or steel sheaves, dynamically balanced, 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.
 4. 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.
 5. Lubrication: Extend lubrication fittings to outside of casing.
- F. Accessories:
1. Guide Vanes: Welded steel construction with airfoil vanes and casing flanges, finished to match casing.
 2. Adjustable Inlet Vanes: Steel construction with blades supported at both ends with two permanently lubricated bearings, variable mechanism out of air stream terminating in single control lever with control shaft for double width fans and locking quadrant.
 3. Inlet Bell: Bell mouth inlet fabricated of steel with flange.
 4. Outlet Cones: Fabricated of steel with flanges, outlet area/inlet area ratio of 1.5/1.0, with center pod as recommended by manufacturer.
 5. Inlet Screens: Galvanized steel welded grid to fit inlet bell.
 6. Dampers: Welded steel construction, consisting of two semi-circular vanes pivoted on oil-retaining bearings in short casing section, finished with one coat enamel. Provide airstream operation closing blades by reverse air flow and gravity.
 7. Access Doors: Shaped to fit casing with quick opening latches and gaskets.

2.03 MIXED FLOW FANS

- A. Manufacturers:
1. Loren Cook Company; _____: www.lorencook.com/#sle.
 2. Twin City Fan & Blower; QSL: www.tcf.com/#sle.
 3. Greenheck.
 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Performance Requirements:
1. Performance Ratings: Determined in accordance with AMCA 210 and bearing the AMCA Certified Rating Seal.
 2. Sound Ratings: AMCA 301, tested to AMCA 300, and bearing the AMCA Certified Sound Rating Seal.
 3. Fabrication: Comply with AMCA 99.
 4. Performance Base: Sea level conditions.
 5. Temperature Limit: Maximum 300 degrees F.

2.04 PROPELLER FANS

- A. Manufacturers:
1. Loren Cook Company; _____: www.lorencook.com/#sle.
 2. Twin City Fan & Blower; _____: www.tcf.com/#sle.
 3. Greenheck.
 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Impeller: Shaped steel or steel reinforced aluminum blade with heavy hubs, statically and dynamically balanced, keyed and locked to shaft, directly connected to motor.
- C. Frame: One piece, square steel with die formed venturi orifice, mounting flanges and supports, with baked enamel finish.
- D. Accessories:

1. Backdraft Damper: Multiple blade with offset hinge pin, blades linked.
2. Safety Screens: Expanded galvanized metal over inlet, motor, drive; to comply with 29 CFR 1910.
3. Hood: Weathershield, to exclude rain and snow.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install with resilient mountings and with flexible electrical leads; refer to Section 23 0548.
- C. Install flexible connections specified in Section 23 3300 between axial fan inlet and discharge ductwork. Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and axial fan while running.
- D. Install fan restraining snubbers; refer to Section 23 0548. Adjust snubbers to prevent tension in flexible connectors when fan is operating.
- E. Provide Adjustable sheaves required for final air balance.
- F. Provide safety screen where inlet or outlet is exposed.
- G. Provide backdraft dampers on discharge of exhaust fans and as indicated.
- H. Provide access to adjustable blade axial fan wheels for varying blade angle setting. Adjust blades for varying range of volume and pressure.

END OF SECTION 23 3413

**SECTION 23 3416
CENTRIFUGAL HVAC FANS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Backward inclined centrifugal fans.
- B. Forward curved centrifugal fans.
- C. Airfoil wheel centrifugal fans.
- D. Radial centrifugal fans.
- E. Bearings and drives.
- F. Accessories.

1.02 RELATED REQUIREMENTS

- A. Section 22 0513 - Common Motor Requirements for Plumbing Equipment.
- B. Section 22 0548 - Vibration and Seismic Controls for Plumbing Piping and Equipment.
- C. Section 23 0513 - Common Motor Requirements for HVAC Equipment.
- D. Section 23 0548 - Vibration and Seismic Controls for HVAC.
- E. Section 23 0713 - Duct Insulation.
- F. Section 23 3300 - Air Duct Accessories: Backdraft dampers.
- G. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings; 2015.
- B. ABMA STD 11 - Load Ratings and Fatigue Life for Roller Bearings; 1990 (Reapproved 2008).
- C. AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program; 2015.
- D. AMCA 99 - Standards Handbook; 2010.
- E. NEMA MG 00001 - Motors and Generators; 2024.
- F. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on centrifugal fans and accessories including fan curves with specified operating point clearly plotted, power, RPM, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate assembly of centrifugal fans and accessories including fan curves with specified operating point clearly plotted, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.
- D. Manufacturer's Instructions: Include complete installation instructions.
- E. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

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

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Protect motors, shafts, and bearings from weather and construction dust.

1.07 FIELD CONDITIONS

- A. Permanent fans may be used for ventilation during construction only after ductwork is clean, filters are in place, bearings have been lubricated, and fan has been test run under observation. Review application with Facilities Engineering for approval.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Loren Cook Company; _____: www.lorencook.com/#sle.
- B. Greenheck; www.greenheck.com_____.

2.02 PERFORMANCE REQUIREMENTS

2.03 WHEEL AND INLET

- A. Backward Inclined: Steel or aluminum construction with smooth curved inlet flange, heavy back plate, backwardly curved blades welded or riveted to flange and back plate; cast iron or cast steel hub riveted to back plate and keyed to shaft with set screws.
- B. Forward Curved: Black enameled steel construction with inlet flange, back plate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and back plate; steel hub swaged to back plate and keyed to shaft with set screw.
- C. Airfoil Wheel: Steel construction with smooth curved inlet flange, heavy back plate die formed hollow airfoil shaped blades continuously welded at tip flange, and back plate; cast iron or cast steel hub riveted to back plate and keyed to shaft with set screws.
- D. Radial: Steel construction with inlet flange, heavy reinforced back plate, plate blades with reinforcing gussets welded or riveted to back plate and flange; cast iron or cast steel hub riveted to back plate and keyed to shaft with set screws.

2.04 HOUSING

- A. Heavy gage steel, spot welded for AMCA 99 Class I and II fans, and continuously welded for Class III, adequately braced, designed to minimize turbulence with spun inlet bell and shaped cut.
- B. Factory finish before assembly to manufacturer's standard. For fans handling air downstream of humidifiers, provide two additional coats of paint. Prime coating on aluminum parts is not required.

2.05 BEARINGS AND DRIVES

- A. Bearings: Heavy duty pillow block type, selfgreasing roller bearings, or ABMA STD 11 life at 400,000 hours.
- B. Shafts: Hot rolled steel, ground and polished, with keyway, protectively coated with lubricating oil, and shaft guard.
- C. Drive: Cast iron or steel sheaves, dynamically balanced, keyed. Variable and adjustable pitch sheaves for motors 15 hp and under, selected so required rpm is obtained with sheaves set at mid 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.
- D. 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.

2.06 ACCESSORIES

- A. Inlet/Outlet Screens: Galvanized steel welded grid.
- B. Access Doors: Shaped to fit scroll, with quick opening latches and gaskets.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install fans with resilient mountings and flexible electrical leads. Refer to Section 23 0548.
- C. Install flexible connections between fan inlet and discharge ductwork; refer to Section 23 3300. Ensure metal bands of connectors are parallel with minimum one inch flex between ductwork and fan while running.
- D. Provide Adjustable sheaves required for final air balance.
- E. Provide safety screen where inlet or outlet is exposed.
- F. Provide backdraft dampers on discharge of exhaust fans and as indicated; refer to Section 23 3300.

END OF SECTION 23 3416

**SECTION 23 3423
HVAC POWER VENTILATORS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Roof exhausters.
- B. Roof ventilators.
- C. Wall exhausters.
- D. Upblast roof exhausters.
- E. Inline centrifugal fans.
- F. Kitchen hood upblast roof exhausters.
- G. Utility vent set.
- H. Laboratory and fume exhaust.

1.02 RELATED REQUIREMENTS

- A. Section 22 0513 - Common Motor Requirements for Plumbing Equipment.
- B. Section 23 0513 - Common Motor Requirements for HVAC Equipment.
- C. Section 23 0548 - Vibration and Seismic Controls for HVAC.
- D. Section 23 3300 - Air Duct Accessories: Backdraft dampers.
- E. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program; 2015.
- B. AMCA 99 - Standards Handbook; 2010.
- C. AMCA 204 - Balance Quality and Vibration Levels for Fans; 2005.
- D. AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating; 2007.
- E. AMCA 211 - Certified Ratings Program Product Rating Manual for Fan Air Performance; 13th Edition, Revised October 2016.
- F. AMCA 260 - Laboratory Methods of Testing Induced Flow Fans for Rating; 2016.
- G. AMCA 300 - Reverberant Room Method for Sound Testing of Fans; 2014.
- H. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data; 2014.
- I. AMCA 311 - Certified Ratings Program Product Rating Manual for Fan Sound Performance; 2016.
- J. ANSI Z9.5 - Laboratory Ventilation; 2012.
- K. NEMA MG 00001 - Motors and Generators; 2024.
- L. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- M. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations; 2014.
- N. UL 705 - Power Ventilators; Current Edition, Including All Revisions.
- O. UL 762 - Outline of Investigation for Power Roof Ventilators for Restaurant Exhaust Appliances; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination: Coordinate the installation of each fan with size, location and installation of service utilities.

- B. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.
- C. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.05 SUBMITTALS

- A. See Section 01 3000 - 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. Manufacturer's Instructions: Indicate installation instructions.
- D. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.
- E. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 6000 - Product Requirements, for additional provisions.
 - 2. Extra Fan Belts: One set for each individual fan.

1.06 QUALITY ASSURANCE

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

1.07 FIELD CONDITIONS

- A. Permanent ventilators may be used for ventilation during construction only after ductwork is clean, filters are in place, bearings have been lubricated, and fan has been test run under observation. Upon review and approval of Facilities Engineering

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Greenheck Fan Corporation; _____: www.greenheck.com/#sle.
- B. Loren Cook Company; _____: www.lorencook.com/#sle.
- C. Twin City Fan & Blower; _____: www.tcf.com/#sle.
- D. Substitutions: See Section 01 6000 - Product Requirements.

2.02 POWER VENTILATORS - GENERAL

- A. Manufacturers:
 - 1. Greenheck Fan Corporation; _____: www.greenheck.com/#sle.
 - 2. Lauren Cook.
- B. Static and Dynamically Balanced: AMCA 204 - Balance Quality and Vibration Levels for Fans.
- C. Performance Ratings: Determined in accordance with AMCA 210 and bearing the AMCA Certified Rating Seal.
- D. Sound Ratings: AMCA 301, tested to AMCA 300 and bearing AMCA Certified Sound Rating Seal.
- E. Fabrication: Comply with AMCA 99.
- F. UL Compliance: UL listed and labeled, designed, manufactured, and tested in accordance with UL 705.
- G. Electrical Components: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
- H. Enclosed Safety Switches: Comply with NEMA EN 10250.
- I. Kitchen Hood Exhaust Fans: Comply with requirements of NFPA 96 and UL 762.

2.03 DOWNBLAST ROOF EXHAUSTER

- A. Manufacturers:
 - 1. Loren Cook; ACE: www.lorencook.com
 - 2. Greenheck Fan Corporation; MODEL G: www.greenheck.com
 - 3. Twin City Fan & Blower; BCRD: www.tcf.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Fan Unit: Direct drive preferred unless noted otherwise, 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.
- C. Roof Curb: 16 inch high self-flashing of galvanized steel with continuously welded seams, built-in cant strips.
- D. Disconnect Switch: Factory wired, non-fusible, on external housing for thermal overload protected motor and wall mounted multiple speed switch.
- E. Backdraft Damper or Motorized as indicated, aluminum multiple blade construction, neoprene edged with offset hinge pin, nylon bearings, blades linked, and line voltage motor drive, power open, spring return.
- F. Sheaves: For V-belt drives, provide cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheave selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

2.04 WALL EXHAUSTERS

- A. Manufacturers:
 - 1. Loren Cook; _____: www.lorencook.com
 - 2. Greenheck Fan Corporation; _____: www.greenheck.com
- B. Fan Unit: Direct drive as indicated with spun aluminum housing; resiliently mounted motor; 1/2 inch mesh, 0.062 inch thick aluminum wire bird screen.
- C. Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload protected motor, and wall mounted multiple speed switch.
- D. Backdraft Damper Gravity or Motor actuated , aluminum multiple blade construction, neoprene edged with offset hinge pin, nylon bearings, blades linked.
- E. Sheaves: For V-belt drives, provide cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

2.05 UPBLAST ROOF EXHAUSTERS

- A. Manufacturers:
 - 1. Loren Cook; ACRU: www.lorencook.com
 - 2. Greenheck Fan Corporation; CUE: www.greenheck.com
- B. Direct Drive Fan:
 - 1. Fan Wheel:
 - a. Type: Non-overloading, backward inclined centrifugal.
 - b. Material: Aluminum.
 - 2. Statically and dynamically balanced.
 - 3. Motors:
 - a. Open drip-proof (ODP).
 - b. Heavy duty ball bearing type.
 - c. Mount on vibration isolators or resilient cradle mounts, out of air stream.
 - 4. Housing:
 - a. Construct of heavy gage aluminum including curb cap, windband, and motor compartment.
 - b. Rigid internal support structure.

- c. One-piece fabricated or fully welded curb-cap base to windband for leak proof construction.
 - d. Provide breather tube for fresh air motor cooling and wiring.
- C. Shafts and Bearings:
 - 1. Fan Shaft:
 - a. Ground and polished steel with anti-corrosive coating.
 - b. First critical speed at least 25 percent over maximum cataloged operating speed.
 - 2. Bearings:
 - a. Permanently sealed or pillow block type.
 - b. Minimum L10 life in excess of 100,000 hours (equivalent to L50 average life of 500,000 hours), at maximum cataloged operating speed.
 - c. 100 percent factory tested.
- D. Disconnect Switches:
 - 1. Factory mounted and wired.
 - 2. Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Outdoor Locations: Type 3R.
 - 3. Positive electrical shutoff.
 - 4. Wired from fan motor to junction box installed within motor compartment.
- E. Roof Curb: 16 inch high self-flashing of galvanized steel with continuously welded seams, built-in cant strips, insulation and curb bottom, curb bottom, and factory installed nailer strip.
- F. Drain Trough: Allows for single-point drainage of water, grease, and other residues.
- G. Options/Accessories:
 - 1. Birdscreen:
 - a. Provide galvanized steel construction.
 - 2. Dampers: Provide motorized type.

2.06 INLINE CENTRIFUGAL FANS

- A. Manufacturers:
 - 1. Greenheck Fan Corporation; _____: www.greenheck.com/#sle.
 - 2. Loren Cook Company; _____: www.lorencook.com/#sle.
 - 3. Twin City Fan & Blower; BSI: www.tcf.com/#sle.
- B. Centrifugal Fan Unit: V-belt or direct driven with galvanized steel housing lined with acoustic insulation, resilient mounted motor, gravity backdraft damper in discharge.
- C. Disconnect Switch: Cord and plug in housing for thermal overload protected motor and wall mounted switch.
- D. Sheaves: Cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required rpm is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

2.07 KITCHEN HOOD UPBLAST ROOF EXHAUSTERS

- A. Manufacturers:
 - 1. Greenheck Fan Corporation; _____: www.greenheck.com/#sle.
 - 2. Twin City Fan & Blower; BCRUR: www.tcf.com/#sle.
 - 3. Lauren Cook.
- B. Direct Drive Fan:
 - 1. Fan Wheel:
 - a. Type: Non-overloading, backward inclined centrifugal.
 - b. Material: Aluminum.
 - 2. Statically and dynamically balanced.
 - 3. Motors:

- a. Open drip-proof (ODP).
 - b. Heavy duty ball bearing type.
 - c. Mount on vibration isolators or resilient cradle mounts, out of air stream.
 - d. Fully accessible for maintenance.
- 4. Housing:
 - a. Construct of heavy gage aluminum, windband, and motor compartment.
 - b. Rigid internal support structure.
 - c. One-piece fabricated base to windband for leak proof construction.
 - d. Construct drive frame assembly of heavy gage steel, mounted on vibration isolators.
 - e. Provide breather tube for fresh air motor cooling and wiring.
- C. Shafts and Bearings:
 - 1. Fan Shaft:
 - a. Ground and polished steel with anti-corrosive coating.
 - b. First critical speed at least 25 percent over maximum cataloged operating speed.
 - 2. Bearings:
 - a. Permanently sealed or pillow block type.
 - b. Minimum L10 life in excess of 100,000 hours (equivalent to L50 average life of 500,000 hours), at maximum cataloged operating speed.
 - c. 100 percent factory tested.
- D. Drive Assembly:
 - 1. Belts, pulleys, and keys oversized for a minimum of 150 percent of driven horsepower.
 - 2. Belts: Static free and oil resistant.
 - 3. Fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.
 - 4. Motor pulley adjustable for final system balancing.
 - 5. Readily accessible for maintenance.
- E. Disconnect Switches:
 - 1. Factory mounted and wired.
 - 2. Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Outdoor Locations: Type 3R.
 - 3. Finish for Painted Steel Enclosures: Provide manufacturer's standard, factory applied gray, or _____ unless otherwise indicated.
 - 4. Positive electrical shutoff.
 - 5. Wired from fan motor to junction box installed within motor compartment.
- F. Roof Curb: 16 inch high self-flashing of galvanized steel with continuously welded seams, built-in cant strips, insulation and curb bottom, curb bottom, ventilated double wall, factory installed nailer strip, and _____.
- G. Drain Trough: Allows for single-point drainage of water, grease, and other residues.
- H. Options/Accessories:
 - 1. Automatic Belt Tensioner: Automatic device that adjusts for correct belt tension for single drives.
 - 2. Birdscreen:
 - a. Provide galvanized steel construction.
 - b. Protects fan discharge.
 - 3. Clean Out Port: Removable grease repellent compression rubber plug allows access for cleaning wheel through windband.
 - 4. Roof Curb Extension: Vented curb extension where required for compliance with minimum clearances required by NFPA 96.
 - 5. Dampers: Provide motorized type.
 - 6. Drain Connection:
 - a. Aluminum construction.

- b. Allows single-point drainage of grease, water, or other residues.
- 7. Finishes: Factory primed.
- 8. Grease Trap:
 - a. Aluminum.
 - b. Includes drain connection.
 - c. Collects grease residue.
- 9. Hinge Kit:
 - a. Aluminum hinges.
 - b. Hinges and restraint cables mounted to base (sleeve).
 - c. Allows fan to tilt away for access to wheel and ductwork for inspection and cleaning.
- 10. Heat Baffle: Prevents heat from radiating into motor compartment.
- 11. Tie-down Points: Four brackets located on windband secures fan in heavy wind applications.
- 12. External motor speed controllers for field mounting.

2.08 UTILITY VENT SET

- A. Manufacturers:
 - 1. Greenheck Fan Corporation; _____: www.greenheck.com/#sle.
 - 2. Loren Cook Company; _____: www.lorencook.com/#sle.
 - 3. Twin City Fan & Blower; BCF: www.tcf.com/#sle.
- B. Direct Drive Fan:
 - 1. Fan Wheel:
 - a. Type: Non-overloading, backward inclined centrifugal.
 - b. Material: Aluminum.
 - 2. Statically and dynamically balanced.
 - 3. Motors:
 - a. Open drip-proof (ODP).
 - b. Heavy duty ball bearing type.
 - c. Mount on vibration isolators or resilient cradle mounts, out of air stream.
 - d. Fully accessible for maintenance.
 - 4. Housing:
 - a. Construct of heavy gage aluminum including curb cap, windband, and motor compartment.
 - b. Rigid internal support structure.
 - c. One-piece fabricated or fully welded curb-cap base to windband for leak proof construction.
 - d. Construct drive frame assembly of heavy gage steel, mounted on vibration isolators.
 - e. Provide breather tube for fresh air motor cooling and wiring.
- C. Shafts and Bearings:
 - 1. Fan Shaft:
 - a. Ground and polished steel with anti-corrosive coating.
 - b. First critical speed at least 25 percent over maximum cataloged operating speed.
 - 2. Bearings:
 - a. Permanently sealed or pillow block type.
 - b. Minimum L10 life in excess of 100,000 hours (equivalent to L50 average life of 500,000 hours), at maximum cataloged operating speed.
 - c. 100 percent factory tested.
- D. Drive Assembly:
 - 1. Belts, pulleys, and keys oversized for a minimum of 150 percent of driven horsepower.
 - 2. Belts: Static free and oil resistant.
 - 3. Fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.
 - 4. Motor pulley adjustable for final system balancing.

5. Readily accessible for maintenance.
- E. Disconnect Switches:
 1. Factory mounted and wired.
 2. Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Outdoor Locations: Type 3R.
 3. Positive electrical shutoff.
 4. Wired from fan motor to junction box installed within motor compartment.
- F. Roof Curb: 16 inch high; self-flashing of galvanized steel with continuously welded seams, built-in cant strips, insulation and curb bottom, curb bottom, and factory installed nailer strip.
- G. Drain Trough: Allows for single-point drainage of water, grease, and other residues.
- H. Options/Accessories:
 1. Automatic Belt Tensioner: Automatic device that adjusts for correct belt tension for single drives.
 2. Birdscreen:

2.09 LABORATORY AND FUME EXHAUST

- A. Manufacturers:
 1. Strobic Air Corporation; _____: www.strobicair.com/#sle.
 2. Greenheck .
- B. General Requirements:
 1. Provide fan types tested in accordance with AMCA 210, AMCA 260 (Induced Flow Fans) and AMCA 300 in an AMCA-accredited laboratory.
 2. Provide fan units rated in accordance with AMCA 211 and AMCA 311.
- C. Fan Assemblies:
 1. Provide unit suitable for maintaining structural integrity and operation in 125 mph wind without external guy-wires or supplemental supports when mounted on manufacturer-supplied roof curbs.
- D. Direct or Belt Drive Fan:to fit application
 1. Fan Wheel:
 - a. Type: Non-overloading, backward inclined centrifugal.
 - b. Material: Aluminum.
 2. Statically and dynamically balanced.
 3. Motors:
 - a. Open drip-proof (ODP).
 - b. Heavy duty ball bearing type.
 - c. Mount on vibration isolators or resilient cradle mounts, out of air stream.
 - d. Fully accessible for maintenance - preferred out of airstream.
- E. Shafts and Bearings:
 1. Fan Shaft:
 - a. Ground and polished steel with anti-corrosive coating.
 - b. First critical speed at least 25 percent over maximum cataloged operating speed.
 2. Bearings:
 - a. Permanently sealed or pillow block type.
 - b. Minimum L10 life in excess of 100,000 hours (equivalent to L50 average life of 500,000 hours), at maximum cataloged operating speed.
 - c. 100 percent factory tested.
- F. Drive Assembly:
 1. Belts, pulleys, and keys oversized for a minimum of 150 percent of driven horsepower.
 2. Belts: Static free and oil resistant.
 3. Fully machined cast iron type, keyed and securely attached to the wheel and motor shafts.

4. Motor pulley adjustable for final system balancing.
 5. Readily accessible for maintenance.
- G. Disconnect Switches:
1. Factory mounted and wired.
 2. Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Outdoor Locations: Type 3R.
- H. High Plume Discharge Nozzle:
1. Provide combination discharge nozzle and windband to induce ambient airflow from outside fan housing and increase discharge velocities to velocities that comply with ANSI Z9.5, minimum 3,000 fpm.
 2. Provide a windband with a minimum of 120 inches discharge height above the roof surface.
- I. Roof Curb: 16 inch high self-flashing of galvanized steel with continuously welded seams, built-in cant strips, insulation and curb bottom, curb bottom, ventilated double wall, and factory installed nailer strip
- J. Isolation Dampers:
1. Parallel blade design, constructed of 304 stainless steel.
- K. Options/Accessories:
1. Birdscreen: Galvanized steel construction for fan discharge protection.
 2. Dampers: Provide motorized type.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Secure roof exhausters with stainless 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 Motorized dampers on inlet to roof and wall exhausters.

END OF SECTION 23 3423

**SECTION 23 3600
AIR TERMINAL UNITS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Single-duct terminal units.
 - 1. Single-duct, constant-volume units.
 - 2. Single-duct, variable-volume units.
- B. Fan-powered units.

1.02 RELATED REQUIREMENTS

- A. Section 23 0513 - Common Motor Requirements for HVAC Equipment.
- B. Section 23 0548 - Vibration and Seismic Controls for HVAC.
- C. Section 23 0913 - Instrumentation and Control Devices for HVAC: Thermostats and actuators.
- D. Section 23 0923 - Direct-Digital Control System for HVAC.
- E. Section 23 0993 - Sequence of Operations for HVAC Controls.
- F. Section 23 2113 - Hydronic Piping: Connections to heating coils.
- G. Section 23 2114 - Hydronic Specialties: Connections to heating coils.
- H. Section 23 3100 - HVAC Ducts and Casings.
- I. Section 23 3300 - Air Duct Accessories.
- J. Section 23 3700 - Air Outlets and Inlets.
- K. Section 23 8200 - Convection Heating and Cooling Units: Air coils.
- L. Section 25 1400 - Integrated Automation Local Control Units: HVAC controllers.
- M. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. AHRI 410 - Standard for 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. AHRI 885 - Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Air Outlets; 2008 with Addendum 1.
- D. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size; 2012, with 2015 amendments.
- E. ASHRAE Std 130 - Methods of Testing Air Terminal Units; 2008 (R2014).
- F. ASTM A492 - Standard Specification for Stainless Steel Rope Wire; 1995 (Reapproved 2013).
- G. ASTM A603 - Standard Specification for Metallic-Coated Steel Structural Wire Rope; 2019.
- H. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2023d.
- I. ASTM E488/E488M - Standard Test Methods for Strength of Anchors in Concrete Elements; 2015.
- J. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- K. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- L. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2015.
- M. SMACNA (SRM) - Seismic Restraint Manual Guidelines for Mechanical Systems; Sheet Metal and Air Conditioning Contractors' National Association; 2008.

- N. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; current edition, including all revisions.
- O. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.
- B. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.
- C. Only Fan Powered Boxes need Asset tagged

1.05 SUBMITTALS

- A. See Section 01 3000 - 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.
- D. Certificates: Certify that coils are tested and rated in accordance with AHRI 410.
- E. Manufacturer's Installation Instructions: Indicate support and hanging details, installation instructions, recommendations, and service clearances required.
- F. Project Record Documents: Record actual locations of units and locations of access doors required for access of valving.
- G. 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.
- H. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.07 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturer warranty for air terminal units.

PART 2 PRODUCTS

2.01 SINGLE-DUCT, VARIABLE-VOLUME AND CONSTANT-VOLUME UNITS

- A. Manufacturers:
 - 1. Price Industries, Inc; SDV: www.priceindustries.com
 - 2. Trane, a brand of Trane Technologies; VCC, VCW, VCE: www.trane.com
 - 3. Titus; www.titus-hvac.com DESV.
- B. Basis of Design: Trane.
 - 1. Single-Duct Terminal Unit: SDV, (direct digital controls).
- C. General:

1. Factory-assembled, AHRI 880 (I-P) rated and bearing the AHRI seal, air volume control terminal with digital controls, 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.
 3. No smaller than 6" inlet duct connection.
- D. Unit Casing:
1. Minimum 22 gage, 0.0299 inch galvanized steel.
 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. Patient care Sites - 1" Double Wall insulation 1Lb
 - b. Non Patient care sites - 1" foil faced insulation 1.5Lb
- E. 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.
 - a. Air Leakage Past Closed Damper: Maximum two percent of unit maximum airflow at 3 inch wg inlet static pressure, tested in accordance with ASHRAE Std 130.
- F. 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. Access Door: Gasketed and insulated located Upstream of the coil.
 2. Coil Fins: Aluminum or aluminum plated fins, mechanically-bonded to seamless copper tubes.
 - a. Minimum two rows with maximum ten fins-per-inch heating capacity density.
 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.
- G. Electric Heating Coil:
1. Listed and provided by the terminal unit manufacturer.
 2. Coil Casing: 20 gage, 0.0359 inch galvanized steel.
 3. Heating Elements: Nickel chrome, supported by ceramic insulators.
 4. Integral Control Panel: NEMA EN 10250, Type 2 enclosure with hinged access door for access to all controls and safety devices.
 5. Furnish a primary automatic reset thermal cutout and differential pressure airflow switch for proof of airflow.
 6. Provide the following additional components, mounted and/or wired within the control enclosure:
 - a. Fused or non-fused door interlocking disconnect switch.
 - b. Mercury contactors.
 - c. Fuse block.
 7. Factory wired, including all limit switches and steps of control as indicated on the equipment schedule, with the SSR (solid-state relay) proportional heat control.
- H. Electrical Requirements:
1. Single-point power connection.
 2. Equipment wiring to comply with requirements of NFPA 70.
- I. Control Transformers: Factory supplied and mounted for electric and electronic control applications.

J. Controls:

1. DDC (Direct-Digital Controls):
 - a. Basis of Design: Trane Tracer Ensemble.
 - 1) The unit level controller to include the following:
 - (a) 24 VAC power terminal
 - (b) T-Stat Port for thermostat connection.
 - (c) Service Port for Price Linker diagnostic equipment.
 - (d) Damper actuator.
 - (e) Fan output connection.
 - (f) LED indication for troubleshooting.
 - (g) Three binary staged heating outputs.
 - (h) Binary cooling output.
 - (i) Discharge air temperature sensor input.
 - (j) Thermal cutout or safety trip in
 - (k) Fan Power speed
 - 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.
 - 5) Time-proportional reheat coil control.
 - d. Room Sensor:
 - 1) Compatible with temperature controls specified.
 - 2) Wall-mounted, with digital display.
 - 3) Wireless connection to controller
 - e. See Section 25 1400.
2. Control Sequence:
 - a. Suitable for operation with duct pressures between 0.25 and 3.0 inch wg inlet static pressure.
 - b. Include factory-mounted and piped, 5-micron filter; and adjustable, velocity-resetting, high-limit control with amplifying relay.
 - c. See Section 23 0993.

2.02 FAN-POWERED PARALLEL UNITS

- A. Manufacturers:
 1. Price Industries, Inc: www.priceindustries.com/#sle.
 2. Trane, a brand of Trane Technologies: www.trane.com/#sle.
 3. Titus: www.titus-hvac.com.
- B. Basis of Design: Trane.
 1. Variable-Volume Parallel Fan-Powered Unit: _____.
- C. General:
 1. Factory-assembled and wired, AHRI 880 (I-P) rated, horizontal fan-powered terminal unit with digital controls, blower, blower motor, mixing plenum, and primary air damper contained in a single unit housing.
- D. Unit Casing:
 1. Minimum 22 gage, 0.0299 inch galvanized steel.
 2. Primary Air Inlet Collar: Suitable for standard flexible duct sizes.
 3. Unit Discharge: Rectangular, suitable for flanged duct connection.
 4. Plenum Inlet: Filter rack with disposable filters.

- a. Minimum Efficiency Reporting Value (MERV): MERV-8, when tested in accordance with ASHRAE Std 52.2.
- 5. Acceptable Liners:
- E. Primary Air Damper Assembly:
 - 1. Heavy-gage, galvanized steel or extruded aluminum construction with solid shaft rotating in bearings.
 - 2. Provide indicator on damper shaft or alternative method for indicating damper position over full range of 90 degrees.
 - 3. Incorporate low leak (2 percent) damper blades for tight airflow shutoff.
 - 4. Fan(s): Forward curved, centrifugal type.
 - 5. Fan Motor:
 - a. ECM (Electrically Commutated Motor):
 - 1) Brushless DC controlled by an integrated controller/inverter that operates the wound stator and senses rotor position to electrically commutate the stator.
 - 2) Permanent magnet type motor with near-zero rotor losses designed for synchronous rotation.
 - 3) Designed to maintain 70 percent efficiency over the entire operating range.
 - b. Fan motor shaft directly connected to fan and isolated from unit casing to prevent transmission of vibration.
- F. Electric Heating Coil:
 - 1. Listed and provided by the terminal unit manufacturer.
 - 2. Coil Casing: Minimum 20 gage, 0.0359 inch galvanized steel.
 - 3. Heating Elements: Open wire, nickel chrome, supported by ceramic insulators.
 - 4. Integral Control Panel: NEMA EN 10250, Type 2 enclosure, with hinged access door for access to all controls and safety devices.
 - 5. Provide a primary automatic reset thermal cutout and differential pressure airflow switch for proof of airflow or electrical interlock to prevent heater operation when fan is not running.
 - 6. Provide the following additional components, mounted and/or wired within the control enclosure:
 - a. Fused or non-fused door interlocking disconnect switch.
 - b. Mercury contactors.
 - c. Fuse block.
- G. Hot Water Heating Coil:
 - 1. Coil Casing: Minimum 22 gage, 0.0299 inch galvanized steel, factory-installed on terminal unit with flanged discharge for attachment to downstream ductwork.
 - 2. Copper Tubes: 0.016 inch minimum wall thickness with male solder header connections.
 - 3. Coil leak tested to minimum 305 psig.
 - 4. Base performance data on tests run in accordance with AHRI 410.
 - 5. Minimum [two] rows with maximum ten fins-per-inch heating capacity density.
- H. Electrical Requirements:
 - 1. Single-point power connection.
 - 2. Equipment wiring to comply with requirements of NFPA 70.
- I. Controls:
 - 1. DDC (Direct-Digital Controls):
 - a. Basis of Design: Trane Tracer Ensemble.
 - 1) The unit level controller to include the following:
 - (a) 24 VAC power terminal
 - (b) T-Stat Port for thermostat connection.
 - (c) Service Port for Price Linker diagnostic equipment.
 - (d) Damper actuator.
 - (e) Fan output connection.

- (f) LED indication for troubleshooting.
 - (g) Three binary staged heating outputs.
 - (h) Binary cooling output.
 - (i) Discharge air temperature sensor input.
 - (j) Contact closure input.
 - (k) Fan Speed
 - b. Include a factory-installed, unit-mounted, direct-digital controller.
 - c. Bi-directional Damper Actuator: 24 volt, powered closed, spring return open.
 - d. 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.
 - e. Room Sensor:
 - 1) Compatible with temperature controls specified.
 - 2) Wall-mounted with Digital Display
 - 3) Wireless connection to controller.
2. Control Sequence: See Section 23 0993.

PART 3 EXECUTION

3.01 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. See drawings for the size(s) and duct location(s) of the air terminal units.
- D. Provide ceiling access doors or locate units above easily removable ceiling components.
- E. Support units individually from structure with wire rope complying with ASTM A492 and ASTM A603 in accordance with SMACNA (SRM). See Section 23 0548.
- F. Embed anchors in concrete in accordance with ASTM E488/E488M.
- G. Do not support from ductwork.
- H. Connect to ductwork in accordance with Section 23 3100.
- I. Verify that electric power is available and of the correct characteristics.
- J. For exam and patient rooms with an exterior wall, each room is to have its own VAV box and thermostat. For rooms with an exterior window they will also have ceiling mounted radiant heater.
- K. Medication storage rooms are to be supplied with a dedicated VAV box and thermostat.

3.02 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 50 percent full flow.

3.03 CLEANING

- A. See Section 01 7419 - Construction Waste Management and Disposal, for additional requirements.
- B. Vacuum clean coils and inside of units.
- C. Install new filters.

END OF SECTION 23 3600

SECTION 23 3700
AIR OUTLETS AND INLETS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Diffusers.
 - 1. Critical environment diffusers.
 - 2. Perforated ceiling diffusers.
- B. Rectangular ceiling diffusers.
- C. Slot ceiling diffusers.
- D. Registers/grilles.
 - 1. Ceiling-mounted, egg crate exhaust and return register/grilles.
 - 2. Ceiling-mounted, exhaust and return register/grilles.
 - 3. Wall-mounted, supply register/grilles.
 - 4. Wall-mounted, exhaust and return register/grilles.
- E. Duct-mounted supply and return registers/louvers.
- F. Louvers.
 - 1. Combination louvers.
- G. Roof hoods.

1.02 RELATED REQUIREMENTS

- A. Section 09 9123 - Interior Painting: Painting of ducts visible behind outlets and inlets.

1.03 REFERENCE STANDARDS

- A. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating; 2012.
- B. ASHRAE Std 70 - Method of Testing the Performance of Air Outlets and Inlets; 2006 (R2011).
- C. SMACNA (ASMM) - Architectural Sheet Metal Manual; 2012.
- D. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.

1.04 SUBMITTALS

- A. See Section 01 3000 - 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 air outlet and inlet performance in accordance with ASHRAE Std 70.
- B. Test and rate louver performance in accordance with AMCA 500-L.
- C. 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 MANUFACTURERS

- A. Hart & Cooley, Inc; _____: www.hartandcooley.com/#sle.
- B. Price Industries; _____: www.priceindustries.com/#sle.
- C. Ruskin Company; _____: www.ruskin.com/#sle.
- D. Titus HVAC, Inc.; _____: www.titus-hvac.com/#sle.
- E. Substitutions: See Section 01 6000 - Product Requirements.

2.02 RECTANGULAR CEILING DIFFUSERS

- A. Manufacturers:
 - 1. Price Industries; SPD: www.priceindustries.com/#sle.
 - 2. Titus HVAC, Inc; OMNI: www.titus-hvac.com/#sle.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Type: Provide square plaque diffuser to discharge air in 360 degree radial, horizontal airflow pattern.
- C. Connections: Round.
- D. Frame: Provide surface mount, snap-in, inverted T-bar, and spline type.
- E. Fabrication: Steel with baked enamel finish. In areas where moisture can be present, the diffuser shall be aluminum.
- F. Color: As indicated.

2.03 CEILING SLOT DIFFUSERS

- A. Manufacturers:
 - 1. Price Industries; SDS: www.priceindustries.com/#sle.
 - 2. Titus HVAC, Inc.; ML-39: www.titus-hvac.com/#sle.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Type: Continuous 1 inch wide slot, 1 to 4 slots wide, with adjustable vanes for left, right, or vertical discharge.
- C. Fabrication: Aluminum extrusions with factory baked enamel finish.
- D. Color: As indicated.
- E. Plenum: Integral, galvanized steel, un-insulated.
- F. Not preferred installed directly into spiral due to noise.

2.04 CEILING EXHAUST AND RETURN REGISTERS/GRILLES

- A. Manufacturers:
 - 1. Price Industries; _____: www.priceindustries.com/#sle.
 - 2. Titus HVAC, Inc; []: www.titus-hvac.com/#sle
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with blades set at 45 degrees, vertical face.
- C. Frame: 1-1/4 inch margin with countersunk screw mounting.
- D. Fabrication: Steel with 20 gage, 0.0359 inch minimum frames and 22 gage, 0.0299 inch minimum blades, steel and aluminum with 20 gage, 0.0359 inch minimum frame, or aluminum extrusions, with factory baked enamel finish.
- E. Color: As indicated.

2.05 CEILING EGG CRATE EXHAUST AND RETURN GRILLES

- A. Type: Egg crate style face consisting of 1/2 by 1/2 by 1/2 inch, 1/2 by 1/2 by 1 inch, and 1 by 1 by 1 inch grid core.
- B. Fabrication: Grid core consists of aluminum with mill aluminum finish.
- C. Color: As indicated.
- D. Frame: Channel lay-in frame for suspended grid ceilings.

2.06 WALL SUPPLY REGISTERS/GRILLES

- A. Type: Streamlined and individually adjustable curved blades to discharge air along face of grille with two-way deflection.
- B. Frame: 1-1/4 inch margin with countersunk screw mounting and gasket.

- C. Fabrication: Aluminum extrusions with factory clear lacquer finish.
- D. Color: As indicated.
- E. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.

2.07 WALL EXHAUST AND RETURN REGISTERS/GRILLES

- A. Type: Streamlined blades, 3/4 inch minimum depth, 3/4 inch maximum spacing, with spring or other device to set blades, vertical face.
- B. Frame: 1-1/4 inch margin with countersunk screw mounting.
- C. Fabrication: Aluminum extrusions, with factory baked enamel finish.
- D. Color: As indicated on the drawings.
- E. Damper: Integral, gang-operated, opposed blade type with removable key operator, operable from face.
- F. Low Wall Return to be HD resistant to Chemicals.

2.08 CRITICAL ENVIRONMENTS DIFFUSERS

- A. Laminar Flow Diffusers:
 - 1. Construction: Aluminum .
 - 2. Frame: Provide framing per manufacturer's recommendations.

2.09 LOUVERS

- A. Manufacturers:
 - 1. NCA, a brand of Metal Industries Inc; _____: www.ncamfg.com/#sle.
 - 2. Ruskin Company; _____: www.ruskin.com/#sle.
 - 3. American Warming and Ventilating.
- 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. Fabrication: 16 gage, 0.0598 inch thick galvanized steel welded assembly, with factory prime coat finish.
- D. Color: As indicated.
- E. Mounting: Furnish with interior flat flange for installation. include drainable drains.
- F. Size outside air intake louvers to keep velocity low enough to not entrain rain and snow into the AHU.

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.
- C. Check location of outlets and inlets and make necessary adjustments in position to comply with architectural features, symmetry, and lighting arrangement.
- D. Install diffusers to ductwork with air tight connection.
- E. Provide balancing dampers on duct take-off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.
- F. Paint ductwork visible behind air outlets and inlets matte black. Refer to Section 09 9123.

END OF SECTION 23 3700

**SECTION 23 4000
HVAC AIR CLEANING DEVICES**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Disposable, extended area panel filters.
- B. Disposable panel filters.
- C. Extended surface high efficiency media filters.
- D. High efficiency particulate air (HEPA) filters.
- E. Filter frames and housings.
- F. Filter gauges.

1.02 RELATED REQUIREMENTS

- A. Section 01 5000 - Temporary Facilities and Controls: Filters for temporary heating and ventilating.

1.03 REFERENCE STANDARDS

- A. AHRI 850 (I-P) - Performance Rating of Commercial and Industrial Air Filter Equipment; 2013 (Reaffirmed 2023).
- B. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size; 2012, with 2015 amendments.
- C. MIL-STD-282 - Filter Units, Protective Clothing, Gas-Mask Components, and Related Products: Performance-Test Methods; 2012.
- D. UL 586 - High Efficiency, Particulate, Air Filter Units; Current Edition, Including All Revisions.
- E. UL 900 - Standard for Air Filter Units; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data on filter media, filter performance data, filter assembly and filter frames, dimensions, motor locations and electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate filter assembly and filter frames, dimensions, motor locations, and electrical characteristics and connection requirements.
- D. Manufacturer's Installation Instructions: Indicate assembly and change-out procedures.
- E. Operation and Maintenance Data: Include instructions for operation, changing, and periodic cleaning.

PART 2 PRODUCTS

2.01 FILTER MANUFACTURERS

- A. American Filtration Inc; _____: www.americanfiltration.com/#sle.
- B. AAF International/American Air Filter; _____: www.aafintl.com/#sle.
- C. The Camfil Group; _____: www.camfilfarr.com/#sle.

2.02 DISPOSABLE, EXTENDED AREA PANEL FILTERS

- A. Media: UL 900 Class 1, pleated, lofted, non-woven, reinforced cotton fabric; supported and bonded to welded wire grid by corrugated aluminum separators.
 - 1. Frame: Non-flammable.
 - 2. Nominal size: 24 by 24 inches.
 - 3. Nominal thickness: 2 inches.
- B. Minimum Efficiency Reporting Value (MERV): 8, when tested in accordance with ASHRAE Std 52.2.

- C. Rating, per ASHRAE Std 52.2:
 - 1. Weight arrestance: 85 percent.
 - 2. Initial resistance at 500 FPM face velocity: 0.20 inch WG.
 - 3. Recommended final resistance: 0.9 inch WG.

2.03 EXTENDED SURFACE HIGH EFFICIENCY MEDIA FILTERS

- A. Media: Pleated, water-resistant glass fiber with aluminum separators; in 16 gage, 0.0598 inch steel holding frame with corrosion resistant coating.
 - 1. Nominal Size: 24 by 24 by 6 inches deep.
- B. Minimum Efficiency Reporting Value (MERV): 15, when tested in accordance with ASHRAE Std 52.2.
- C. Performance Rating, per ASHRAE Std 52.2:
 - 1. MIL-STD-282 Test 0.3 Micron Dioctyl Phthalate Smoke (DOP) Efficiency: 99 percent.
 - 2. Initial Resistance at 150 fpm Face Velocity: 0.35 inch WG.
 - 3. Recommended Final Resistance: 1.5 inch WG.

2.04 HIGH EFFICIENCY PARTICULATE AIR (HEPA) FILTERS

- A. Media: UL 586, pleated, water-resistant glass fiber with separators of aluminum:
 - 1. Holding Frame: Galvanized steel.
 - 2. Media to Frame Side Bond: Polyurethane foam.
 - 3. Face Gasket: Silicone.
 - 4. Nominal Size: 24 by 24 by 12 inches deep.
- B. Minimum Efficiency Reporting Value (MERV): 15, when tested in accordance with ASHRAE Std 52.2.
- C. Performance Rating:
 - 1. MIL-STD-282 Test 0.3 Micron Dioctyl Phthalate Smoke (DOP) Efficiency: 99.97 percent.
 - 2. Rated Air Flow Capacity at 1.0 inch WG: 1150 CFM.
 - 3. Recommended Final Resistance: 3.0 inch WG.

2.05 FILTER FRAMES AND HOUSINGS

- A. General: Fabricate filter frames and supporting structures of 16 gage, 0.0598 inch galvanized steel or extruded aluminum T-section construction with necessary gasketing between frames and walls.
- B. Standard Sizes: Provide for interchangeability of filter media of other manufacturers; for panel filters, size for 24 by 24 inches filter media, minimum 2 inches thick; for extended surface and high efficiency particulate air filters, provide for upstream mounting of panel filters.
- C. Side Servicing Housings: Flanged for insertion into ductwork, of reinforced 16 gage, 0.0598 inch galvanized steel; access doors with continuous gasketing and positive locking devices on both sides; extruded aluminum tracks or channels for primary secondary filters with positive sealing gaskets.

2.06 FILTER GAUGES

- A. Manufacturers:
 - 1. Dwyer Instruments, Inc; _____: www.dwyer-inst.com/#sle.
 - 2. H.O. Trerice Co; _____: www.trerice.com/#sle.
 - 3. Weiss Instruments; _____: www.weissinstruments.com/#sle.
- B. Direct Reading Dial: 3-1/2 inch diameter diaphragm actuated dial in metal case, vent valves, black figures on white background, front recalibration adjustment, range 0-0.5 inch WG, 2 percent of full scale accuracy.
- C. Inclined Manometer: One piece molded plastic with epoxy coated aluminum scale, inclined-vertical indicating tube and built-in spirit level, range 0-3 inch WG, 3 percent of full scale accuracy.

- D. Accessories: Static pressure tips with integral compression fittings, 1/4 inch aluminum tubing, 2-way or 3-way vent valves.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install air cleaning devices in accordance with manufacturer's instructions.
- B. Prevent passage of unfiltered air around filters with proper gasketing material.
- C. Install filter gauge static pressure tips upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum, in accessible position. Adjust and level.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with clean set.
- E. Provide filter gauges on filter banks, installed with separate static pressure tips upstream and downstream of filters.
- F. All air handling units installed with HEPA filters shall be HEPA certified as part of the installation, startup and commissioning process.

END OF SECTION 23 4000

**SECTION 23 5100
BREECHINGS, CHIMNEYS, AND STACKS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Field fabricated breechings.
- B. Manufactured breechings.
- C. Type B double wall gas vents.
- D. Double wall metal stacks.
- E. Induced draft fans.
- F. Stationary auxiliary power generator engine exhaust piping.

1.02 RELATED REQUIREMENTS

- A. Section 07 8400 - Firestopping.
- B. Section 21 0716 - Fire Suppression Equipment Insulation.
- C. Section 22 0513 - Common Motor Requirements for Plumbing Equipment: Induced draft fan motor.
- D. Section 22 0716 - Plumbing Equipment Insulation.
- E. Section 22 0719 - Plumbing Piping Insulation.
- F. Section 23 0513 - Common Motor Requirements for HVAC Equipment: Induced draft fan motor.
- G. Section 23 0716 - HVAC Equipment Insulation.
- H. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.
- I. Section 26 3213 - Engine Generators: Exhaust silencer.

1.03 REFERENCE STANDARDS

- A. ANSI Z21.66 - American National Standard for Automatic Vent Damper Devices for Use with Gas-Fired Appliances; 1996 (R2006).
- B. ASME B16.5 - Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard; 2013.
- C. ASME B16.21 - Nonmetallic Flat Gaskets for Pipe Flanges; 2011.
- D. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless; 2012.
- E. ASTM A181/A181M - Standard Specification for Carbon Steel Forgings, for General - Purpose Piping; 2013.
- F. ASTM A193/A193M - Standard Specification for Alloy - Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications; 2014.
- G. ASTM A194/A194M - Standard Specification for Carbon and Alloy Nuts for Bolts for High Pressure or High Temperature Service, or Both; 2015.
- H. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service; 2015.
- I. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process; 2023.
- J. ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength; 2023.

- K. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation; 2009.
- L. NFPA 31 - Standard for the Installation of Oil Burning Equipment; 2011.
- M. NFPA 54 - National Fuel Gas Code; 2015.
- N. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- O. NFPA 82 - Standard on Incinerators and Waste and Linen Handling Systems and Equipment; 2014.
- P. NFPA 211 - Guide for Smoke and Heat Venting; 2013, Including All Amendments.
- Q. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- R. UL 103 - Factory-Built Chimneys for Residential Type and Building Heating Appliances; Current Edition, Including All Revisions.
- S. UL 378 - Standard for Draft Equipment; Current Edition, Including All Revisions.
- T. UL 441 - Standard for Gas Vents; Current Edition, Including All Revisions.
- U. UL 641 - Type L Low Temperature Venting Systems; Current Edition, Including All Revisions.
- V. UL 959 - Medium Heat Appliance Factory Built Chimneys; Current Edition, Including All Revisions.

1.04 DEFINITIONS

- A. Breeching: Vent connector.
- B. Chimney: Primarily vertical shaft enclosing at least one vent for conducting flue gases outdoors.
- C. Smoke Pipe: Round, single wall vent connector.
- D. Vent: That portion of a venting system designed to convey flue gases directly outdoors from a vent connector or from an appliance when a vent connector is not used.
- E. Vent Connector: That part of a venting system that conducts the flue gases from the flue collar of an appliance to a chimney or vent, and may include a draft control device.

1.05 DESIGN REQUIREMENTS

- A. Factory built vents and chimneys used for venting natural draft appliances to comply with NFPA 211 and be UL listed and labeled.
- B. Design refractory lined metal stacks for wind loading of 110 mph and seismic loads for Zone _____.

1.06 ADMINISTRATIVE REQUIREMENTS

- A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.
- B. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.07 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data indicating factory built chimneys, including dimensional details of components and flue caps, dimensions and weights, electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate general construction, dimensions, weights, support and layout of breechings. Submit layout drawings indicating plan view and elevations where factory built units are used.

- D. Manufacturer's Instructions: Include installation instructions, and indicate assembly, support details, and connection requirements.
- E. Manufacturer's Certificate: Certify that refractory lined metal stacks meet or exceed specified requirements.

1.08 QUALITY ASSURANCE

- A. Designer Qualifications: Design stacks under direct supervision of a Professional Structural Engineer experienced in design of the type of work specified and licensed in Michigan.
- B. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- C. Installer Qualifications: Company specializing in performing the type of work specified in this section with minimum 3 years documented experience, and approved by manufacturer.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. AMPCO by Hart & Cooley, Inc; Model VSI: www.ampcostacks.com/#sle.
- B. DuraVent; DuraStack Pro (DIS2): www.duravent.com/#sle.
- C. Metal-Fab, Inc; _____: www.mtlfab.com/#sle.
- D. Selkirk Corporation; Model PS: www.selkirkcommercial.com/#sle.
- E. Substitutions: See Section 01 6000 - Product Requirements.

2.02 BREECHINGS, CHIMNEYS, AND STACKS - GENERAL REQUIREMENTS

- A. Regulatory Requirements:
 - 1. Comply with applicable codes for installation of natural gas burning appliances and equipment.
 - 2. Comply with NFPA 31 for installation of oil burning appliances and equipment.
 - 3. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

2.03 FIELD FABRICATED BREECHINGS

- A. Breechings Less Than 24 inches in Diameter: Fabricate from Stainless steel sheet; make longitudinal seams using pipe lock or flat lock groove seam and make end joints beaded and crimped.
- B. Minimum Metal Thicknesses based on SMACNA (DCS):
 - 1. Sizes up to 12 inches: 18 gage, 0.0478 inch.
 - 2. Sizes 13 to 24 inches: 16 gage, 0.0598 inch.
- C. Provide adjustable self-actuating barometric draft dampers, where indicated on drawings, full size of breeching.
- D. Provide cleanout doors of same gage as breeching where indicated on drawings.
- E. Reinforcing: Provide angle frames for rectangular breeching and flanged girth joints or angle frames for round breeching in accordance with SMACNA (DCS), at following intervals:
 - 1. Sizes up to 30 inches: No reinforcing required.
- F. Fabricate breeching fittings to match adjoining breechings. Fabricate elbows with center-line radius equal to breeching width. Limit angular tapers to 20 degrees maximum.

2.04 MANUFACTURED BREECHINGS

- A. Provide factory-built, modular connector and manifold system, tested to UL 103 with positive pressure rating.
- B. Assembly to be UL listed for use with building equipment in compliance with NFPA 211.
- C. Fabricate with 1 inch minimum air space between walls and construct inner liner of 304 stainless steel and outer jacket of 304 stainless steel.

1. Protect aluminized steel surfaces exposed to the elements with a minimum of one base coat of primer and one finish coat of corrosion resistant paint suitable for outer jacket skin temperatures of the application.
- D. Design, fabricate, and install gas-tight preventing products of combustion leaking into the building.
 1. Securely connect inner joints and seal with factory supplied overlapping V-bands and appropriate sealant in accordance with manufacturer's instructions.
 2. System design to compensate for all flue gas induced thermal expansion.

2.05 TYPE B DOUBLE WALL GAS VENTS

- A. Fabrication: Inner pipe of sheet aluminum, and outer pipe of galvanized sheet steel, tested in compliance with UL 441.
- B. Electrically Actuated Vent Dampers: Same size as draft hood collar, constructed of stainless steel or galvanized steel, with corrosion-resistant components, in compliance with ANSI Z21.66.

2.06 DOUBLE WALL METAL STACKS

- A. Provide double wall metal stacks, tested to UL 103 and UL listed with positive pressure rating, for use with building heating equipment, in compliance with NFPA 211.
- B. Fabricate with 1 inch minimum air space between walls and construct inner liner of 304 stainless steel and outer jacket of AL29-4C stainless steel.
 1. Protect aluminized steel surfaces exposed to the elements with a minimum of one base coat of primer and one finish coat of corrosion resistant paint suitable for outer jacket skin temperatures of the application.
- C. Accessories, UL labeled:
 1. Ventilated Roof Thimble: Consists of roof penetration, vent flashing with spacers and storm collar.

2.07 INDUCED DRAFT FANS

- A. Mechanical Draft Induction Type:
 1. Venturi Tube Section Fabrication: Type 304 stainless steel.
 2. Fan: Forward curved venturi type, tested to UL 378, with shaded pole, sleeve bearing motor, refer to Section 22 0513.
- B. Induced Draft Type:
 1. Fabrication: Forward curved fan and scroll of mild steel with direct drive shaded pole motor with ball bearings, internal cooling fan, stainless steel shaft, and internal centrifugal switch, tested to UL 378.
- C. Capacity: _____ cu ft/min standard air at _____ inch negative static pressure, and _____ inch negative static pressure at tight suction shut-off.
- D. Electrical Characteristics:
 1. Motor: Refer to Section 22 0513.
 2. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.
 3. Disconnect Switch: Factory mount disconnect switch in control panel.
- E. Control: Refer to Section 26 2717.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install in accordance with NFPA 54.
- C. Install breechings with minimum of joints. Align accurately at connections, with internal surfaces smooth.

- D. Support breechings from building structure, rigidly with suitable ties, braces, hangers and anchors to hold to shape and prevent buckling. Support vertical breechings, chimneys, and stacks at 12 foot spacing, to adjacent structural surfaces, or at floor penetrations. Refer to SMACNA (DCS) for equivalent duct support configuration and size.
- E. Install concrete inserts for support of breechings, chimneys, and stacks in coordination with formwork.
- F. Pitch breechings with positive slope up from fuel-fired equipment to chimney or stack.
- G. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 07 8400.
- H. Coordinate installation of dampers, and induced draft fans. Refer to Section 26 0583.
- I. Insulate breechings in accordance with Section 22 0716.
- J. For Type B double wall gas vents, maintain UL listed minimum clearances from combustibles. Assemble pipe and accessories as required for complete installation.
- K. Assemble and install stack sections in accordance with NFPA 82, industry practices, and in compliance with UL listing. Join sections with acid-resistant joint cement. Connect base section to foundation using anchor lugs.
- L. Level and plumb chimney and stacks.
- M. Clean breechings, chimneys, and stacks during installation, removing dust and debris.
- N. At appliances, provide slip joints permitting removal of appliances without removal or dismantling of breechings, breeching insulation, chimneys, or stacks.
- O. Provide maximum 2 feet of breeching to connect appliance to chimney. Provide Type B chimney continuously from appliances.

END OF SECTION 23 5100

SECTION 23 5216 CONDENSING BOILERS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Manufactured units.
- B. Boiler construction.
- C. Boiler trim.
- D. Fuel burning system.
- E. Factory installed controls.

1.02 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete.
- B. Section 23 0913 - Instrumentation and Control Devices for HVAC.
- C. Section 23 2114 - Hydronic Specialties.
- D. Section 23 2123 - Hydronic Pumps.
- E. Section 23 2500 - HVAC Water Treatment.
- F. Section 23 5100 - Breechings, Chimneys, and Stacks.
- G. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI); current edition at www.ahrinet.org.
- B. AHRI 1500 (I-P) - Performance Rating of Commercial Space Heating Boilers; 2024.
- C. ANSI Z21.13 - American National Standard for Gas-Fired Low-Pressure Steam and Hot Water Boilers; 2022.
- D. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; 2013, Including All Amendments and Errata.
- E. ASHRAE Std 103 - Methods of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers; 2007, Including All Amendments.
- F. ASME BPVC-IV - Boiler and Pressure Vessel Code, Section IV - Rules for Construction of Heating Boilers; 2015.
- G. NBBI Manufacturer and Repair Directory - The National Board of Boiler and Pressure Vessel Inspectors (NBBI); current edition at www.nationalboard.org.
- H. NFPA 54 - National Fuel Gas Code; 2015.
- I. SCAQMD 1146.1 - Emissions of Oxides of Nitrogen from Small Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters; 1990, with Amendment (2018).

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.
- B. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.05 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittals procedures.
- B. Product Data: Provide data indicating general assembly, components, controls, safety controls, and wiring diagrams with electrical characteristics and connection requirements, and service connections.

- C. Manufacturer's Installation Instructions: Indicate assembly, support details, connection requirements, and include start up instructions.
- D. Manufacturer's Factory Inspection Report: Submit boiler inspection prior to shipment.
- E. Manufacturer's Field Reports: Burner manifold gas pressure, percent carbon monoxide (CO), percent oxygen (O), percent excess air, flue gas temperature at outlet, ambient temperature, net stack temperature, percent stack loss, percent combustion efficiency, and heat output.
 - 1. Indicate compliance with specified performance and efficiency.
 - 2. Provide results of the following combustion tests:
 - a. Boiler firing rate.
 - b. Over fire draft.
 - c. Gas flow rate.
 - d. Heat input.
 - e. Burner manifold gas pressure.
 - f. Percent carbon monoxide.
 - g. Percent oxides of nitrogen.
 - h. Percent oxygen.
 - i. Percent excess air.
 - j. Flue gas temperature at outlet.
 - k. Ambient temperature.
 - l. Net stack temperature.
 - m. Percent stack loss.
 - n. Percent combustion efficiency.
 - o. Heat output.
- F. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, cleaning procedures, replacement parts list, and maintenance and repair data.
- G. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.
- H. Software: Copy of software provided under this section.

1.06 QUALITY ASSURANCE

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

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Protect boilers from damage by leaving factory inspection openings and shipping packaging in place until final installation.

1.08 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide a five year warranty to include coverage for heat exchanger.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Natural Gas, Propane, or Combination Natural Gas/Propane for Indoor Applications:
 - 1. Aerco.
 - 2. Lochinvar LLC; _____: www.lochinvar.com/#sle.
 - 3. The Fulton Companies; _____: www.fulton.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.

2.02 MANUFACTURED UNITS

- A. Factory assembled, factory fire-tested, self-contained, readily transported unit ready for automatic operation except for connection of water, fuel, electrical, and vent services.

- B. Unit: Metal membrane wall, water or fire tube, condensing boiler on integral structural steel frame base with integral fuel burning system, firing controls, boiler trim, insulation, and removable jacket, suitable for indoor application.
- C. Electrical Characteristics:
 - 1. Refer to Section 26 0583.
- D. Annual Fuel Utilization Efficiency (AFUE): 0.82 in accordance with ASHRAE Std 103.
- E. Thermal Efficiency as defined by AHRI 1500 (I-P): ____.

2.03 BOILER CONSTRUCTION

- A. Comply with the minimum requirements of ASME BPVC-IV and ANSI Z21.13 for construction of boilers.
- B. Assembly to bear the ASME "H" stamp and comply with the efficiency requirements of the latest edition of ASHRAE Std 90.1 I-P.
- C. Required Directory Listings:
 - 1. AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI); current edition at www.ahrinet.org.
 - 2. NBBI Manufacturer and Repair Directory - The National Board of Boiler and Pressure Vessel Inspectors (NBBI); current edition at www.nationalboard.org.
- D. Heat Exchanger: Construct with materials that are impervious to corrosion where subject to contact with corrosive condensables. Aluminum HX shall not be used.
- E. Provide adequate tappings, observation ports, removable panels, and access doors for entry, cleaning, and inspection.
- F. Insulate casing with insulation material, protected and covered by heavy-gage metal jacket.
- G. Factory apply boiler base and other components, that are subject to corrosion, with durable, acrylic, powder coated, painted, weather-proofed, or _____ finish.

2.04 BOILER TRIM

- A. ASME rated pressure relief valve.
- B. Flow switch.
- C. Electronic Low Water Cut-off: Complete with test light and manual reset button to automatically prevent firing operation whenever boiler water falls below safe level.
- D. Temperature and pressure gauge.
- E. Pressure Switches:
 - 1. High gas pressure.
 - 2. Low gas pressure.
 - 3. Air pressure.
- F. Manual reset high limit.
- G. Boiler Pumps (where required by boiler design):
 - 1. Primary pump, factory supplied and sized for field installation to ensure minimum, continuous circulation through boiler. Provide redundant pumps.
 - 2. Where pump is not provided by boiler manufacturer, provide pump in accordance with boiler manufacturer's recommendations.
 - 3. Pump time delay.

2.05 FUEL BURNING SYSTEM

- A. Provide forced draft automatic burner, integral to boiler, designed to burn natural gas, and maintain fuel-air ratios automatically.
 - 1. Blower Design: Statically and dynamically balanced to supply combustion air; direct connected to motor.

2. Forced Draft Design: Mixes combustion air and gas to achieve 90 percent combustion efficiency.
 3. Combustion Air Filter: Protects fuel burning system from debris.
- B. Gas Train: Plug valve, safety gas valve, gas-air ratio control valve, and pressure regulator controls air and gas mixture.
 - C. Emission of Oxides of Nitrogen Requirements: Comply with SCAQMD 1146.1 for natural gas fired system, as applicable.
 - D. Intakes: Combustion air intake capable of accepting free mechanical room air or direct outside air through a sealed intake pipe.

2.06 FACTORY INSTALLED CONTROLS

- A. Option for internal or external (0-10) VDC control.
- B. Temperature Controls:
 1. Automatic reset type to control fuel burning system on-off, firing rate, and _____ to maintain temperature.
 2. Manual reset type to control fuel burning system to prevent boiler water temperature from exceeding safe system water temperature.
 3. Low-fire start time delay relay.
- C. Electronic PI setpoint/modulation control system.
- D. Microprocessor-based, fuel/air mixing controls.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install boiler and provide connection of natural gas service in accordance with requirements of NFPA 54 and applicable codes.
- C. Install boiler on concrete housekeeping base, sized minimum of 4 inches larger than boiler base in accordance with Section 03 3000.
- D. Coordinate factory installed controls with Section 23 0913.
- E. Coordinate provisions for water treatment in accordance with Section 23 2500.
- F. Pipe relief valves to nearest floor drain.
- G. Pipe cooled condensate produced by the combustion process from the boiler condensate connection and/or flue stack with suitable piping material to neutralizer prior to discharging into nearest floor drain.
- H. Install primary boiler pump in accordance with Section 23 2123.
- I. Provide piping connection and accessories in accordance with Section 23 2114.
- J. Provide for connection to electrical service in accordance with Section 26 0583.
- K. Vent combustion fumes in accordance with manufacturer's recommendations. Refer to Section 23 5100.

3.02 CLOSEOUT ACTIVITIES

- A. See Section 01 7800 - Closeout Submittals, for closeout submittals.
- B. See Section 01 7900 - Demonstration and Training, for additional requirements.
- C. Demonstrate proper operation of equipment to Owner's designated representative.
- D. Demonstration: Demonstrate operation of system to Owner's personnel.
 1. Use operation and maintenance data as reference during demonstration.
 2. Conduct walking tour of project.
 3. Briefly describe function, operation, and maintenance of each component.

- E. Training: Train Owner's personnel on operation and maintenance of system.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of two hours of training.

END OF SECTION 23 5216

**SECTION 23 5533
FUEL-FIRED UNIT HEATERS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Gas fired unit heaters.
- B. Gas fired industrial heaters.
- C. Gas fired duct furnaces.
- D. High-intensity infrared heaters.
- E. Room thermostats.

1.02 RELATED REQUIREMENTS

- A. Section 23 0513 - Common Motor Requirements for HVAC Equipment: Fan motors.
- B. Section 23 0548 - Vibration and Seismic Controls for HVAC.
- C. Section 23 0913 - Instrumentation and Control Devices for HVAC: Thermostats, time clocks.
- D. Section 23 5100 - Breechings, Chimneys, and Stacks.
- E. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; 2013, Including All Amendments and Errata.
- B. ASHRAE Std 103 - Methods of Testing for Annual Fuel Utilization Efficiency of Residential Central Furnaces and Boilers; 2007, Including All Amendments.
- C. NFPA 54 - National Fuel Gas Code; 2015.
- D. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- E. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2015.
- F. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems; 2015.
- G. NFPA 211 - Guide for Smoke and Heat Venting; 2013, Including All Amendments.
- H. UL (DIR) - Online Certifications Directory; current listings at database.ul.com.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's literature and data indicating rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.
- C. Shop Drawings: Indicate assembly, required clearances, and locations and sizes of field connections.
- D. Manufacturer's Instructions: Indicate rigging, assembly, and installation instructions.
- E. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts listing.
- F. Warranty: Submit manufacturers warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.05 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturers warranty for heat exchangers.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

- A. Comply with NFPA 70.
- B. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for the purpose specified and indicated.

2.02 GAS FIRED UNIT HEATERS

- A. Manufacturers:
 - 1. Modine Manufacturing Company; _____: www.modine.com/#sle.
 - 2. Sterling HVAC/Mestek Technology, Inc; _____: www.sterlinghvac.com/#sle.
 - 3. Reznor/Thomas & Betts Corporation; _____: www.reznorhvac.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Unit Heaters: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, heat exchanger, burner, controls, and accessories:
 - 1. Heating: Natural gas fired.
 - 2. Discharge Louvers: Individually adjustable horizontal and vertical louvers to match cabinet finish.
- C. Cabinet: Galvanized steel with baked enamel finish, easily removed and secured access doors, glass fiber insulation and reflective liner.
- D. Supply Fan: Propeller type with direct drive, variable pitch motor pulley.
- E. Heat Exchanger: Type 321 stainless steel welded construction.
- F. Gas Burner:
 - 1. Sealed Combustion type with adjustable combustion air supply.
 - 2. Gas valve, Fully Modulating provides 100 percent safety gas shut-off; 24 volt combining pressure regulation, safety pilot, manual set (On-Off), pilot filtration, automatic electric valve.
 - 3. Electronic pilot ignition, with hot surface igniter.
 - 4. Automatic vent damper with synchronous spring return damper motor.
 - 5. Non-corrosive combustion air blower with permanently lubricated motor.
- G. Gas Burner Safety Controls:
 - 1. Thermocouple Sensor: Prevents opening of gas valve until pilot flame is proven and stops gas flow on ignition failure.
 - 2. Vent Safety Shutoff Sensor: Temperature sensor installed on draft hood and prevents operation, manual reset.
- H. Operating Controls:
 - 1. Room Thermostat: Cycles burner to maintain room temperature setting.
 - 2. Supply Fan Control: Energize from bonnet temperature independent of burner controls, with adjustable timed off delay and fixed timed on delay, with manual switch for continuous fan operation. Provide continuous low speed fan operation.
- I. Requirements:
 - 1. Equipped with intermittent ignition device.
 - 2. Equipped with power venting.
- J. Performance:
 - 1. Ratings: Energy Efficiency Rating (EER)/Coefficient of Performance (COP) not less than requirements of ASHRAE Std 90.1 I-P; seasonal efficiency to ASHRAE Std 103.

2.03 GAS FIRED INDUSTRIAL HEATERS

- A. Manufacturers:
 - 1. Modine Manufacturing Company; _____: www.modine.com/#sle.
 - 2. Sterling HVAC/Mestek Technology, Inc; _____: www.sterlinghvac.com/#sle.
 - 3. Reznor/Thomas & Betts Corporation; _____: www.reznorhvac.com/#sle.

- B. Industrial Unit Heaters: Gas fired, self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, heat exchanger, burner or heater, air filter, and controls.
- C. Cabinet: Galvanized steel with baked enamel finish, easily removed and secured access doors, glass fiber insulation and reflective liner.
- D. Heat Exchanger: Titanium stainless steel welded construction.
- E. Supply Fan: Centrifugal type with belt drive, variable pitch motor pulley.
- F. Filter: 1 inch thick glass fiber throw-away type, located to filter air before fan.
- G. Mixing:
 - 1. Dampers: Outside and return dampers with damper operator and control package to automatically vary outside air quantity. Outside air damper shall fall to closed position.
 - 2. Damper Operator: 24 volt with gear train sealed in oil.
 - 3. Mixed Air Control Sequence: Maintain selected supply air temperature and return dampers to minimum position on call for heating.
- H. Gas Burner:
 - 1. Forced draft type with adjustable combustion air supply.
 - 2. Gas valve, Fully Modulating provides 100 percent safety gas shut-off; 24 volt combining pressure regulation, safety pilot, manual set (On-Off), pilot filtration, automatic electric valve.
 - 3. Electronic pilot ignition, with hot surface igniter.
 - 4. Combustion air damper with synchronous spring return damper motor.
 - 5. Non-corrosive combustion air blower with permanently lubricated motor.
- I. Gas Burner Safety Controls:
 - 1. Thermocouple Sensor: Prevents opening of gas valve until pilot flame is proven and stops gas flow on ignition failure.
 - 2. Flame Rollout Switch: Installed on burner box and prevents operation.
 - 3. Vent Safety Shutoff Sensor: Temperature sensor installed on draft hood and prevents operation, manual reset.
 - 4. Limit Control: Fixed stop at maximum permissible setting, de-energizes burner on excessive bonnet temperature, automatic resets.
- J. Burner Operating Controls:
 - 1. Room Thermostat: Cycles burner to maintain room temperature setting.
- K. Room Thermostat: Low voltage, to control burner operation. Include fan control switch (auto-on).
- L. Performance:
 - 1. Ratings: Energy Efficiency Rating (EER)/Coefficient of Performance (COP) not less than requirements of ASHRAE Std 90.1 I-P; seasonal efficiency to ASHRAE Std 103.
- M. Electrical Characteristics:
- N. Disconnect Switch: Factory mount disconnect switch in control panel.

2.04 GAS FIRED DUCT FURNACES

- A. Duct Furnaces: Gas fired, self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, heat exchanger, burner, controls, and accessories.
- B. Cabinet: Galvanized steel with baked enamel finish, easily removed and secured access doors, glass fiber insulation and reflective liner.
- C. Heat Exchanger: Aluminized steel welded construction.
- D. Gas Burner:
 - 1. Atmospheric type with adjustable combustion air supply.
 - 2. Gas valve, two stage provides 100 percent safety gas shut-off; 24 volt combining pressure regulation, safety pilot, manual set (On-Off), pilot filtration, automatic electric valve.

3. Electronic pilot ignition, with electric spark igniter.
- E. Gas Burner Safety Controls:
 1. Thermocouple sensor: Prevents opening of gas valve until pilot flame is proven and stops gas flow on ignition failure.
 2. Vent Safety Shutoff Sensor: Temperature sensor installed on draft hood and prevents operation, manual reset.
- F. Performance:
 1. Ratings: Energy Efficiency Rating (EER)/Coefficient of Performance (COP) not less than requirements of ASHRAE Std 90.1 I-P; seasonal efficiency to ASHRAE Std 103.

2.05 HIGH INTENSITY INFRARED HEATERS

- A. Manufacturers:
 1. Detroit Radiant Products Company; _____: www.detroitradiant.com/#sle.
 2. Solaronics, Inc; _____: www.solaronicsusa.com/#sle.
 3. Space-Ray, Division of Gas Fired Products, Inc; _____: www.spaceray.com/#sle.
 4. Superior Radiant Products Inc; Series KMI High Intensity Heater: www.superiorradiant.com/#sle.
- B. Infrared Heaters: High-intensity type; self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, heat exchanger, burner, reflector, controls.
- C. Cabinet: Galvanized steel with baked enamel finish.
- D. Ceramic Emitter: Assembly of high temperature ceramic tiles with stainless steel housing and reflector.
- E. Gas Burner:
 1. Atmospheric type with adjustable combustion air supply.
 2. Gas valve provides 100 percent safety gas shut-off; 24 volt combining pressure regulation, safety pilot, manual set (On-Off), pilot filtration, automatic electric valve.
 3. Electronic pilot ignition, with hot surface igniter.
- F. Gas Burner Safety Controls: Thermo-couple sensor prevents opening of solenoid gas valve until pilot flame is proven and stops gas flow on ignition failure.
- G. Room Thermostat: Low voltage, to control burner operation.
- H. Performance:

2.06 ROOM THERMOSTATS

- A. Manufacturers:

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that space is ready for installation of units and openings are as indicated on shop drawings.
- B. Verify that proper power supply is available.
- C. Verify that proper fuel supply and Gas pressure is available for connection.

3.02 INSTALLATION

- A. Install in accordance with NFPA 90A.
- B. Install gas fired units in accordance with NFPA 54 and applicable codes.
- C. Provide vent connections in accordance with NFPA 211. Refer to Section 23 5100.
- D. Install unit heaters with vibration isolation. Refer to Section 23 0548.

END OF SECTION 23 5533

**SECTION 23 5700
HEAT EXCHANGERS FOR HVAC**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Shell and tube type heat exchangers.
- B. Plate type heat exchangers.
- C. Accessories and trim.

1.02 RELATED REQUIREMENTS

- A. Section 23 0913 - Instrumentation and Control Devices for HVAC.
- B. Section 23 2113 - Hydronic Piping.
- C. Section 23 2114 - Hydronic Specialties.
- D. Section 23 2213 - Steam and Condensate Heating Piping.
- E. Section 23 2214 - Steam and Condensate Heating Specialties.

1.03 REFERENCE STANDARDS

- A. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1 - Rules for Construction of Pressure Vessels; 2015.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data with dimensions, locations, and size of tapings and performance data.
- C. Shop Drawings: Indicate dimensions, locations, and size of tapings and performance data.
 - 1. Design Data: Indicate in sufficient detail to verify that heat exchangers meet or exceed specified requirements.
 - 2. Test Reports: Indicate tube bundle pressure tests.
- D. Certificates: Certify that Products meet or exceed specified requirements.
- E. Manufacturer's Instructions: Indicate installation and support requirements.
- F. Operation and Maintenance Data: Include start up and shut down instructions, assembly drawings, and spare parts lists.
- G. Warranty: Submit manufacturer's warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Protect internals from entry of foreign material by temporary caps on flanged openings.

1.06 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturer warranty.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

- A. Comply with ASME BPVC-VIII-1 for manufacture of tubular heat exchangers and heat exchanger shells.

2.02 SHELL AND TUBE TYPE HEAT EXCHANGER

- A. Manufacturers:
 - 1. Armstrong Pumps Inc; _____: www.armstrongpumps.com/#sle.
 - 2. Baltimore Aircoil Company; _____: www.baltimoreaircoil.com/#sle.
 - 3. Bell & Gossett, a xylem brand; _____: www.bellgossett.com/#sle.

- 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Comply with ASME BPVC-VIII-1 for manufacture of tubular heat exchangers and heat exchanger shells.
- C. Tubes: U-tube type with 3/4 inch OD minimum seamless copper tubes suitable for 125 psi working pressure.
- D. Shell: Steel pipe with threaded or flanged piping connections and necessary tappings, steel saddle and attaching U-bolts, prime coated.
- E. Heads: Cast iron or fabricated steel with steel or bronze tube sheets, threaded or flanged for piping connections.
- F. Water Chamber and Tube Bundle: Removable for inspection and cleaning.

2.03 PLATE AND FRAME TYPE HEAT EXCHANGER

- A. Manufacturer:
 - 1. Alfa Laval; _____: www.alfalaval.com/#sle.
 - 2. Armstrong Pumps Inc; _____: www.armstrongpumps.com/#sle.
 - 3. ITT Standard; _____: www.ittstandard.com/#sle.
- B. Comply with ASME BPVC-VIII-1 for manufacture of plate and frame type heat exchangers.
- C. Heat Exchanger Selection, Frame and Plate sizing to be selected to allow 20% future capacity
- D. Frames: Carbon steel with baked epoxy enamel paint, stainless steel side bolts and shroud.
- E. Plates: Stainless steel Type 304.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install to permit removal of plates with minimum disturbance to installed equipment and piping.
- C. Support heat exchangers on concrete housekeeping pad.
- D. Pitch shell to completely drain condensate.
- E. Pipe relief valves to nearest floor drain.
- F. Pipe drain valves to nearest floor drain.

3.02 STEAM TO WATER HEAT EXCHANGER TRIM

- A. Shell: Pressure gauge tapping with pigtail siphon, vacuum breaker; refer to Section 23 2214.
- B. Water Inlet: Thermometer well, pressure gauge tapping, valved drain; refer to Section 23 2114.
- C. Water Outlet: Thermometer well for temperature regulator sensor, ASME rated pressure and temperature relief valve, thermometer well, pressure gauge tapping; refer to Section 23 2114.

END OF SECTION 23 5700

SECTION 23 6416
CENTRIFUGAL WATER CHILLERS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Chiller package.
- B. Charge of refrigerant and oil.
- C. Controls and control connections.
- D. Chilled water connections.
- E. Condenser water connections.
- F. Variable speed drives.
- G. Starters.
- H. Electrical power connections.

1.02 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete: Concrete housekeeping pads.
- B. Section 23 0513 - Common Motor Requirements for HVAC Equipment.
- C. Section 23 0548 - Vibration and Seismic Controls for HVAC.
- D. Section 23 0553 - Identification for HVAC Piping and Equipment.
- E. Section 23 0593 - Testing, Adjusting, and Balancing for HVAC.
- F. Section 23 0800 - Commissioning of HVAC.
- G. Section 23 0923 - Direct-Digital Control System for HVAC.
- H. Section 23 2113 - Hydronic Piping.
- I. Section 23 2114 - Hydronic Specialties.
- J. Section 23 2123 - Hydronic Pumps.
- K. Section 23 2500 - HVAC Water Treatment.
- L. Section 23 6513 - Forced-Draft Cooling Towers.

1.03 REFERENCE STANDARDS

- A. AHRI 550/590 (I-P) - Performance Rating of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle; 2023.
- B. ASHRAE Std 15 - Safety Standard for Refrigeration Systems; 2013.
- C. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; 2013, Including All Amendments and Errata.
- D. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1 - Rules for Construction of Pressure Vessels; 2015.
- E. IEEE 519 - IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems; 2014.
- F. UL 508 - Industrial Control Equipment; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.

- C. Shop Drawings: Indicate components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Indicate equipment, piping and connections, valves, strainers, and thermostatic valves required for complete system.
- D. Manufacturer's Certificate: Certify that components of package not furnished by manufacturer have been selected in accordance with manufacturer's requirements.
- E. Test Reports: Indicate energy input versus cooling load output from 0 to 100 percent of full load at specified and minimum condenser water temperature.
- F. Manufacturer's Instructions: Submit manufacturer's complete installation instructions.
- G. Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.
- H. Operation and Maintenance Data: Include start-up instructions, maintenance data, parts lists, controls, and accessories. Include trouble- shooting guide.
- I. 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. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

1.07 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide a five year warranty to include coverage for compressor including materials and labor.
- C. Variable Speed Drives: Provide manufacturer warranty for period of twelve months from date of installation or eighteen months from date of shipment (whichever comes first). Warranty to include parts, labor, travel costs, and living expenses incurred by manufacturer to provide factory-authorized on-site services.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Trane, a brand of Trane Technologies; _____: www.trane.com/#sle.
- B. Substitutions: See Section 01 6000 - Product Requirements.
 - 1. The chilled water system has been designed based on specific capacities and characteristics of equipment specified in this section and other sections.
 - 2. Coordinate approval with Corewell Engineering.
 - 3. If the related equipment must be modified to perform acceptably with the substitute, the entity proposing the substitution is responsible for all additional costs due to re-design and provision of different related equipment.

2.02 CHILLER APPLICATIONS

- A. Chiller: Water-cooled, Centravac, Symbio controls.
 - 1. Basis of Design: Trane.
 - 2. Refrigerant: R-514A or R-1233zd.
 - 3. Rating: Energy Efficiency Rating (EER)/Coefficient of Performance (COP) not less than prescribed by ASHRAE Std 90.1 I-P.
 - 4. Evaporator:
 - a. Working Pressure: 150 psi.

- b. Fouling Factor: _____.
- 5. Condenser Water:
 - a. Working Pressure: 150 psi.
 - b. Fouling Factor: _____.

2.03 CHILLERS

- A. Chillers: Factory assembled and tested, packaged, water cooled, chillers consisting of centrifugal compressors, compressor motor, condenser, evaporator, refrigeration accessories, instrument and control panel including gauges and indicating lights, auxiliary components and accessories, and motor starters.
- B. Rating: Comply with AHRI 550/590 (I-P).
- C. Comply with ASME BPVC-VIII-1 for construction and testing of centrifugal chillers.
- D. Comply with ASHRAE Std 15 for safe construction and operation of centrifugal chillers.
- E. Energy efficiency for electrically operated, water-cooled units:
 - 1. Capacity: Less than 150 tons:
 - a. Integrated Part Load Value: 5.25.
 - b. Coefficient of Performance: 5.0.
 - 2. Capacity: Greater than or equal to 150 tons and less than 300 tons:
 - a. Integrated Part Load Value: 5.90.
 - b. Coefficient of Performance: 5.55.
 - 3. Capacity: Greater than or equal to 300 tons:
 - a. Integrated Part Load Value: 6.40.
 - b. Coefficient of Performance: 6.10.

2.04 COMPRESSORS

- A. Compressor Casing: Cast iron, horizontally or vertically split with machined passages and leak tested to 45 psig. Provide refrigerant sight glass.
- B. Impellers: Single or multi-stage, in-line design, fully shrouded, statically and dynamically balanced, tested to 20 percent over operating speed, mounted on heat treated forged or rolled steel shaft, nonferrous, labyrinth seals between stages.
- C. Guide Vanes: Modulating radial blade dampers, on each stage, with externally mounted electric operator, suitable for capacity reduction to 10 percent of specified load without hot gas bypass when supplied with design entering water quantity and temperature.
- D. Bearings: Steel or aluminum journal bearings, pressure lubricated.
- E. Gear Box: Double helical design, symmetrical and center supported by spherically seated, self aligning bearing, arranged for inspection without disassembly.
 - 1. Provide speed increasing transmissions for variable speed chillers to not exceed 10,000 rpm compressor speed.
- F. Motor: Hermetically sealed, singled speed, low slip induction type. Refer to Section 23 0513.
- G. Lubrication: Oil pump, with oil cooler, pressure regulator, oil filters, thermostatically controlled oil heater, and motor controls. Interlock to start before chiller motor and run after motor is shut down. Provide sight glass or electronic sensors for monitoring oil level.
- H. Refrigerant: Factory pre-charge unit with refrigerant specified above.

2.05 EVAPORATOR

- A. Provide evaporator of shell and tube type, seamless or welded steel construction with cast iron or fabricated steel heads, seamless copper tubes or red brass tubes with integral fins, rolled or silver brazed into tube sheets. Position intermediate tube support sheets along length of shell to avoid contact and relative motion between adjacent tubes.
- B. Test and, where applicable, stamp refrigerant side for 45 psig working pressure and water side for 150 psig working pressure, in accordance with ASME BPVC-VIII-1.

- C. Provide marine type water boxes, machine welded to heat exchanger with tapped drain and vent connections, and flanged or mechanical joint connections arranged to permit inspection of tubes from either end without disturbing refrigerant and removable without disturbing water piping.
- D. Insulate evaporator and cold surfaces with 0.75 inch minimum thick flexible expanded polyvinyl chloride insulation with maximum K value of 0.28.
- E. Provide thermometer wells or thermistors for temperature controller and low temperature cutout.
- F. Design and construct evaporator to prevent liquid refrigerant from entering the compressor.
- G. Provide carbon rupture disc or relief valve on shell in accordance with ASHRAE Std 15.
- H. Construction and materials to comply with ASME BPVC-VIII-1 or ASHRAE Std 15 as applicable to chiller manufacturer and chiller model.

2.06 CONDENSERS

- A. Provide condensers of shell and tube type, seamless or welded steel construction with cast iron or fabricated steel heads, seamless copper tubes or red brass tubes with integral fins, rolled or silver brazed into tube sheets. Position intermediate tube support sheets along shell length to avoid contact and relative motion between adjacent tubes. Provide additional condensers on heat recovery units.
- B. Test and, where applicable, stamp refrigerant side for 45 psig working pressure and water side for 150 psig working pressure; in accordance with ASME BPVC-VIII-1.
- C. Provide marine type water boxes, machine welded to heat exchanger with tapped drain and vent connections, and flanged or mechanical joint connections arranged to permit inspection of tubes from either end without disturbing refrigerant and removable without disturbing water piping.
- D. Provide carbon rupture disc or relief valve on shell in accordance with ASHRAE Std 15.
- E. Provide baffles to ensure even distribution of incoming gas and to concentrate non-condensable gases.
- F. Construction and materials to comply with ASME BPVC-VIII-1.

2.07 PURGE SYSTEM

- A. Provide purge system on positive pressure units, incorporating a low temperature refrigeration system to automatically remove non-condensibles, water and air.
- B. System discharge shall be maximum 0.60 pound of refrigerant per pound of air discharged.

2.08 CONTROLS

- A. Disconnect Switch: Factory mount disconnect switch in starter control panel.
- B. On or near chiller, provide microprocessor based control panel containing solid state, fully automatic operating and safety controls.
- C. Provide the following manufacturer's standard safety controls, including the following minimum functions, so that operating any one will shut down machine and require manual reset:
 - 1. Low evaporator refrigerant temperature.
 - 2. High condenser refrigerant pressure.
 - 3. Low oil pressure.
 - 4. Low refrigerant (evaporator) pressure.
- D. Provide the manufacturer's standard safety controls arranged so that operating any one will shut down machine and automatically reset.
- E. Provide the following devices on control panel:
 - 1. Manual Switches:
 - a. Machine off-auto switch.
 - b. Oil pump switch (manual or automatic).

- c. Purge pump switch (manual-off-auto).
- 2. Manual Set Point Adjustments:
 - a. Leaving chilled water temperature.
 - b. Current demand limit.
- 3. Status Lights:
 - a. Chilled water flow proven.
 - b. Cooling required.
 - c. Unit running.
 - d. Unit loading.
 - e. Unit unloading.
 - f. Manual reset required.
 - g. Remote chilled water set point active.
 - h. Remote current water set point active.
- 4. Setpoint and Temperature Display:
 - a. Current limit set point.
 - b. Entering evaporator water temperature.
 - c. Leaving evaporator water temperature.
 - d. Entering condenser water temperature.
 - e. Leaving condenser water temperature.
- 5. Dial Type Pressure Gauges:
 - a. Evaporator refrigerant pressure.
 - b. Condenser refrigerant pressure.
 - c. Low oil pressure (oil sump).
 - d. High oil pressure (oil supply).
- F. Provide the following operating controls:
 - 1. Solid state, chilled water temperature controller that controls electronic guide vane operator and hot gas bypass. Locate temperature sensor in entering chilled water.
 - 2. Adjustable thirty minute off timer prevents compressor from short cycling.
 - 3. Demand limit device to manually set maximum current infinitely between 40 percent and 100 percent of full load amperes.
 - 4. Automatic start that determines demand for chilled water from proof of chilled water flow and temperature differential between chilled water set point and supply temperature.

2.09 VARIABLE SPEED DRIVE (VSD), UNIT MOUNTED

- A. Furnish chiller with factory-mounted, liquid-cooled variable speed drive (VSD) shipped completely factory-assembled, wired, and tested.
- B. Specifically design VSD to interface with the centrifugal water chiller controls and allow for the operating ranges and specific characteristics of the chiller. VSD control logic is to optimize chiller efficiency by coordinating compressor motor speed and compressor inlet guide vane position to maintain the chilled water setpoint while avoiding surge. If surge is detected, VSD surge avoidance logic is to make adjustments to move away from and avoid surge at similar conditions in the future.
- C. VSD Efficiency: 97 percent or better at full speed and full load.
- D. Fundamental Displacement Power Factor: Minimum of 0.96.
- E. Provide voltage and current regulated, solid state, microprocessor-based pulse-width modulated (PWM) VSD. Output power devices to be IGBT transistors.
- F. Provide liquid-cooled heatsink to cool the power semi-conductor and capacitor.
- G. Provide cleanable shell and tube heat exchanger with water-cooled design. Do not provide plate and frame heat exchanger.

- H. Furnish VSD in a NEMA Type 1 metal enclosure having a minimum short circuit withstand rating of 65,000 amps per UL 508. Include three phase input lugs plus a grounding lug for electrical connections, output motor connection via factory-installed bus bars and all components properly segregated and completely enclosed in a single, metal enclosure.
 - 1. Enclosure to include a padlockable, door-mounted circuit breaker with shunt trip and AIC rating of 65,000 amps.
 - 2. Entire chiller package to be listed by Underwriter's Laboratories Inc.
- I. VSD to be tested according to UL 508 and listed by a Nationally Recognized Testing Laboratory (NRTL) as designated by OSHA.
- J. Comply with recommendations stated in IEEE 519.
 - 1. Include integrated active rectification control system to limit total demand distortion (TDD) in current at the VSD to less than or equal to 5 percent as measured at the VSD input. If active filters are used to meet this requirement, then the losses associated with the filter are to be included in the chiller performance on the selection.
- K. Fundamental Displacement Power Factor: Minimum of 0.96.
- L. Voltage Input: Nominal 480 volts, three phase, 60 hertz AC, plus or minus 10 percent of nominal voltage.
- M. Line Frequency: 38 to 60 hertz.
- N. VSD to include the following:
 - 1. All control circuit voltages physically and electrically isolated from power circuit voltage.
 - 2. 150 percent instantaneous torque available for improved surge control.
 - 3. Soft start, adjustable linear acceleration, coast-to-stop.
 - 4. Adjustable current limiting and UL approved electronic motor overload protection.
 - 5. Insensitivity to incoming power phase sequence.
 - 6. VSD and motor protection from the following faults:
 - a. Output line-to-line short circuit.
 - b. Line-to-ground short circuit.
 - c. Phase loss at AFD input.
 - d. Phase reversal/imbalance.
 - e. Over-voltage.
 - f. Under-voltage.
 - g. Over-temperature.
- O. Include the following VSD status indicators available to facilitate startup and maintenance:
 - 1. Output speed in hertz and rpm.
 - 2. Input line voltage.
 - 3. Input line kW.
 - 4. Output/load amps.
 - 5. Average current in percent RLA.
 - 6. Load power factor.
 - 7. Fault.
 - 8. VSD transistor temperature.
- P. Service Conditions (at full output power; no external venting or heat exchangers required):
 - 1. Operating Ambient Temperature: Between 32 degrees F and 104 degrees F.
 - 2. Room Ambient Relative Humidity: Up to 95 percent.
 - 3. Elevation: Up to 3,300 feet. For every 300 feet above 3,300 feet, decrease the rated output current by one percent.

2.10 VARIABLE SPEED DRIVE (VSD), REMOTE-MOUNTED.

- A. Furnish chiller with remote (free-standing) mounted, air-cooled variable speed drive (VSD) shipped completely factory-assembled, wired, and tested.

- B. Specifically design VSD to interface with the centrifugal water chiller controls and allow for the operating ranges and specific characteristics of the chiller. VSD control logic is to optimize chiller efficiency by coordinating compressor motor speed and compressor inlet guide vane position to maintain the chilled water setpoint while avoiding surge. If surge is detected, VSD is to move away from and avoid surge at similar conditions in the future.
- C. VSD Efficiency: 97 percent or better at full speed and full load.
- D. Fundamental Displacement Power Factor: Minimum of 0.97.
- E. Provide voltage and current regulated, solid state, microprocessor-based pulse-width modulated (PWM) VSD. Output power devices to be IGBT transistors.
- F. Provide liquid- or air-cooled heatsink to cool power semi-conductor and capacitor.
- G. Furnish VSD in a NEMA Type 1 metal enclosure having a minimum short circuit withstand rating of 65,000 amps per UL 508. Include three phase input lugs plus a grounding lug for electrical connections, output motor connection via factory installed bus bars and all components properly segregated and completely enclosed in a single metal enclosure.
 - 1. Enclosure to include padlockable, door-mounted circuit breaker with minimum AIC rating of 65,000 amps.
 - 2. Entire chiller package to be listed by Underwriter's Laboratories Inc.
- H. VSD to be tested according to UL 508 and listed by a National Recognized Testing Laboratory (NRTL) as designated by OSHA.
- I. Comply with recommendations for harmonic mitigation.
 - 1. Include a DC link reactor on positive and negative rails to minimize power line harmonics and protect the VSD from power line transients.
- J. Voltage Input: Nominal 460 volts, three phase, 60 Hertz AC power, plus or minus 10 percent of nominal voltage.
- K. Line Frequency: 38 to 60 Hertz.
- L. VSD is to include the following features:
 - 1. All control circuit voltages physically and electrically isolated from power circuit voltage.
 - 2. 150 percent instantaneous torque available for improved surge control.
 - 3. Soft start, adjustable linear acceleration, coast-to-stop.
 - 4. Adjustable current limiting and UL-approved electronic motor overload protection.
 - 5. Insensitivity to incoming power phase sequence.
 - 6. VSD and motor protection from the following faults:
 - a. Output line-to-line short circuit.
 - b. Line-to-ground short circuit.
 - c. Phase loss at AFD input.
 - d. Phase reversal/imbalance.
 - e. Over-voltage.
 - f. Under-voltage.
 - g. Over-temperature.
- M. Include the following VSD status indicators available to facilitate startup and maintenance:
 - 1. Output speed in hertz and rpm.
 - 2. Input line voltage.
 - 3. Input line kW.
 - 4. Output/load amps.
 - 5. Average current in percent RLA.
 - 6. Load power factor.
 - 7. Fault.
 - 8. VSD transistor temperature.
- N. Service Conditions:
 - 1. Operating Ambient Temperature: Between 14 degrees F and 104 degrees F.

2. Room Ambient Relative Humidity: Up to 95 percent.
3. Elevation: Up to 3,300 feet. For every 3,300 feet above 3,300 feet, decrease the rated output current by 4 percent up to 9,900 feet.

2.11 STARTER

- A. Starter Manufacturers:
 1. Eaton Electrical/Cutler-Hammer; _____: www.eatonelectrical.com/#sle.
 2. Schneider Electric Company; _____: www.schneider-electric.com/#sle.
 3. Square D _____.
 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. On or near chiller, mount steel NEMA 1 type enclosure, containing Star-Delta closed transition starter, manufactured in accordance with chiller manufacturer's specifications and factory tested.
- C. Enclosure shall be designed for top or bottom cable entry with front access. Door, interlocked with circuit breaker, and shall accommodate padlock.
- D. Mount the following devices within enclosure:
 1. Disconnect switch on line side with fuses.
 2. Standard interrupting capacity circuit breaker with ground fault protection.
 3. Pilot relays to start and stop compressor on signal from chiller control panel.
 4. Electronic overload provides overload protection, protects compressor motor from distribution system irregularities, and provides motor current signal to chiller capacity control module.
 5. Control power transformer.
 6. Fused control circuits for control circuit, oil pump motor, oil heater, and purge control unit.
 7. Contactor interlocks for communication between starter and control panel.
 8. Capacitors, one per phase, to correct power factor to minimum 95 percent.
 9. Fused disconnect and starter for oil pump.
 10. Relay for remote mounted emergency shut-down switch.
- E. Provide the following devices on starter door:
 1. Starter fault trip indicator and reset.
 2. Overload trip indicator and reset.
 3. Distribution fault trip indicator and reset.
 4. Ground fault trip indicator and reset.
 5. Ammeters, one per phase.
 6. Voltmeters, one per phase.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Align chiller on concrete foundations, sole plates, and sub-bases. Level, grout, and bolt in place.
- C. Install units on vibration isolation.
- D. Provide evaporator connections to chilled water piping.
 1. On inlet, provide:
 - a. Thermometer well for temperature controller.
 - b. Thermometer well and thermometer.
 - c. Strainer.
 - d. Nipple and flow switch.
 - e. Flexible pipe connector.
 - f. Pressure gauge.
 - g. Shut-off valve.

2. On outlet, provide:
 - a. Thermometer well and thermometer.
 - b. Flexible pipe connector.
 - c. Pressure gauge.
 - d. Shut-off valve.
- E. Furnish and install necessary auxiliary water piping for oil cooling units and purge condensers.
- F. Insulate evaporator and cold surfaces.
- G. Provide condenser connection to condenser water piping.
 1. On inlet, provide:
 - a. Thermometer well for temperature controller.
 - b. Thermometer well and thermometer.
 - c. Strainer.
 - d. Nipple and flow switch.
 - e. Flexible pipe connector.
 - f. Pressure gauge.
 - g. Shut-off valve.
 2. On outlet, provide:
 - a. Thermometer well and thermometer.
 - b. Flexible pipe connector.
 - c. Pressure gauge.
 - d. Shut-off valve.
- H. Arrange piping for easy dismantling to permit tube cleaning.
- I. Provide piping from chiller rupture disc to outdoors. Size as recommended by manufacturer.

3.02 SYSTEM STARTUP

- A. See Section 01 7800 - Closeout Submittals, for closeout submittals.
- B. See Section 01 7900 - Demonstration and Training, for additional requirements.
- C. Provide services of factory trained representative for minimum of one day to leak test, refrigerant pressure test, evacuate, dehydrate, charge, start-up, and calibrate controls.
- D. Supply initial charge of refrigerant and oil.
- E. Demonstrate system operation and verify specified performance. Refer to Section 23 0593.

3.03 CLOSEOUT ACTIVITIES

- A. See Section 01 7800 - Closeout Submittals, for closeout submittals.
- B. See Section 01 7900 - Demonstration and Training, for additional requirements.
- C. Train operating personnel in operation and maintenance of units.
- D. Provide the services of the manufacturer's field representative to conduct training.

3.04 MAINTENANCE

- A. See Section 01 7000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- B. Provide a separate maintenance contract for specified maintenance service.
- C. Furnish service and maintenance of complete assembly for one year from Date of Substantial Completion.

END OF SECTION 23 6416

SECTION 23 6426
ROTARY-SCREW WATER CHILLERS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Factory-assembled packaged chiller.
- B. Charge of refrigerant and oil.
- C. Controls and control connections.
- D. Chilled water connections.
- E. Electrical power connections.

1.02 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete: Concrete housekeeping pads.
- B. Section 23 0513 - Common Motor Requirements for HVAC Equipment.
- C. Section 23 0548 - Vibration and Seismic Controls for HVAC.
- D. Section 23 0553 - Identification for HVAC Piping and Equipment.
- E. Section 23 0593 - Testing, Adjusting, and Balancing for HVAC.
- F. Section 23 0800 - Commissioning of HVAC.
- G. Section 23 0923 - Direct-Digital Control System for HVAC.
- H. Section 23 0993 - Sequence of Operations for HVAC Controls.
- I. Section 23 2113 - Hydronic Piping.
- J. Section 23 2114 - Hydronic Specialties.
- K. Section 26 0583 - Wiring Connections.

1.03 REFERENCE STANDARDS

- A. AHRI 550/590 (I-P) - Performance Rating of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapor Compression Cycle; 2023.
- B. ASHRAE Std 15 - Safety Standard for Refrigeration Systems; 2013.
- C. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; 2013, Including All Amendments and Errata.
- D. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1 - Rules for Construction of Pressure Vessels; 2015.
- E. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- F. NEMA MG 00001 - Motors and Generators; 2024.
- G. UL 1995 - Heating and Cooling Equipment; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination: Coordinate physical size, weight and location of major pieces of equipment to be installed. Notify Architect of any major deviations from the equipment originally specified prior to ordering equipment.

1.05 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide rated capacities, weights, specialties and accessories, electrical requirements and wiring diagrams.
- C. Shop Drawings: Indicate components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Indicate equipment, piping and connections, valves, strainers, and thermostatic valves required for complete system.

- D. Manufacturer's Certificate: Certify that components furnished but not produced by manufacturer meet or exceed manufacturer's requirements.
- E. Manufacturer's Performance Data: Indicate energy input versus cooling load output from 0 to 100 percent of full load at specified and minimum condenser water temperature for water-cooled chillers and at specified and minimum outdoor air temperature for air-cooled chillers.
- F. Manufacturer's Instructions: Submit manufacturer's complete installation instructions.
- G. Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.
- H. Operation and Maintenance Data: Include start-up instructions, maintenance data, parts lists, controls, and accessories; include trouble-shooting guide.
- I. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years of documented experience.
- B. When required, provide certification of inspection in compliance with the requirements of Authority Having Jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Comply with manufacturer's written installation instructions for rigging, unloading, and transporting units.
- B. Deliver units to the job site completely assembled and charged with refrigerant and oil by manufacturer.

1.08 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Manufacturer's Warranty: Provide minimum five year warranty to include coverage for materials only for compressor.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Trane, a brand of Ingersoll Rand; _____: www.trane.com/#sle.
- B. Substitutions: See Section 01 6000 - Product Requirements.
 - 1. The chilled water system has been designed based on specific capacities and characteristics of equipment specified in this section and other sections.

2.02 CHILLERS

- A. Chillers: Factory assemble and test chiller consisting of compressor(s), compressor motor(s), motor starter(s) or variable frequency drives as indicated, evaporator, condenser, enclosure, refrigeration circuits(s) and specialties, interconnecting piping, microprocessor-based controls, readouts, and diagnostics.
 - 1. Rating: AHRI 550/590 (I-P).
 - 2. Safety: ASHRAE Std 15 and UL 1995.
 - 3. Construction & Testing: ASME BPVC-VIII-1.
 - 4. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
 - 5. Energy Efficiency: ASHRAE Std 90.1.
 - 6. Enclosures:
 - a. Chiller Structural Framing:
 - 1) Mount structural steel on welded steel base.
 - 2) Factory apply hot-dip galvanized finish.
 - b. Steel Chiller Cabinets:

- 1) Factory apply baked on enamel finish.
- c. Steel Control Panels:
 - 1) Factory apply baked on powder paint or applied corrosion resistant paint prior to assembly.
 - 2) Provide gasketing and weather-proofing to panels with fully opening doors containing starters or variable frequency drives, terminal blocks, through-the-door type disconnects and circuit breaker with lockable handles indicating "power-on" or "power-off".
 - 3) Provide door stays.
- d. Electrical Equipment: NEMA EN 10250.
- 7. Motors: NEMA MG 00001. See Section 23 0513 for additional requirements.

2.03 COMPRESSORS AND EVAPORATOR

- A. Compressors: Rotary-screw type.
 - 1. Unit: Semi-hermetic type with two, direct drive compressors with multiple independent refrigeration circuit(s), internal muffler, discharge, check, suction, and _____ service valves.
 - 2. Oil Lubrication System: Positive pressure system, oil heater, oil separator, check valves, solenoid valves, and filtration devices.
 - 3. Valves: Check valves in compressor discharge.
 - 4. Capacity Reduction System: Load/unload valve control down to 20 percent of full load without the activation of hot gas by-pass.
 - 5. Motor: 3600 rpm, suction gas-cooled, hermetically sealed, squirrel cage induction with starter.
- B. Evaporator: Shell and tube type.
 - 1. Three pass type, with three independent refrigeration circuits.
 - 2. Shell, Removable Heads and Tube Support Sheets: Carbon steel.
 - 3. Tubes: Mechanically expand and fasten, seamless, externally or internally enhanced, copper tubes into intermediate tube support sheets along the length of shell to avoid contact and relative motion between tubes with the capability of being cleanable.
 - 4. Tube Size: 1.0 inches diameter.
 - 5. Comply with ASME BPVC-VIII-1 as applicable.
 - 6. Refrigerant Working-Side Pressure Rating: 200 psig.
 - 7. Water Working-Side Pressure Rating: 150 psig.
 - 8. Connections: Flanged and designed for 150 psig waterside working pressure.
- C. Insulation for All Cold Surfaces:
 - 1. Factory install on shell and all other cold surfaces.
 - 2. 0.75 inches minimum thick, closed cell, expanded polyvinyl chloride flexible foam insulation with a maximum K value of 0.28.
- D. Provide vents and water drain connections.
- E. Provide fittings for temperature control sensors.
- F. Freeze Protection: Provide evaporator heater with thermostat to protect from freezing at ambient temperatures down to minus 20 degrees F.

2.04 AIR-COOLED CONDENSER AND FANS

- A. Heat Exchanger:
 - 1. Tubes: Round.
 - 2. Arrangement: Two pass.
 - 3. Mechanically bond aluminum fins to internally enhanced, seamless copper tubing and protect with corrosion resistant materials or coatings.
 - 4. Clean, dehydrate and test.
 - 5. Leak Test: 506 psig.
 - 6. Seal: Nitrogen holding charge.

- B. Coil Guards: Provide expanded metal with lint screens. Provide coil protection for shipping by enclosing entire condenser coil with heavy plastic to prevent inadvertent damage to coil during shipping or rigging.
- C. Fans and Motors:
 - 1. Fans: Dynamically balance propeller type, direct drive fans of reinforced polymer corrosion resistant construction and equip with sealed, permanently lubricated ball bearings.
 - 2. Discharge Fan Guards: Coated steel wire.
 - 3. Discharge Direction: Vertical.
 - 4. Motors: Totally enclosed, high efficiency, suitable for outdoor use, three phase, permanent split capacitor, single speed with internal overload protection.

2.05 REFRIGERATION CIRCUITS

- A. Provide two independent refrigeration circuit(s) with two compressor(s) per circuit.
- B. Minimum Refrigerant Specialties per Circuit:
 - 1. Isolation and service valves for refrigerant removal and charging.
 - 2. Removable-core filter driers.
 - 3. ASHRAE Std 15 compliant relief valves.
 - 4. Liquid line sight glass with moisture indicator.
 - 5. Refrigerant expansion valves or metering devices.
 - 6. Complete operating charge of both refrigerant and oil.

2.06 STARTERS AND DRIVES

- A. Starters: Design unit mounted, across-the-line starter to operate in temperatures up to 104 degrees F.
 - 1. Provide incoming line provisions for aluminum, mechanical type incoming line lugs based on the number and cable sizes shown on drawings.
 - 2. Provide properly sized, double break main contacts with weld resistant silver cadmium faces and low resistance auxiliary interlocks with palladium silver contacts for interlocks that interface with control panel.
 - 3. Provide control power transformer with fused primary, secondary, and current transformers of the proper size, ratio and burden capacity.
 - 4. Provide control relays to interface with control panel.
 - 5. Wiring:
 - a. Type MTW copper stranded 90 degree C for power and control wiring.
 - b. 14 gage, 0.0641 inch, minimum, for control wiring.
 - 6. Motor Protection System Attributes:
 - a. Three phase overload protection.
 - b. Startup overload protection.
 - c. Phase imbalance, loss and reversal.
 - d. Low voltage.
 - e. Distribution fault protection.

2.07 MICROPROCESSOR-BASED, PROPORTIONAL AND INTEGRAL CONTROLLER

- A. Control Components for Preventing Shutdown:
 - 1. Provide high pressure limit with indicating light for each compressor, set lower than factory pressure switch to automatically unload compressor and prevent nuisance high pressure condenser control trip.
 - 2. Provide one protector with indicating light for each compressor, with current limit set point of 120 percent of compressor running load amperage to automatically unload compressor preventing over-current trip.
 - 3. Provide low refrigerant limit to automatically unload each compressor preventing a low evaporator temperature trip.
- B. Chiller Operation in Abnormal Operating Conditions:

1. Unloaded Running: Adequate chilled water production.
 2. Trip-out Limit Reached: Chiller goes off-line and manual reset is required for continued operation.
- C. Control Panel Display:
1. Evaporator pressure.
 2. Condenser refrigerant pressure.
 3. Entering and leaving evaporator water temperature.
 4. Chilled water set-point.
 5. Electrical 3 phase current limit and percent RLA setpoint.
 6. Electrical 3 phase amp draw.
 7. Chiller operating mode.
 8. Condenser refrigerant temperature.
 9. Elapsed time and number of starts counter.
 10. Chiller compressor run status relay.
 11. Minimum of 20 diagnostics with time and date stamp.
 12. Identification of the fault, date, time and operating mode at time of occurrence, type of reset required, and help message.
- D. Points for BAS Control and Monitoring:
1. Relay output energized upon detecting a fault requiring manual reset.
 2. Relay output energized whenever unit is operating in a limit mode for an extended period of time.
 3. Analog input to control leaving chilled water temperature set-point based upon a 4-20ma or 0-10 VDC signal from the building automation system.
 4. Programmable soft during pull-down period via ramped current limit or fully adjustable, temperature pull-down rate.
 5. Leaving chilled water reset based upon return water temperature.
 6. Provide RS-232 for printer interface.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Align chiller package on steel or concrete foundations.
- C. Install units on vibration isolators.
- D. Connect to electrical service.
- E. Connect to chilled water piping.
- F. Arrange piping for easy dismantling to permit tube cleaning and removal.

3.02 MANUFACTURER'S FIELD SERVICES

- A. Perform factory startup of the chiller by factory trained and authorized servicing technicians confirming equipment has been correctly installed prior to equipment becoming operational and covered under the manufacturer's warranty.
- B. Supply initial charge of refrigerant and oil if not completely factory charged.
- C. Demonstrate system operations and verify specified performance.

3.03 CLOSEOUT ACTIVITIES

- A. See Section 01 7900 - Demonstration and Training, for additional requirements.
- B. Demonstrate proper operation of equipment to Owner's designated representative.
- C. Demonstration: Demonstrate operation of system to Owner's personnel.
 1. Use operation and maintenance data as reference during demonstration.
 2. Briefly describe function, operation, and maintenance of each component.

- D. Training: Train Owner's personnel on operation and maintenance of system.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of two hours of training.

END OF SECTION 23 6426

**SECTION 23 6514
INDUCED-DRAFT COOLING TOWERS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Induced-draft cooling towers.
- B. Controls.

1.02 REFERENCE STANDARDS

- A. CTI STD-201 OM - Operations Manual for Thermal Performance Certification of Evaporative Heat Rejection Equipment; 2021.
- B. CTI STD-201 RS - Performance Rating of Evaporative Heat Rejection Equipment; 2021.
- C. UL (DIR) - Online Certifications Directory; current listings at database.ul.com.

1.03 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide rated capacities, dimensions, weights and point loadings, accessories, required clearances, electrical requirements and wiring diagrams, and location and size of field connections. Submit schematic indicating capacity controls.
- C. Shop Drawings: Indicate suggested structural steel supports including dimensions, sizes, and locations for mounting bolt holes.
- D. Manufacturer's Certificate: Certify that cooling tower performance, based on CTI STD-201 OM or CTI STD-201 RS, meets or exceeds specified requirements and submit performance curve plotting leaving water temperature against wet bulb temperature.
- E. Manufacturer's Instructions: Submit manufacturer's complete installation instructions.
- F. Operation and Maintenance Data: Include start-up instructions, maintenance data, parts lists, controls, and accessories.
- G. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. Factory assemble unit. For shipping, disassemble into as large as practical sub-assemblies so that minimum amount of field work is required for re-assembly.
- B. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

1.05 WARRANTY

- A. See Section 01 7800 - Closeout Submittals for additional warranty requirements.
- B. Provide a five year warranty to include labor and materials coverage for corrosion resistance of cooling tower structure and fan drive.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. SPX Cooling Technologies/Marley; _____: www.spxcooling.com/#sle.

2.02 INDUCED-DRAFT COOLING TOWERS

- A. General Requirements:
 - 1. Provide units for outdoor use, factory assembled, sectional, counterflow, vertical discharge, blow-through design, with fan assemblies built into pan and casing.
 - 2. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for purpose specified and indicated.
 - 3. Tower Construction: All Stainless Steel on all wet parts and air stream components.

4. For closed loop tower, corrosion resistant copper tube bundle. capable of dry operation in the winterized season. 30% Propylene Glycol. for winter operation, include bypass through the tower while still including tower dampers.
5. Include a minimum 15% extra capacity.
6. Tower Sump shall include Probe electronic water level sensor with High/Low Level alarms.
7. Makeup water valve shall be ball valve type NOT a solenoid valve. air gap between water fill and tower water is required.
8. Sump shall include electric immersion heater for freeze protection with low water cutout.
9. provisions should be made to automatically drain/fill the tower sump from BAS.
10. guard rails, platforms and ladders should be provided by manufacturer.
11. Hydronic system shall include side stream filter with minimum 15% flow of total flow.
12. Tower shall include variable flow nozzles.
13. tower shall include outlet trash screen and antivortex plate.
14. tower fill shall be minimum 15 mil thickness.
15. Provisions should include a water treatment system as advised and approved by Corewell Engineering.

2.03 CONTROLS

END OF SECTION 23 6514

SECTION 23 7200
AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Energy recovery ventilators.
- B. Energy recovery heat exchangers.
- C. Heat recovery ventilators.
- D. Heat recovery heat exchangers.

1.02 REFERENCE STANDARDS

- A. AHRI 410 - Standard for Forced-Circulation Air-Cooling and Air-Heating Coils; 2001 (R2011).
- B. AHRI 1060 (I-P) - Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment; 2011.
- C. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size; 2012, with 2015 amendments.
- D. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; 2013, Including All Amendments and Errata.

1.03 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Shop Drawings: Show design and assembly of energy recovery unit and installation and connection details.
- C. Manufacturer's qualification statement.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with at least five years of documented experience.
- B. All Heat exchanger media to include filters on intake and exhaust air.
- C. Fan orientation shall meet healthcare cross contamination prevention requirements.
- D. Installer Qualifications: Company specializing in performing work of the type specified and with at least three years of documented experience.

1.05 WARRANTY

- A. See Section 01 7800 - Closeout Submittals for additional warranty requirements.
- B. Manufacturer Warranty: Provide 1-year manufacturer warranty for equipment including parts, materials, workmanship, and operation commencing on date of Substantial Completion. Complete forms in Owner's name and register with manufacturer.
- C. Motor Warranty: Provide 36-month manufacturer warranty against breakdowns, malfunctions, or defects in material and workmanship under expected service conditions.
- D. Energy Wheel Warranty: Provide 5-year manufacturer warranty against desiccant coating or wheel material and workmanship defects including issues arising from reduced performance under circumstances of normal use from listed design figures.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Greenheck; _____: www.greenheck.com/#sle.
- B. RenewAire; _____: www.renewaire.com/#sle.
- C. Nortek.

END OF SECTION 23 7200

SECTION 23 7313
MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Casing construction.
- B. Fan section.
- C. Coil section.
- D. Integral face and bypass coil section.
- E. Humidifier section.
- F. Filter and air cleaner section.
- G. Damper section.
- H. Airflow measurement.
- I. Total energy recovery wheel section.
- J. Desiccant wheel.
- K. Indirect-fired gas heat section.
- L. Silencer section.
- M. Access section.
- N. Air blender section.
- O. Diffuser section.
- P. Turning and discharge plenum section.
- Q. Controls.
- R. Roof mounting curb.

1.02 RELATED REQUIREMENTS

- A. Section 07 7200 - Roof Accessories: Roof curb.
- B. Section 21 0719 - Fire Suppression Piping Insulation.
- C. Section 22 0513 - Common Motor Requirements for Plumbing Equipment.
- D. Section 22 0548 - Vibration and Seismic Controls for Plumbing Piping and Equipment.
- E. Section 22 0719 - Plumbing Piping Insulation.
- F. Section 22 1005 - Plumbing Piping: Equipment drains.
- G. Section 23 0513 - Common Motor Requirements for HVAC Equipment.
- H. Section 23 0548 - Vibration and Seismic Controls for HVAC.
- I. Section 23 0593 - Testing, Adjusting, and Balancing for HVAC.
- J. Section 23 0719 - HVAC Piping Insulation.
- K. Section 23 3300 - Air Duct Accessories: Flexible duct connections.
- L. Section 23 3413 - Axial HVAC Fans.
- M. Section 23 3416 - Centrifugal HVAC Fans.
- N. Section 23 8200 - Convection Heating and Cooling Units: Air coils.
- O. Section 23 8413 - Humidifiers.
- P. Section 23 8415 - Steam Humidifiers.
- Q. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.
- R. Section 26 2923 - Variable-Frequency Motor Controllers.

1.03 REFERENCE STANDARDS

- A. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings; 2015.
- B. ABMA STD 11 - Load Ratings and Fatigue Life for Roller Bearings; 1990 (Reapproved 2008).
- C. AHRI 260 - Sound Rating of Ducted Air Moving and Conditioning Equipment; 2011.
- D. AHRI 410 - Standard for Forced-Circulation Air-Cooling and Air-Heating Coils; 2001 (R2011).
- E. AHRI 430 (I-P) - Performance Rating of Central Station Air-Handling Units; 2014.
- F. AHRI 610 (I-P) - Performance Rating Of Central System Humidifiers for Residential Applications; 2014.
- G. AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program; 2015.
- H. AMCA 99 - Standards Handbook; 2010.
- I. AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating; 2007.
- J. AMCA 300 - Reverberant Room Method for Sound Testing of Fans; 2014.
- K. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data; 2014.
- L. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating; 2012.
- M. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating; 2012.
- N. AMCA 611 - Certified Ratings Program for Airflow Measurement Stations; 2010.
- O. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size; 2012, with 2015 amendments.
- P. ASHRAE Std 62.1 - Laboratory Method of Testing to Determine the Sound Power in a Duct; 2013.
- Q. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; 2013, Including All Amendments and Errata.
- R. ASTM B177/B177M - Standard Guide for Engineering Chromium Electroplating; 2011.
- S. CGA 3.2 - Industrial and Commercial Gas-Fired Package Furnaces; Current Edition, Including All Amendments.
- T. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- U. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2015.
- V. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- W. UL (DIR) - Online Certifications Directory; current listings at database.ul.com.
- X. UL 153 - Portable Electric Luminaires; Current Edition, Including All Revisions.
- Y. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; current edition, including all revisions.
- Z. UL 508 - Industrial Control Equipment; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.
- AA. UL 508A - Industrial Control Panels; Current Edition, Including All Revisions.
- BB. UL 795 - Commercial-Industrial Gas Heating Equipment; Current Edition, Including All Revisions.
- CC. UL 1598 - Luminaires; Current Edition, Including All Revisions.
- DD. UL 1812 - Ducted Heat Recovery Ventilators; Current Edition, Including All Revisions.
- EE. UL 1995 - Heating and Cooling Equipment; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination: Coordinate factory authorized start up technician with and provide start up report.
- B. Coordinate the work with other trades for installation of roof mounted air handling units on roof curbs.
- C. Preinstallation Meeting: Conduct a preinstallation meeting at least one week prior to the start of the work of this section; require attendance by all affected installers.
- D. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.05 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data:
 - 1. Published Literature: Indicate dimensions, weights, capacities, ratings, gauges 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. Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.
- D. Shop Drawings: Indicate assembly, unit dimensions, weight loading, required clearances, construction details, field connection details, and electrical characteristics and connection requirements.
- E. Specimen Warranty: Submit sample of manufacturer's warranty.
- F. Executed Warranty: Submit documentation of final executed warranty completed in Owner's name and registered with manufacturer.
- G. Manufacturer's Instructions: Include installation instructions.
- H. Maintenance Data: Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.
- I. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Filters: One set for each unit.

1.06 QUALITY ASSURANCE

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

1.07 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.
- D. Filters will ship loose from factory with unit as scheduled.
- E. All loose-shipped items need to be packed, protected, and secured with the units.
- F. Do not operate units until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

- G. Motors should be protected and inspected in accordance with the manufacturer's specific instructions regarding periods of long storage. Provisions should be made to ensure no water is allowed to collect and remain in the motor terminal box or any electrical junction box.
- H. Tag each unit or each unit component with the number on the drawing schedules. Match-mark factory disassembled parts to facilitate erection in the field.

1.08 WARRANTY

- A. See Section 01 7800 - 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 MANUFACTURERS

- A. Daikin: <https://www.daikinapplied.com/>
- B. Airflow Equipment: www.airflowequipment.com.
- C. Trane Inc: www.trane.com.
- D. Nortek Air Solutions.
- E. Annexair.
- F. Substitutions: See Section 01 6000 - Product Requirements.

2.02 REGULATORY REQUIREMENTS

- A. Comply with NFPA 70.
- B. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for the purpose specified and indicated.

2.03 CASING CONSTRUCTION

- A. Full Perimeter Base Rail:
 - 1. Construct of galvanized steel.
 - 2. Provide base rail of sufficient height to raise unit for external trapping of condensate drain pans.
- B. 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.
 - 4. Casing Air Pressure Performance Requirements:
 - a. Able to withstand up to 8 inches w.g. positive or negative static pressure.
 - b. Not to exceed 0.0042 inches per inch deflection at 1.5 times design static pressure up to a maximum of plus 8 inches w.g. in positive pressure sections and minus 8 inches w.g. in negative pressure sections.
- C. Access Doors:
 - 1. Construction, thermal and air pressure performance same as casing.
 - 2. Provide surface mounted Single Lever Cam-Lock handles on hinged, swing doors.
 - 3. Provide shatterproof viewing window designed to withstand operating pressures.
 - 4. Door swing to be oriented for safe operator protection. Access doors serving positive pressure AHU sections shall open "In" to corresponding section. Where section clearances do not allow for internal door swing; appropriate safety devices shall be provided, including: door safety catch/detachable safety chains and door-swing safety/warning labels on the exterior of each applicable door.
- D. Outdoor Unit Roof:
 - 1. Factory install single layer outer roof above inner roof.

2. Slope at a minimum of 0.125 inches per foot from one side of unit to the other side, or from center to sides of unit.
 3. Roof assembly to overhang each unit wall or base rail to overhang curb to facilitate water runoff and prevent water intrusion into roof curb to base connection.
- E. Outside Air and Exhaust Air Weather Hood:
1. Fabricate from same material as casing outer panel.
 2. Extend hood past perimeter of unit casing opening so as not to obstruct airflow path.
 3. Hoods shall be coated with same finish as external surface of outdoor units.
 4. Provide inlet hood for each fresh air damper with a sine wave moisture eliminator to prevent entrainment of water into the unit from outside air.
 5. Provide exhaust hoods for each exhaust air opening.
 6. Size each hood for 100 percent of nominal fresh air damper capacities.
 7. Protect each hood with bird screen to prevent nesting at intake or exhaust air flow paths.
- F. Unit Flooring: Construct with sufficient strength to support expected people and equipment loads associated with maintenance activities. Flooring shall be provided with anti-slip "diamond pattern" or similar surface for slip/fall protection.
- G. 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.
- H. 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.
- I. Drain Pan Construction:
1. Provide cooling coil and humidifier sections with an insulated, double wall, stainless steel drain pan complying with ASHRAE Std 62.1 for indoor air quality and sufficiently sized to collect all 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.
- J. Bottom Inlet Units: Provide galvanized steel or aluminum walking grate on structural supports.
- K. 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.
- L. Marine Lights:
1. Provide factory furnished water- and dust-resistant LED fixture(s) at all viewable and/or accessible sections, with the following characteristics:
 - a. Non-ferrous metal housing.
 - b. Glass or polycarbonate lens.
 - c. Factory wired to a single switch within factory provided service module.
 - d. Instant on LED white light with minimum 50,000 hour service life.
 2. Provide factory installed service module including GFCI receptacle independent from load side; designed to receive power from field supplied 120 volt source.
- M. Finish:
1. Outdoor Units:
 - a. Coat external surface of unit casing with primer and minimum 1.5 mil, enamel paint finish.
 - b. Comply with salt spray test in accordance with ASTM B177/B177M.

- c. Color: Chosen by Owner.
- 2. Indoor Units:
 - a. Provide exterior, galvanized steel panels without paint.
 - b. Color: Manufacturer's standard color.

2.04 FAN SECTION

- A. Type: Backward inclined, double width, double inlet, centrifugal plug type fan, conforming to AMCA 99. Refer to Section 23 3413.
- B. Multiple Direct-Drive fan arrangements are preferred with quantity and sizing to allow for N+1 Back-Up redundancy of a failed fan unit. An individual VFD fan speed controller shall be provided for each Fan.
- C. Performance Ratings: Determined in accordance with AMCA 210 and labeled with AMCA Certified Rating Seal.
- D. Sound Ratings: AMCA 301; tested to AMCA 300 and label with AMCA Certified Sound Rating Seal.
- E. Bearings: Self-aligning, grease lubricated, with lubrication fittings extended to exterior of casing with plastic tube and grease fitting rigidly attached to casing.
- F. Mounting:
 - 1. Locate fan and motor internally on welded steel base coated with corrosion resistant paint.
 - 2. Factory mount motor on slide rails.
 - 3. Provide access to motor, drive, and bearings through removable casing panels or hinged access doors.
 - 4. Mount base on vibration isolators.
 - 5. Provide protective cage/screening around each individual fan assembly
- G. External Motor Junction Box: Factory mount NEMA 4 external junction box and connect to extended motor leads from internally mounted motors.
- H. Motor Wiring Conduit: Factory wire fan motor wiring to the unit mounted starter-disconnect, variable frequency drive, external motor junction box, and _____.
- I. Fan Accessories:
 - 1. Discharge dampers - gravity back-draft dampers to prevent bypass airflow of de-energized/ failed fan. motorized dampers are preferred over back-draft.
- J. Flexible Duct Connections:
 - 1. For separating fan, coil, and adjacent sections.
- K. Direct Drives and Motors:
 - 1. Provide fans of type and class as specified on the schedule. Fan shafts shall be solid steel, coated with a rust-inhibiting coating, and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. All fans shall be statically and dynamically tested by the manufacturer for vibration and alignment as an assembly at the operating RPM to meet design specifications. Fans controlled by variable frequency drives shall be statically and dynamically tested for vibration and alignment at speeds between 25% and 100% of design RPM. Fan wheels shall be keyed to fan shafts to prevent slipping.
 - 2. Fans shall be mounted on spring isolation bases. Internally-mounted motor shall be on the same isolation base. Fan and motor shall be internally isolated with spring isolators. Unit sizes up to nominal 4,000 cfm shall have 1-inch springs. Unit sizes larger than nominal 4,000 cfm shall have 2-inch spring isolators. A flexible connection (e.g. canvas duct) shall be installed between fan and unit casing to ensure complete isolation. Flexible connection shall comply with NFPA 90A and UL 181 requirements. If fans and motors are not internally isolated, then the entire unit shall be externally isolated from the building, including supply and return duct work, piping, and electrical connections. External isolation shall be furnished by the installing contractor in order to avoid transmission of noise and vibration through the ductwork and building structure.

3. Fan sections containing multiple fans shall be provided as indicated on the schedule and drawings. Each fan shall operate in parallel to each other fan in the array. The fans shall be SWSI plenum type with high efficient AF blades. Fans shall be direct-driven. Fan wheels shall be aluminum. The Hp characteristic of the fans shall be non-overloading.
4. Fan sections containing multiple fans shall be controlled using a common control signal, such as the duct static control signal, to modulate the fan speed.
5. Fan airflow measurement systems shall be provided to measure fan airflow directly or to measure differential pressure that can be used to calculate airflow. The accuracy of the devices shall be no worse than +/- 5 percent when operating within stable fan operating conditions. Devices shall not affect the submitted fan performance and acoustical levels. Devices that obstruct the fan inlet or outlet shall not be acceptable. Devices shall be connected to transducers with a 2-10 VDC output. Signal shall be proportional to air velocity.
6. All motors and drives shall be factory-installed and run tested. All motors shall be installed on a slide base to permit adjustment of belt tension. Slide base shall be designed to accept all motor sizes offered by the air-handler manufacturer for that fan size to allow a motor change in the future, should airflow requirements change.
7. Motors shall meet or exceed all NEMA Standards Publication MG 1 – 2006 requirements and comply with NEMA Premium efficiency levels when applicable. Motors shall comply with applicable requirements of NEC and shall be UL Listed.
8. Fan Motors shall be heavy duty, NEMA Premium efficient ODP, operable at 460/60/3, exceeding the EPAct efficiency requirements.
9. Direct-driven fan sections shall use 4-pole (1800 rpm) motors, NEMA Design B, with Class B insulation to operate continuously at 104°F (40°C) ambient without tripping of overloads. Multiple fan selections utilizing alternate rpm motors are unacceptable due to motor inefficiency, cost, and replacement lead times.
10. Motors shall have a +/- 10 percent voltage utilization range to protect against voltage variation.
11. Frequency Drive shall be Corewell standard equipment and motor shall have grounding ring.

2.05 COIL SECTION

- A. Casing: Provide access to both sides of 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.
- B. Drain Pans: 36 inch downstream of coil and down spouts for cooling coil banks more than one coil high. Stainless Steel construction.
- C. Eliminators: Three break of Type 304 stainless steel, mounted over drain pan.
- D. Air Coils:
 1. Certify capacities, pressure drops, and selection procedures in accordance with AHRI 410.
- E. Fabrication:
 1. Tubes: 5/8 inch OD seamless copper expanded into fins, brazed joints.
 2. Fins: Aluminum.
 3. Casing: Die formed channel frame of galvanized steel.
- F. Water Heating Coils:
 1. Headers: seamless copper tube, with brazed joints.
 2. Configuration: Drainable, with threaded plugs for drain and vent; serpentine type with return bends on smaller sizes and return headers on larger sizes.
 3. Extended Vents and Drains on all indoor units.
 4. No more than 120 Finns per foot.
 5. All heating coils shall be equipped with a freeze protection pump.
- G. Steam Heating Coils:

1. Shall utilize integral Face and Bypass airflow/control operation.
 2. Headers: Cast iron with tubes expanded into header, seamless copper tube with silver brazed joints, or prime coated steel pipe with brazed joints.
 3. Configuration: Drainable, with threaded plugs for drain and vent, threaded plugs in return bends and in headers opposite each tube, sloped within frame to condensate connection.
- H. Water Cooling Coils:
1. Headers: seamless copper tube, with brazed joints.
 2. Configuration: Drainable, with threaded plugs for drain and vent; threaded plugs in return bends and in headers opposite each tube.
 3. Face velocity not to exceed 500 FPM
 4. No more than 120 Fins per foot.
 5. Extended Vents and Drains on all indoor units.
 6. No greater than 8 rows.

2.06 INTEGRAL FACE AND BYPASS COIL SECTION

- A. Provide horizontal or vertical tube, integral face and bypass, steam coil certified in accordance with AHRI 410.
- B. Enclose headers and return bends within unit casing.
- C. Assembly to consist of finned heating elements and bypasses with interlocked dampers.
- D. Provide factory damper actuator.

2.07 HUMIDIFIER SECTION

- A. General: Capacities and selection in accordance with AHRI 610 (I-P).
- B. Steam Grid Humidifier:
 1. Stainless steel distribution tube with evenly spaced orifices extended full width of unit, factory mounted in plenum with drain pan for draw-through units.
 2. Refer to Section 23 8415.

2.08 FILTER AND AIR CLEANER 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. To be installed so filters are pulled toward frame by airflow. Design for airflow velocity less than 400 FPM.
- B. All Units Shall have Final Filters section capable of housing HEPA filters. Fan Must be accounted for Future HEPA Pressure Drop.
- C. Pleated Media Pre Filters:
 1. Media: 4 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: MERV 8 when tested in accordance with ASHRAE Std 52.2.
 4. Refer to Section 23 4000.
- D. HEPA Filters:
 1. Media: Continuously pleated, waterproof, micro-fiberglass; enclosed in a galvanized, steel frame with neoprene rubber seal applied to leaving air side, and capable of operating up to a maximum of 500 fpm without loss of efficiency and holding capacity.
 2. Frame: Continuously welded, gasketed, front loaded filter frames, mounted inside section casing along with filter holding clips, requiring tooling to tighten and hold filter cells.
 3. Minimum Efficiency: Not less than: 99.97 percent when tested in accordance with ASHRAE Std 52.2.
 4. Refer to Section 23 4000.
- E. Differential Pressure Gauge:

1. Provide factory installed dial type differential pressure gauge, flush mounted with casing outer wall, and fully piped to both sides of each filter to indicate status.
2. Maintain plus/minus 5 percent accuracy within operating limits of 20 degrees F to 120 degrees F.

2.09 DAMPER SECTION

- A. Mixing Section: Provide a functional section to support the damper assembly for modulating the volume of outdoor, return, and exhaust air.
- B. Outdoor/Return Air mixing sections shall include Airflow Monitoring device (Trane TRAQ damper or similar as reviewed by Corewell Facilities Engineering.)
- C. 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 Std 90.1 I-P 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.
- D. Barometric Relief Dampers:
 1. Frame: Roll formed galvanized steel.
 2. Blades: Roll formed galvanized steel with nylon or teflon bushed hinge pins.
 3. Blade Seals: Extruded vinyl, mechanically attached to the blade edge.
 4. Material:
 - a. Galvanized steel, single tie bar linkage for damper sections up to 24 inches wide.

2.10 AIRFLOW MEASUREMENT

- A. Air Flow Measurement Station:
 1. Provide factory installed, airflow measurement station tested in accordance with AMCA 611 and bearing the AMCA Ratings Seal for Airflow Measurement Performance.
 2. Outdoor/Return Air mixing sections shall include Airflow Monitoring device (Trane TRAQ damper or similar as reviewed by Corewell Facilities Engineering.)
 3. Supply Air measurement is required. Piezo Rings are preferred.
 4. Station Location: Install in outdoor and return opening to measure airflow.
 5. Damper Blades:
 - a. Stainless steel or extruded aluminum construction.
 - b. Housed in Stainless steel or extruded aluminum frame and mechanically fastened to a rotating axle rod.
 - c. Comply with ASHRAE Std 90.1 I-P for rated maximum leakage rate.
 6. Measurement Range: Minimum of 15 percent to 100 percent of unit nominal flow.
 7. Operation: Provide low voltage signal corresponding to actual airflow for controlling and documenting airflow.
 8. Accuracy: Plus/minus 5 percent.
 9. See Section 23-0913

2.11 INDIRECT-FIRED GAS HEAT SECTION

- A. Comply with UL 795 and CGA 3.2 for commercial-industrial gas heating equipment and CGA 3.2 for industrial gas-fired packaged furnaces.
- B. Construction:
 1. Factory assemble and fire test prior to shipment.
 2. Burner Vestibule Materials and Components:
 - a. Heat Exchanger Assembly: 14 gage, 0.0747 inch, 409 stainless steel.
 - b. Burner: UL (DIR) listed, forced draft, and fully modulating Gas valve.
 - c. Control Panel: Equip with flame management controls and appropriate safeties.

- d. Section construction same as rest of air handling unit with large access door.
- e. Controls to include Carbon Monoxide Safety monitoring/notification and alarm system

2.12 AIR BLENDER SECTION

- A. Provide factory engineered air mixers incorporating fixed blades with no moving parts.
- B. Construction:
 - 1. Material: 0.80 inches aluminum, galvanized steel, aluminized steel, or stainless steel.
 - 2. Welded and mechanically fastened.
 - 3. Finish: Galvanized.
- C. Factory install with adequate distances upstream and downstream, based on cataloged performance with a minimum, effectiveness of 70 percent outside air or within plus/minus 6 degrees F of theoretical mixed air temperature, at a minimum distance of one mixer diameter downstream of the mixer.
- D. Include pressure loss due to mixer design and mixer-to-plenum ratio in the pressure drop rating for the static air mixer.

2.13 TURNING AND DISCHARGE PLENUM SECTION

- A. Provide plenum to efficiently turn and discharge air.
 - 1. Scale plenum vertical height to accommodate discharge duct height.
 - 2. Scale plenum horizontal length to accommodate required dimensional constraints.
- B. Acoustical Liner:
 - 1. Fabricate from corrosion-proof, perforated stainless steel with completely encapsulated fiberglass insulation.
 - 2. Prevent breakaway, flake off, or delamination when tested at 9000 fpm in accordance with UL 181.

2.14 CONTROLS

- A. See Sections 23-0913 and 23-0923
- B. Combination VFD - Disconnects:
 - 1. Provide factory mounted, combination VFD - disconnect for each fan motor.
 - a. Provide in accordance with Section 26 2923.
 - 2. Factory mount in full metal enclosure and wire to fan motor.
 - 3. Mount VFD-disconnect on fan section externally in a NEMA 1 enclosure within a dedicated controls section or housed fan section.
 - a. Internal Enclosure Construction Characteristics:
 - 1) Integral part of unit casing to allow for thermal venting to casing interior.
 - 2) Accessible from unit exterior via access door.
 - 3) Construction of access doors same throughout unit.
 - 4. Include circuit breaker disconnect with through-the-door interlocking handle for externally mounted starters, spring loaded, and designed to rest only in the full and lockable ON or OFF state.
 - 5. Allow enclosure entry via a concealed defeater mechanism when the handle is in the ON position.
 - 6. Provide bypass relays and bypass circuitry with VFD-OFF-BYPASS selector switch.
- C. Factory Installed Direct Digital Control (DDC) System:
 - 1. Factory engineer and test each component.
 - 2. Provide fully functional control system to operate in either stand-alone mode or as part of the building automation system (BAS) via single pair of twisted wires tie-in.
 - 3. DDC Controller:
 - a. Dedicated, field programmable DDC controller with appropriate point capabilities.
 - b. Control manufacturer- Trane
 - 4. Control Options:
 - a. Electronic End Devices:

- 1) Accommodate integration into existing building systems.
- 2) Wire to standard point locations of unit mounted DDC controller or terminal block for remote controller.
- b. Mixing Section Spring Return Damper Actuators:
 - 1) Outdoor Air Damper: Normally closed.
 - 2) Return Air Damper: Normally open.
- c. Air Flow Measurement Stations: 2 to 10 VDC signal corresponding to CFM for controlling and documenting airflow.
- d. Fan Discharge Temperature and Temperature Averaging Sensors: Suitable for integration into the BAS system.
- e. Low Limit Switches:
 - 1) Factory wire to momentary push-button reset circuit.
 - 2) Provide separate low limit for each coil in a coil stack.
- f. Airflow Switches: Pipe to both filter sides to indicate fan status.
- g. Dirty Filter Switches: Pipe to both filter sides to indicate filter status.
- D. Factory Provided Controls for Field Installation:
 - 1. Control valves.
 - 2. Space and outdoor air temperature sensors.

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. Make connections to coils with unions or flanges.
- E. 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.
- F. Steam Coils:
 - 1. Install vacuum breaker in steam line at or in header.
 - 2. Install steam traps with outlet minimum 12 inches below coil return connection.
- G. Cooling Coils:
 - 1. Pipe drain and overflow to nearest floor drain.
 - 2. Refer to Section 22 1005.
- H. Connect Humidifiers to Water Supply:
 - 1. Provide gate valve on water supply line.
 - 2. Provide 3/4 inch hose bibb accessible from interior.
 - 3. Pipe drain and overflow to nearest floor drain.

3.02 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.

3.03 SYSTEM STARTUP

- A. Provide manufacturer's field representative to perform systems startup.

- B. Prepare and start equipment and systems in accordance with manufacturers' instructions and recommendations.
- C. Adjust for proper operation within manufacturer's published tolerances.

3.04 CLOSEOUT ACTIVITIES

- A. See Section 01 7800 - Closeout Submittals, for closeout submittals.
- B. See Section 01 7900 - Demonstration and Training, for additional requirements.
- C. Demonstrate proper operation of equipment to Owner's designated representative.
- D. Demonstration: Demonstrate operation of system to Owner's personnel.
 - 1. Use operation and maintenance data as reference during demonstration.
 - 2. Conduct walking tour of project.
 - 3. Briefly describe function, operation, and maintenance of each component.
- E. Training: Train Owner's personnel on operation and maintenance of system.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of two hours of training.
 - 3. Location: At project site.

END OF SECTION 23 7313

SECTION 23 7416
PACKAGED ROOFTOP AIR-CONDITIONING UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Packaged, small-capacity, rooftop air-conditioning units.
- B. Packaged, intermediate-capacity, rooftop air-conditioning units.
- C. Packaged, large-capacity, rooftop air-conditioning units.
- D. Split-system rooftop units.

1.02 RELATED REQUIREMENTS

- A. Section 23 0548 - Vibration and Seismic Controls for HVAC.
- B. Section 23 4000 - HVAC Air Cleaning Devices.

1.03 REFERENCE STANDARDS

- A. AHRI 210/240 - Standard for Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment; 2008.
- B. AHRI 270 (SI/I-P) - Sound Performance Rating of Outdoor Unitary Equipment; 2025.
- C. AMCA 611 - Certified Ratings Program for Airflow Measurement Stations; 2010.
- D. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; 2013, Including All Amendments and Errata.
- E. ASHRAE Std 135 - BACnet - A Data Communication Protocol for Building Automation and Control Networks; 2012.
- F. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- G. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2015.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical service with electrical characteristics and connection requirements, and duct connections.
- C. Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.
- D. Manufacturer's Instructions: Indicate assembly, support details, connection requirements, and include start-up instructions.
- E. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- 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. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Protect units from physical damage by storing off site until roof mounting curbs are in place and ready for immediate installation of units.

1.07 WARRANTY

- A. See Section 01 7800 - Closeout Submittals for additional warranty requirements.
- B. Provide a five year warranty to include coverage for refrigeration compressors.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Trane Technologies, PLC; _____: www.trane.com/#sle.
- B. Substitutions: See Section 01 6000 - Product Requirements.

2.02 PACKAGED, SMALL-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

- A. Manufacturers:
 - 1. Diakin
 - 2. Aeon
 - 3. Trane Technologies, PLC; _____: www.trane.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. General: Roof mounted units having fully modulated gas burner and electric multi stage refrigeration that are 6 tons and smaller in capacity.
- C. Description: Self-contained, packaged, factory assembled and prewired, consisting of cabinet and frame, supply fan, return fan, heat exchanger and burner, heat recovery coil, controls, air filters, refrigerant cooling coil and compressor, condenser coil and condenser fan.

2.03 PACKAGED, INTERMEDIATE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

- A. Manufacturers:
 - 1. Diakin
 - 2. Aeon
 - 3. Trane Technologies, PLC; _____: www.trane.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. General: Roof mounted units having Fully modulated gas burner and multi circuit and variable capacity electric refrigeration that are 7.5 tons to 25 tons in capacity.
- C. Description: Self-contained, packaged, factory assembled and prewired, consisting of cabinet and frame, supply fan, return fan, heat exchanger and burner, heat recovery coil, controls, air filters, refrigerant cooling coil and compressor, condenser coil and condenser fan.
- D. Must be able to provide full economizer operation.

2.04 PACKAGED, LARGE-CAPACITY, ROOFTOP AIR-CONDITIONING UNITS

- A. Manufacturers:
 - 1. Diakin
 - 2. Aeon
 - 3. Trane Technologies, PLC; _____: www.trane.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. General: Roof mounted units having Fully modulated gas burner and multi circuit and variable capacity electric refrigeration that are 25 tons and larger in capacity.
- C. Description: Self-contained, packaged, factory assembled and prewired, consisting of cabinet and frame, supply fan, return fan, heat exchanger and burner, heat recovery coil, controls, air filters, refrigerant cooling coil and compressor, condenser coil and condenser fan.
- D. Must be able to provide full economizer operation.

2.05 CASING

- A. Cabinet: Steel with baked enamel finish, including access doors with piano hinges and locking handle.

2.06 FANS

- A. Variable speed Supply and Return Fan: adjustable variable pitch pulley, and rubber isolated hinge mounted. Provide with high efficiency motor or direct drive as indicated. Isolate complete fan assembly. See Section 23 0548.

2.07 BURNERS

- A. Gas Burner: Atmospheric type burner with adjustable combustion air supply, pressure regulator, gas valves, manual shut-off, intermittent spark or glow coil ignition, flame-sensing device, and automatic 100 percent shutoff pilot.
- B. Gas Burner Safety Controls: Energize ignition, limit time for establishment of flame, prevent opening of gas valve until pilot flame is proven, stop gas flow on ignition failure, energize blower motor, and after airflow proven and slight delay, allow gas valve to open.

2.08 EVAPORATOR COIL

- A. Provide copper tube aluminum fin coil assembly with galvanized drain pan and connection.
- B. Provide capillary tubes or thermostatic expansion valves for units of 6 tons capacity and less, and thermostatic expansion valves and alternate row circuiting for units 7.5 tons cooling capacity and larger.

2.09 COMPRESSORS

- A. Provide hermetic compressors, 3600 rpm maximum, resiliently mounted with positive lubrication, crankcase heater, high and low pressure safety controls, motor overload protection, suction and discharge service valves and gauge ports, and filter drier.

2.10 AIR FILTERS:

- A. Minimum 2-inch thick, pleated disposable media in metal frames. on small capacity roof top units, 4" on the larger capacity units
- B. See Section 23 4000.

2.11 AIRFLOW MEASUREMENT

- A. See Section 23 0913

2.12 OPERATING CONTROLS

- A. See Section 23 0913
 - 1. Include system selector switch heat-off-cool and auto-on fan control switch.
- B. See Section 23 0923
- C. See Section 23 0993

2.13 ROOF CURBS

- A. Roof Mounting Curb: 16 inches high, galvanized steel, channel frame with gaskets, nailer strips. shall be insulated and sound proofed.
- B. Provide 3 layers of water proofed gypsum boards inside the curb on roof deck. staggered seams.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that roof is ready to receive work and opening dimensions are as required by manufacturer.
- B. Verify that proper power supply is available.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Mount units on factory built roof mounting curb providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level.

3.03 SYSTEM STARTUP

- A. Prepare and start equipment. Adjust for proper operation. record and submit manufacturer start up document.

B. Implement owner asset tag

END OF SECTION 23 7416

**SECTION 23 7433
DEDICATED OUTDOOR AIR UNITS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Direct fired make-up air heater.
- B. Cooling coil section and compressor-condenser unit.
- C. Service platform.
- D. Controls.

1.02 RELATED REQUIREMENTS

- A. Section 22 0513 - Common Motor Requirements for Plumbing Equipment.
- B. Section 22 0548 - Vibration and Seismic Controls for Plumbing Piping and Equipment.
- C. Section 23 0513 - Common Motor Requirements for HVAC Equipment.
- D. Section 23 0548 - Vibration and Seismic Controls for HVAC.
- E. Section 23 0913 - Instrumentation and Control Devices for HVAC: Control components, time clocks.
- F. Section 23 1123 - Facility Natural-Gas Piping: Natural gas connections.
- G. Section 23 4000 - HVAC Air Cleaning Devices: Filters.

1.03 REFERENCE STANDARDS

- A. AHRI 270 (SI/I-P) - Sound Performance Rating of Outdoor Unitary Equipment; 2025.
- B. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings; 2013, Including All Amendments and Errata.
- C. NEMA MG 00001 - Motors and Generators; 2024.
- D. NFPA 54 - National Fuel Gas Code; 2015.
- 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.

1.04 SUBMITTALS

- A. Product Data: Provide data with dimensions, duct and service connections, accessories, controls, electrical nameplate data, and wiring diagrams.
- B. Shop Drawings: Indicate dimensions, duct and service connections, accessories, controls, electrical nameplate data, and wiring diagrams.
- C. Manufacturer's Instructions: Indicate rigging, assembly, and installation instructions.
- D. Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.
- E. Operation And Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- F. Warranty: Submit manufacturers warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.
- G. Project Record Documents: Record actual locations of components.
- H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Filters: One set of each type and size.

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 WARRANTY

- A. Provide five year manufacturers warranty for compressor/condenser unit.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Greenheck; _____: www.greenheck.com/#sle.
- B. Trane
- C. Absolut-Aire
- D. Rapid Air
- E. Annex Air

2.02 REGULATORY REQUIREMENTS

- A. Comply with NFPA 70.

2.03 MANUFACTURED UNITS

- A. Unit: Outdoor unit with refrigeration package.
 - 1. Construction and Ratings: In accordance with AHRI 210/240 and UL 207. Testing: ASHRAE Std 23.1.
 - 2. Performance Ratings: Energy Efficiency Rating (EER)/Coefficient of Performance (COP) not less than requirements of ASHRAE Std 90.1.

2.04 BURNERS

- A. Assembly: For natural gas, capable of fully modulating turn down ratio of 25:1, including electric modulating main gas valve, motorized shut down valve, main and pilot gas regulators, pilot electric gas valve, manual shut-off valve and pilot adjustment valve.

2.05 CONTROLS

- A. Controls: Pre-wire unit for connection of power supply. Field wiring from unit to remote control panel makes unit operative. Fully integrated to Trane BAS central network Baacnet sys
- B. Carbon Monoxide Monitoring System: Operates fan on high volume when pre-determined carbon monoxide concentration is detected.
- C. Safety Controls: Sense correct air flow before energizing pilot and sense pilot ignition before activating main gas valve.

2.06 REFRIGERATION PACKAGE

- A. Evaporator Coil: Copper tube aluminum fin coil assembly with alternate row circuiting, and with galvanized drain pan and thermostatic expansion valve.
- B. Compressor: Multiple refrigeration compressor system, 2-stage operation.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Install to NFPA 90A.
- C. Install to NFPA 54. Provide connection to natural gas system; refer to Section 23 1123.
- D. Install unit on vibration isolators; refer to Section 23 0548.

3.02 MAINTENANCE

- A. See Section 01 7000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.

- B. Provide service and maintenance of units for one year from Date of Substantial Completion.

SECTION 23 8124
COMPUTER ROOM AIR CONDITIONERS - FLOOR MOUNTED

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Air conditioning units.
- B. Controls and control panels.

1.02 RELATED REQUIREMENTS

- A. Section 09 6900 - Access Flooring.
- B. Section 21 2200 - Clean-Agent Fire-Extinguishing System: Interlock with fire suppression system.
- C. Section 22 3000 - Plumbing Equipment: Cooling condensate removal pumps.
- D. Section 23 0513 - Common Motor Requirements for HVAC Equipment: Evaporator and condenser fan motors.
- E. Section 23 6313 - Air Cooled Refrigerant Condensers.
- F. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size; 2012, with 2015 amendments.
- B. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1 - Rules for Construction of Pressure Vessels; 2015.
- C. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- D. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2015.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide for manufactured products and assemblies. Indicate water, drain, refrigeration, rough-in connections, and electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate manufactured products and assemblies. Indicate water, drain, refrigeration, rough-in connections, and electrical characteristics and connection requirements.
- D. Manufacturer's Instructions: Indicate assembly, support details, connection requirements, and include start-up instructions.
- E. Manufacturer's Field Reports: Indicate conditions at initial start-up including date, and initial set points.
- F. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, and maintenance and repair data.
- G. 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 type of products specified in this section, with minimum three years of documented experience.
- B. Installer Qualifications: Company specializing in performing the work of this section with minimum 3 years of experience.
- C. Comply with NFPA 90A for the installation of computer room air conditioning units.
- D. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.06 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Warranty: Include coverage of refrigeration compressors.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Liebert, a brand of Vertiv Co; _____: www.vertivco.com/#sle.

2.02 PERFORMANCE REQUIREMENTS

- A. Cooling:
 - 1. Capacity: _____ Btuh.
 - 2. Air Flow: _____ cfm.
 - 3. Air Entering Evaporator: _____ degrees F DB and _____ degrees F WB.
 - 4. Air Leaving Evaporator: _____ degrees F DB and _____ degrees F WB.
 - 5. Number of Evaporator Fans: One.
 - 6. Evaporator Fan Motors: _____ hp.
- B. Water Cooled:
 - 1. Condenser Water Flow: _____ gpm.
 - 2. Condenser Entering Water: _____ degrees F.
 - 3. Number of Condenser Fans: One.
 - 4. Condenser Fan Motors: _____ hp.
- C. Humidifier:
 - 1. Total Capacity: _____ lb/hr.
 - 2. Input: _____ W.

2.03 AIR CONDITIONING UNITS

- A. Description: Packaged, water cooled, factory assembled, pre-wired and pre-piped unit, consisting of cabinet, fans, filters, humidifier, and controls. To be installed in all IS rooms.
- B. Assembly: Up-flow air delivery, in draw-through configuration.
- C. Energy Efficiency:
 - 1. Air-Cooled Unit Capacity: Greater than or equal to 65 kBtu/h and less than 135 kBtu/h:
 - a. Energy Efficiency Ratio: 8.90.
 - b. Coefficient of Performance: 3.02.
 - 2. Air-Cooled Unit Capacity: Greater than or equal to 135 kBtu/h and less than 240 kBtu/h:
 - a. Energy Efficiency Ratio: 8.50.
 - b. Coefficient of Performance: 2.84.
 - 3. Water -Cooled Unit Capacity: Less than or equal to 17 kBtu/h:
 - a. Energy Efficiency Ratio: 12.1.
 - 4. Water-Cooled Unit Capacity: Greater than or equal to 17 kBtu/h and less than 65 kBtu/h:
 - a. Energy Efficiency Ratio: 12.1.
 - b. Coefficient of Performance: 3.35.
 - 5. Water-Cooled Unit Capacity: Greater than or equal to 65 kBtu/h and less than 135 kBtu/h:
 - a. Energy Efficiency Ratio: 11.5.
 - b. Coefficient of Performance: 3.37.
 - 6. Water -Cooled Unit Capacity: Greater than or equal to 135 kBtu/h and less than 240 kBtu/h:
 - a. Energy Efficiency Ratio: 9.6.
 - b. Coefficient of Performance: 3.22.

2.04 CABINET AND FRAME

- A. Structural Frame: 10 gage, 0.1345 inch welded steel suitably braced for rigidity, capable of supporting compressors and other mechanical equipment and fittings with welded tubular steel floor stand with adjustable legs and vibration isolation pads.
- B. Doors and Access Panels: 18 gage, 0.0478 inch galvanized steel with polyurethane gaskets, hinges to allow removal of panels, and concealed fastening devices.
- C. Insulation: Thermally and acoustically line cabinet interior with 1 inch thick acoustic duct liner.
- D. Finish of Exterior Surfaces: Baked-on textured vinyl enamel; ____ color.

2.05 EVAPORATOR FANS AND MOTORS

- A. Fans: Double inlet, forward curved centrifugal fans, statically and dynamically balanced, directly driven.
- B. Motor: Refer to Section 23 0513.

2.06 COMPRESSORS

- A. Type: Semi-hermetic with suction gas cooled motors, vibration isolators, thermal overloads, oil sight glass, manual reset high pressure switch, pump down low pressure switch, suction line strainer, reversible oil pumps, 1750 rpm.
- B. Compressors: Individually serviceable without dismantling other components or removing unit from service.
- C. Refrigeration Circuits: Two, each with hot gas mufflers, thermal expansion valve with external equalizer, liquid line solenoid valve, liquid line filter-drier, refrigerant sight glass with moisture indicator, service shut-off valves and charging valves and accumulator sized for liquid seal under light load.

2.07 EVAPORATOR COILS

- A. Alternate row circuits, direct expansion cooling coils of seamless copper tubes expanded into aluminum fins in A-frame configuration.
- B. Mount coil assembly in stainless steel drain pan.

2.08 CONDENSERS

- A. Water Cooled: Shell and tube type to ASME BPVC-VIII-1 with liquid line stop valve and head pressure actuated water regulating valve. Terminate outside cabinet for easy external connections. Size to be able to run on elevated water temperatures.
- B. Air Cooled Refrigerant Condenser:
 - 1. Corrosion resistant cabinet.
 - 2. Copper tube aluminum fin coils arranged for two circuits.
 - 3. Multiple direct drive propeller fans with permanently lubricated ball bearings.
 - 4. Single phase motors with internal overload protection.
 - 5. Refer to Section 23 0513 - Common Motor Requirements for HVAC Equipment.
 - 6. Refer to Section 23 6313 - Air Cooled Refrigerant Condensers.
 - 7. Provide capacity control by cycling fans.

2.09 FILTERS

- A. Media: Pleated, lofted, non-woven, reinforced cotton fabric; supported and bonded to welded wire grid; enclosed in cardboard frame; 2 inch nominal thickness.
- B. Minimum Efficiency Reporting Value (MERV): 13, when tested in accordance with ASHRAE Std 52.2.
- C. Rating, ASHRAE Std 52.2:
 - 1. Weight arrestance: 90-92 percent.
 - 2. Initial resistance at 500 FPM face velocity: 0.30 inch WG.
 - 3. Recommended final resistance: 1.0 inch WG.

2.10 HUMIDIFIER

- A. Electrode Steam Type:
 - 1. Type: Self contained, replaceable cylinder, microprocessor controlled electrode steam generating unit.
 - 2. Cylinders: Disposable, polypropylene plastic with field adjustable steel electrodes.
 - 3. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure reducing and flow regulating orifice, and drain with integral air gap on drain.
 - 4. Cabinet: Steel, 16 gage, 0.0598 inch with enamel finish, with hinged and lockable access door.
 - 5. Control: Fully modulating control to provide gradual 0 to 100 percent capacity with field adjustable maximum capacity; high water probe.
 - 6. Drain Cycle: Field adjustable drain duration and drain interval.
 - 7. Steam Distributor: Stainless steel steam dispersion tube.

2.11 ELECTRICAL PANEL

- A. Control Cabinet: NEMA EN 10250; Type 2 enclosure, UL listed, with piano hinged door, grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, and fusible control circuit transformer.
- B. Disconnect Switch: Non-automatic molded case circuit breaker with handle accessible with panel closed and capable of preventing access until switched to "off" position.

2.12 MICROPROCESSOR CONTROL SYSTEM

- A. Logic Circuitry: Microprocessor shall continuously monitor operation of process cooling system; continuously digitally display room temperature and room relative humidity; sound alarm on system malfunction and simultaneously display problem. When more than one malfunction occurs, display fault in sequence with room temperature, remember alarm even when malfunction cleared, and continue to display fault until reset.
- B. Malfunctions: Power Loss, Loss of Air Flow, Clogged Air Filter, High Room Temperature, Low Room Temperature, High Humidity, Low Humidity, Smoke/Fire, Compressor No. 1 - Overload, Compressor No. 1 - Low Pressure, Compressor No. 1 - High Pressure, Compressor No. 2 - Overload, Compressor No. 2 - Low Pressure, Compressor No. 2 - High Pressure, Water-Under-Floor, and Supply Fan Overload.
- C. Light Emitting Diodes Display: Control Power On, System On, Humidification, De-humidification taking place, Compressor No. 1 operating, Compressor No. 2 operating, Heat or Reheat operating, Economy Cooling.
- D. Push Buttons: Provide to STOP process cooling system, START process cooling system, SILENCE audible alarm, push-to-test LED indicators, and display room relative humidity.
- E. Remote Signalling: Provide termination for remote signalling of system status and alarms.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that flooring system is ready to receive work and opening dimensions are as indicated on shop drawings.
- B. Verify that proper power supply is available and of the correct characteristics.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Coordinate installation of computer room air conditioning units with computer room raised floor installer.

3.03 FIELD QUALITY CONTROL

- A. Provide the services of the manufacturer's field representative to start and adjust systems and equipment and instruct operating personnel.

3.04 SYSTEM STARTUP

- A. Prepare and start systems. Set initial temperature and humidity set points.

END OF SECTION 23 8124

**SECTION 23 8125
COMPUTER ROOM AIR CONDITIONERS - CEILING MOUNTED**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Air conditioning units.
- B. Controls.

1.02 RELATED REQUIREMENTS

- A. Section 22 3000 - Plumbing Equipment: Cooling condensate removal pumps.
- B. Section 23 0913 - Instrumentation and Control Devices for HVAC: Placement of wall mounted thermostat.
- C. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturers literature and data indicating water, drain, and electrical characteristics and connection requirements.
- C. Manufacturer's Instructions: Indicate procedures required for rigging and making service connections.
- D. Manufacturer's Field Reports: Indicate conditions at initial start-up including date, and initial set points.
- E. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data.
- F. Warranty: Submit manufacturer's warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.

1.04 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.05 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide a five year warranty to include coverage for refrigeration compressor.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Liebert, a brand of Vertiv Co; _____: www.vertivco.com/#sle.
- B. Mitsubishi.

2.02 PERFORMANCE REQUIREMENTS

- A. Cooling:
 - 1. Capacity: _____ Btu/hr.
 - 2. Air Flow: _____ cfm.
 - 3. Air Entering Evaporator: _____ degrees F DB and _____ degrees F WB.
 - 4. Air Leaving Evaporator: _____ degrees F DB and _____ degrees F WB.
 - 5. Evaporator Fan Motor: _____ hp.
- B. Water Cooled:
 - 1. Water Flow: _____ gpm.

2. Entering Condenser Water: ____ degrees F.
3. Condenser Fan Motor: ____ hp.
- C. Air Cooled:
 1. Entering Air: ____ degrees F.
 2. Condenser Fan Motors: ____ hp.
- D. Reheat Capacity: ____ Btuh.
- E. Humidifier:
 1. Total Capacity: ____ lb/hr.
 2. Input: ____ W.
- F. Electrical Characteristics:
 1. ____ kW, ____ rated load amperes.
 2. ____ volts, single phase, 60 Hz.
 3. ____ amperes maximum fuse size.
- G. Disconnect Switch: Factory mount disconnect switch in control panel.

2.03 AIR CONDITIONING UNITS

- A. Description: Self contained air cooled, factory assembled, pre-wired and pre-piped unit, consisting of cabinet, fan, filters, humidifier, controls. To be installed in all IS rooms and closets.
- B. Assembly: For horizontal ceiling mounting to fit 24 by 48 inches T-bar ceiling opening.
- C. Energy Efficiency:
 1. Water -Cooled Unit Capacity: Less than or equal to 17 kBtu/h:
 - a. Energy Efficiency Ratio: 12.1.
 2. Water-Cooled Unit Capacity: Greater than or equal to 17 kBtu/h and less than 65 kBtu/h:
 - a. Energy Efficiency Ratio: 12.1.
 - b. Coefficient of Performance: 3.35.
 3. Water -Cooled Unit Capacity: Greater than or equal to 65 kBtu/h and less than 135 kBtu/h:
 - a. Energy Efficiency Ratio: 11.5.
 - b. Coefficient of Performance: 3.37
 4. Water -Cooled Unit Capacity: Greater than or equal to 135 kBtu/h and less than 240 kBtu/h:
 - a. Energy Efficiency Ratio: 9.6.
 - b. Coefficient of Performance: 3.22
- D. Cabinet: 10 gage, 0.1345 inch welded steel with baked enamel finish, and lined with 1/2 inch thick acoustic duct liner.
- E. Evaporator Fan: Forward curved centrifugal, directly driven by two speed motor.
- F. Compressor: Hermetic with resilient suspension system, oil strainer, internal motor overload protection, low pressure switch, manual reset high pressure switch.
- G. Evaporator Coil: Direct expansion cooling coil of seamless copper tubes expanded into aluminum fins, with thermal expansion valve with external equalizer, liquid line filter-drier, service shut-off valves and charging valves. Mount coil assembly in stainless steel drain pan.
- H. Water (Glycol) Cooled Condenser: Coaxial counterflow tube-in-tube type with liquid line stop valve and head pressure actuated water regulating valve, sized for rated capacity with ____ gpm water entering at ____ degrees F.
- I. Filter: 1 inch thick disposable glass fiber media.
- J. Electrode Steam Type Humidifier: Self contained type with replaceable cylinder, microprocessor controlled.

2.04 CONTROL SYSTEM

- A. Cooler: Corrosion resistant cabinet with copper tube aluminum fin coil, direct drive propeller fan with fan guards permanently lubricated ball bearing, single phase ____ hp fan motors with internal overload protection.
- B. Pump: In-line type centrifugal pump with mechanical seal, ____ hp motor, ____ volt, single phase, 60 Hz.
- C. Unit Mounted: Main fan contactor, compressor and condenser fan contactor, compressor start capacitor, controls transformer with circuit breaker, solid state temperature and humidity control modules, humidity contactor, time delay relay, reheat contactor, and high temperature thermostat.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that ceiling system is ready to receive work and opening dimensions are as indicated on shop drawings.
- B. Verify that electric power is available and of the correct characteristics.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Coordinate installation of air conditioning unit with computer room ceiling installer.
- C. Provide adequate drainage connections for water cooled units.
- D. Provide shut-off valves in condenser water inlet and outlet piping on water cooled units.

3.03 SYSTEM STARTUP

- A. Set initial temperature and humidity set points. Instruct operating personnel.

3.04 SCHEDULES

- A. Drawing Code:
 - 1. Location:
 - 2. Manufacturer:
 - 3. Model Number:
 - 4. Cooling Capacity:
 - a. Total:
 - b. Sensible:
 - c. Room DB Temperature:
 - d. Room WB Temperature:
 - e. Air Flow:
 - f. Fan Motor Size:
 - 5. Condenser:
 - a. Water Flow:
 - b. Water Temperature:
 - c. Ambient Air Temperature:
 - d. Fan Motor Size:
 - 6. Reheat:
 - a. Capacity:
 - 7. Humidifier:
 - a. Capacity:
 - b. Power Input:
 - 8. Power Volt/Phase/Cycle:

END OF SECTION 23 8125

SECTION 23 8126.13
SMALL-CAPACITY SPLIT-SYSTEM AIR CONDITIONERS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Air cooled condensing units.
- B. Indoor air handling (fan and coil) units for ductless systems.
- C. Controls.

1.02 RELATED REQUIREMENTS

- A. Section 23 0913 - Instrumentation and Control Devices for HVAC: Thermostats, humidistats, time clocks.
- B. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections and installation and wiring of thermostats and other controls components.

1.03 REFERENCE STANDARDS

- A. AHRI 210/240 - Standard for Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment; 2008.
- B. AHRI 520 - Performance Rating of Positive Displacement Condensing Units; 2004.
- C. ASHRAE Std 15 - Safety Standard for Refrigeration Systems; 2013.
- D. ASHRAE Std 23.1 - Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units; 2010.
- E. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2015.
- F. NFPA 90B - Standard for the Installation of Warm Air Heating and Air-Conditioning Systems; 2015.
- G. UL 207 - Standard for Refrigerant-Containing Components and Accessories, Nonelectrical; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide rated capacities, weights, accessories, electrical nameplate data, and wiring diagrams.
- C. Shop Drawings: Indicate assembly, required clearances, and location and size of field connections.
- D. Design Data: Indicate refrigerant pipe sizing.
- E. Manufacturer's Instructions: Indicate rigging, assembly, and installation instructions.
- F. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- G. Warranty: Submit manufacturers 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 type of products specified in this section, with minimum three years of documented experience.
- B. Installer Qualifications: Company specializing in performing the work of this section with minimum 3 years of experience and approved by manufacturer.

1.06 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Mitsubishi
- B. Trane Inc; _____: www.trane.com/#sle.
- C. Samsung
- D. Daiken.
- E. Substitutions: See Section 01 6000 - Product Requirements.

2.02 SYSTEM DESIGN

- A. Split-System Heating and Cooling Units: Self-contained, packaged, matched factory-engineered and assembled, pre-wired indoor and outdoor units; UL listed.
 - 1. Heating: None.
 - 2. Cooling: Outdoor electric condensing unit with evaporator coils in multiple ductless indoor units ("mini-split").
 - 3. Provide refrigerant lines internal to units and between indoor and outdoor units, factory cleaned, dried, pressurized and sealed, with insulated suction line.
- B. Performance Requirements: See Drawings for additional requirements.
- C. Electrical Characteristics:
 - 1. _____ kW.
 - 2. _____ volts, single phase, 60 Hz.
 - 3. _____ amperes maximum fuse size.
 - 4. Disconnect Switch: Factory mount disconnect switch on equipment under provisions of Section 26 0583.

2.03 INDOOR AIR HANDLING UNITS FOR DUCTLESS SYSTEMS

- A. Indoor Units: Self-contained, packaged, factory assembled, pre-wired unit consisting of cabinet, supply fan, evaporator coil, and controls; wired for single power connection with control transformer.
- B. Evaporator Coils: Copper tube aluminum fin assembly, galvanized or polymer drain pan sloped in all directions to drain, drain connection, refrigerant piping connections, restricted distributor or thermostatic expansion valve.
 - 1. Construction and Ratings: In accordance with AHRI 210/240 and UL 207.
 - 2. Manufacturer: System manufacturer.

2.04 OUTDOOR UNITS

- A. Outdoor Units: Self-contained, packaged, pre-wired unit consisting of cabinet, with compressor and condenser. Compatible with building BAS.
 - 1. Comply with AHRI 210/240.
 - 2. Cabinet: Galvanized steel with baked enamel finish, easily removed and secured access doors with safety interlock switches, glass fiber insulation with reflective liner.
 - 3. Construction and Ratings: In accordance with AHRI 210/240 with testing in accordance with ASHRAE Std 23.1 and UL 207.
- B. Air Cooled Condenser: fan guard and hail guard .
- C. Accessories: Filter drier, high pressure switch (auto reset), low pressure switch (automatic reset), service valves and gage ports.
 - 1. Provide thermostatic expansion valves.
- D. Operating Controls:
 - 1. Control by room thermostat to maintain room temperature setting.
 - 2. Low Ambient Kit: Provide refrigerant pressure switch to cycle condenser fan on when condenser refrigerant pressure is above 285 psig and off when pressure drops below 140 psig for operation to 0 degrees F.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that substrates are ready for installation of units and openings are as indicated on shop drawings.
- B. Verify that proper power supply is available and in correct location.
- C. Verify that proper fuel supply is available for connection.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions and requirements of local authorities having jurisdiction.
- B. Install in accordance with NFPA 90A and NFPA 90B.
- C. Install refrigeration systems in accordance with ASHRAE Std 15.

END OF SECTION 23 8126.13

SECTION 23 8146
WATER-SOURCE UNITARY HEAT PUMPS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Horizontal/vertical WSHP.
- B. High efficiency, horizontal/vertical WSHP.
- C. Variable speed, horizontal/vertical WSHP.
- D. High efficiency, two stage WSHP.
- E. High efficiency, console WSHP.
- F. High efficiency, vertical stack WSHP.
- G. High efficiency, rooftop WSHP.
- H. Hose kits and valves.

1.02 RELATED REQUIREMENTS

- A. Section 22 1005 - Plumbing Piping: Condensate drains.
- B. Section 23 0548 - Vibration and Seismic Controls for HVAC.
- C. Section 23 0593 - Testing, Adjusting, and Balancing for HVAC.
- D. Section 23 0913 - Instrumentation and Control Devices for HVAC.
- E. Section 23 0923 - Direct-Digital Control System for HVAC.
- F. Section 23 0993 - Sequence of Operations for HVAC Controls.
- G. Section 23 2113 - Hydronic Piping.
- H. Section 23 2114 - Hydronic Specialties.
- I. Section 23 2123 - Hydronic Pumps.
- J. Section 23 3300 - Air Duct Accessories.
- K. Section 26 0583 - Wiring Connections.

1.03 REFERENCE STANDARDS

- A. ASHRAE Std 62.1 - Laboratory Method of Testing to Determine the Sound Power in a Duct; 2013.
- B. ASHRAE Std 13256-1 - Water-Source Heat Pumps - Testing and Rating for Performance - Part 1: Water-to-Air and Brine-to-Air Heat Pumps; 1998 (Reaffirmed 2012).
- C. ASTM B283/B283M - Standard Specification for Copper and Copper-Alloy Die Forgings (Hot-Pressed); 2016.
- D. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2023d.
- E. EPA (EPACT) - Energy Policy Act of 2005; 2005.
- F. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2015.
- G. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances; Current Edition, Including All Revisions.
- H. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors; current edition, including all revisions.
- I. UL 508 - Industrial Control Equipment; Underwriters Laboratories Inc.; Current Edition, Including All Revisions.
- J. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials; Current Edition, Including All Revisions.

- K. UL 1995 - Heating and Cooling Equipment; Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide drawings indicating dimensions, rough-in connections, and electrical characteristics and connection requirements.
- C. Manufacturer's Instructions: Include assembly instructions, support details, connection requirements, and start-up instructions.
- D. Sustainable Design Documentation: Submit manufacturer's product data on refrigerant used, showing compliance with specified requirements.
- E. Operation and Maintenance Data: Provide maintenance data, parts lists, controls, and accessories. Include trouble-shooting guide.
- F. Warranty Documentation: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.

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.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
- C. All manufacturer and code minimum clearance guideline to be maintained and entire unit fully capable of removal for replacement.
- D. Shall meet ASHRAE 90.1 minimum energy performance current edition.
- E. Connect Supply/Return Air Ducts to heat pumps with flexible connections.
- F. Connect condensate drain pan to indirect waste connection with a P-trap of adequate depth to seal against fan pressure. Condensate pumps are not preferred.

1.06 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide a five year warranty to include coverage for refrigeration compressors.

PART 2 PRODUCTS

2.01 HIGH EFFICIENCY HORIZONTAL/VERTICAL WATER SOURCE HEAT PUMP

- A. Manufacturers:
 - 1. Water Furnace
 - 2. Trane, a brand of Ingersoll Rand; _____: www.trane.com.
 - 3. Substitutions: Not permitted.
- B. General:
 - 1. Comply with ASHRAE Std 13256-1 and UL 1995.
 - 2. Furnish with filters, factory-installed safety controls, and thermostat field interface strip.
 - 3. System Water Inlet/Outlet Connections: Female NPT copper.
 - 4. Place service and caution labels on the unit in their appropriate locations.
- C. Cabinet:
 - 1. Construct casing from zinc coated, heavy-gage, galvanized steel.
 - 2. Provide access panel(s) for inspection and servicing of refrigerant, controls, condensate drain pan, coils, and fan.
 - 3. Insulation:
 - a. Factory insulate all panels with minimum 1/2 inch thick, dual density, Foil backed bonded glass fiber.
 - 4. Include electrical box for the entrance of line voltage with separate knockout for control wiring.

- D. Sound Attenuation:
 - 1. Units Close to Occupied Spaces:
 - a. Lined compressor enclosure with minimum 1/2 inch cabinet insulation.
 - b. Minimum 12 gage, 0.1046 inch compressor/water-to-refrigerant exchanger pan with 2nd stage of vibration isolation.
 - c. Length-wise unit base stiffeners.
- E. Water-To-Refrigerant Heat Exchanger:
 - 1. Factory insulate heat exchanger, water lines, and refrigerant suction lines for prevention of condensation at temperatures below 60 degrees F.
- F. Drain Pan:
 - 1. Construct of corrosion resistant material and factory insulate to prevent sweating.
 - 2. Float Switch: UL 508 rated for protection against condensate overflow.
- G. Indoor Fan:
 - 1. Direct Drive Units:
 - a. Direct Drive Motors:
 - 1) ECM
- H. Filters:
 - 1. Flat filter rack for non-ducted return air applications.
 - a. 2 inch thick disposable fiberglass filters.
 - b. MERV: 8, when tested in accordance with ASHRAE Std 52.2.
 - c. Ducted filter rack for field installation.
- I. Compressor:
 - 1. High efficiency scroll compressor.
 - 2. 2-ton and above units shall be 2-stage high efficiency
 - 3. External Vibration Isolation: Provide rubber mounting devices located underneath compressor mounting base.
 - 4. Safety Devices:
 - a. Internal thermal overload protection.
 - b. High pressure switch for protection against excessive discharge pressure.
 - c. Low pressure safety for protection against loss of refrigerant charge.
- J. Refrigerant Circuits:
 - 1. Thermal expansion device.
 - 2. Service pressure ports on high and low pressure sides.
 - 3. Filter driers.
- K. All HPs shall be installed with condenser stainless hose kits (Griswold, Hays or Belimo) with the following accessories: shut off valves, Y ball strainer with blowdown valve w/hose connector, Pressure independent Belimo Control Valve. 2'-3' hose length.
- L. Unit Controls: HPs shall be integrated to BAS and include the following controls options: Anti Short Cycle, Random start delay, heating/cooling status, Occupancy schedule and status, Discharge Air Temp, Condenser valve command, Fan Status, Zone Space temp and setpoint Condensate overflow alarm, freeze protection, filter maintenance timer, Fault alarm and the ability to reset the HP remotely.

2.02 HOSE KITS AND VALVES

- A. Manufacturers:
 - 1. Griswold Controls; _____: www.griswoldcontrols.com/#sle.
 - 2. Hays Fluid Controls; _____: www.haysfluidcontrols.com/#sle.
 - 3. Belimo
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Hoses:
 - 1. Provide hoses for all units for connection to main water supply and return headers.

2. Length: 2 feet.
 3. Material: Braided stainless steel rated to minimum 400 psi at 265 degrees F.
- C. Ball Valves:
1. Brass body for shutoff and hydronic balancing.
 2. Provide pressure/temperature ports.
 3. Provide with balancing valves.
- D. Y Strainers:
1. Bronze body.
 2. "Y" type configuration with brass cap.
 3. Maximum Operating Pressure: Minimum 450 psi.
 4. Screen: Stainless steel.
- E. Auto-flow regulators as indicated in the schedule.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Suspended Units: Suspend from structure with threaded steel rods and 0.25 inch minimum static deflection rubber-in-shear vibration isolators, seismic restraints, and _____.
- C. Coordinate installation of units with architectural, mechanical, and electrical work. All manufacturer and code minimum clearance guideline to be maintained and entire unit fully capable of removal for replacement.
- D. On water coils, provide shut-off valve on supply line and balancing valve on return line. Provide manual air vents at high points complete with stop valve.
- E. Install Trane controls. as required in section 23 0913

3.02 CONNECTIONS

- A. Connect supply/return hydronic piping to heat pump with hose kits.
- B. Connect condensate drain pan to indirect waste connection with a P-trap of adequate depth to seal against fan pressure. Condensate pumps are not preferred.
- C. Install cleanouts at each directional change in piping.
- D. Connect supply/return air ducts to WSHPs with flexible connectors in accordance with Section 23 3300 - Air Duct Accessories.
- E. Installation of piping adjacent to heat pump to allow for maintenance and service.
- F. Field Install all electrical devices provided by the heat pump manufacturer not specified to be factory-installed.

3.03 SYSTEM STARTUP

- A. Provide manufacturer's field representative to perform systems startup.
- B. Prepare and start equipment and systems in accordance with manufacturers' instructions and recommendations. provide start up report documentation.
- C. Adjust for proper operation within manufacturer's published tolerances.

3.04 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Provide manufacturer's field representative to test, inspect, instruct, observe, and _____.
- C. Inspect for and remove blocks, shipping bolts, and tie-down straps.
- D. Test the heat pumps for performance compliance upon completion of the installation and energization of all electrical circuitry.
- E. Operational Test: Start units to confirm unit operation and motor rotation.

- F. Controls and Safety Switches: Test, adjust, and replace damaged/malfunctioning controls and equipment.
- G. Coordinate all temperature control work with the BAS Control Manufacturer, Section 23 0993 - Sequence of Operations for HVAC Controls.
- H. Malfunctioning Units: Remove, replace, and retest as specified above.
- I. Coordination of Other Tests and Inspections: Owner will employ independent testing agency to test and/or inspect _____; provide access and _____ as required to accommodate timely performance.

3.05 COMMISSIONING

- A. See Section 01 9113 - General Commissioning Requirements, for commissioning requirements.
- B. Perform the following Functional Tests:

3.06 CLOSEOUT ACTIVITIES

- A. See Section 01 7800 - Closeout Submittals, for closeout submittals.
- B. See Section 01 7900 - Demonstration and Training, for additional requirements.
- C. Demonstrate proper operation of equipment to the designated representative of the Owner.
- D. Equipment needs to be asset tagged and documentation provided to the Corewell PM.
- E. Demonstration: Demonstrate operation of system to Owner personnel.
 - 1. Use operation and maintenance data as reference during demonstration.
 - 2. Conduct walking tour of project.
 - 3. Briefly describe function, operation, and maintenance of each component.
- F. Training: Train Owner's personnel on operation and maintenance of system.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of two hours of training.
 - 3. Location: At project site.

END OF SECTION 23 8146

SECTION 23 8200
CONVECTION HEATING AND COOLING UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Baseboard radiation.
- B. Finned tube radiation.
- C. Convectors.
- D. Unit heaters.
- E. Cabinet unit heaters.
- F. Fan-coil units.
- G. Unit ventilators.
- H. Electric unit heaters.
- I. Blower-coil units.

1.02 RELATED REQUIREMENTS

- A. Section 22 0716 - Plumbing Equipment Insulation.
- B. Section 22 0719 - Plumbing Piping Insulation.
- C. Section 23 0513 - Common Motor Requirements for HVAC Equipment.
- D. Section 23 0716 - HVAC Equipment Insulation.
- E. Section 23 0719 - HVAC Piping Insulation.
- F. Section 23 0913 - Instrumentation and Control Devices for HVAC.
- G. Section 23 0993 - Sequence of Operations for HVAC Controls.
- H. Section 23 2113 - Hydronic Piping.
- I. Section 23 2114 - Hydronic Specialties.
- J. Section 23 2213 - Steam and Condensate Heating Piping.
- K. Section 23 2214 - Steam and Condensate Heating Specialties.
- L. Section 23 2300 - Refrigerant Piping.
- M. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.
Installation of room thermostats. Electrical supply to units.

1.03 REFERENCE STANDARDS

- A. AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI); current edition at www.ahrinet.org.
- B. AHRI 350 - Sound Performance Rating of Non-Ducted Indoor Air-Conditioning Equipment; 2008.
- C. AHRI 410 - Standard for Forced-Circulation Air-Cooling and Air-Heating Coils; 2001 (R2011).
- D. AHRI 440 - Performance Rating of Room Fan-Coil Units; 2008.
- E. AHRI 840 - Unit Ventilators; 1998.
- F. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications; 2015.
- G. ASHRAE Std 62.1 - Laboratory Method of Testing to Determine the Sound Power in a Duct; 2013.
- H. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems; 2015.

- J. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible; 2020.
- K. UL 674 - Electrical Motors and Generators for Use in Hazardous (Classified) Locations; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.
- B. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.05 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide typical catalog of information including arrangements.
- C. Shop Drawings:
 - 1. Indicate cross sections of cabinets, grilles, bracing and reinforcing, and typical elevations.
 - 2. Indicate air coil and frame configurations, dimensions, materials, rows, connections, and rough-in dimensions.
 - 3. Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.
 - 4. Submit the following for blower-coil units indicating:
 - a. Overall dimensions including installation, operation, and service clearances.
 - b. Lift points, recommendations, and center of gravity.
 - c. Unit shipping, installation, and operating weights including dimensions.
 - d. Fan curves with specified operating point clearly plotted.
 - e. Safety and start-up instructions.
 - 5. Indicate mechanical and electrical service locations and requirements.
- D. Certificates: Certify that coils are tested and rated in accordance with AHRI 410.
- E. Manufacturer's Instructions: Indicate installation instructions and recommendations.
- F. Project Record Documents: Record actual locations of components and locations of access doors in radiation cabinets required for access or valving.
- G. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.
- H. Warranty: Submit manufacturer's warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.

1.07 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide 5 year manufacturer's warranty for _____.

PART 2 PRODUCTS

2.01 SEE SECTION 01 6000 FOR ADDITIONAL REQUIREMENTS.

2.02 HYDRONIC BASEBOARD RADIATION

- A. Manufacturers:
 - 1. Runtal

2. Slant/Fin Corporation; _____: www.slantfin.com/#sle.
 3. Sterling Hydronics, a Mestek Company; _____: www.sterlingheat.com/#sle.
 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Perform factory run test under normal operating conditions, water, and steam flow rates.
- C. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum or aluminum/copper fins.
- D. Enclosure:
1. Steel material with high back and top, of one piece construction.
 2. Removable front panel, end panel, end caps, corners, and joiner pieces.
 3. Full length control damper.
 4. Provisions for return piping.
- E. Finish:
1. Factory applied, baked enamel finish.
 2. Color: As selected from color chart.
- F. Element Brackets: Galvanized or pre-painted steel supported from panel with non-metal element cradles or shoes, that allow for noise free expansion and contraction.

2.03 HYDRONIC FINNED TUBE RADIATION

- A. Manufacturers:
1. Runtal
 2. Slant/Fin Corporation; _____: www.slantfin.com/#sle.
 3. Zehnder Rittling; _____: www.rittling.com/#sle.
- B. Required Directory Listing: AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI); current edition at www.ahrinet.org.
- C. Heating Elements: 1 inch ID seamless copper tubing, mechanically expanded into evenly spaced aluminum fins sized 4 by 4 inches, suitable for soldered fittings.
- D. Element Hangers: Quiet operating, ball bearing cradle type providing unrestricted longitudinal movement, on enclosure brackets.
- E. Enclosures: 18 gage, 0.0478 inch sheet steel up to 18 inches in height, 16 gage, 0.0598 inch sheet steel over 18 inches in height or aluminum as detailed, with easily jointed components for wall to wall installation.
1. Support rigidly, on wall or floor mounted brackets.
- F. Finish: Factory applied baked primer coat.
- G. Damper: Where not thermostatically controlled, provide knob-operated internal damper at enclosure air outlet.
- H. Access Doors: For otherwise inaccessible valves, provide factory-made permanently hinged access doors, 6 by 7 inch minimum size, integral with cabinet.

2.04 HYDRONIC UNIT HEATERS

- A. Manufacturers:
1. Modine Manufacturing Company; _____: www.modineHVAC.com/#sle.
 2. Sterling Hydronics, a Mestek Company; _____: www.sterlingheat.com/#sle.
 3. Trane, a brand of Ingersoll Rand; _____: www.trane.com/#sle.
- B. Coils: Seamless copper tubing, silver brazed to steel headers, and with evenly spaced aluminum fins mechanically bonded to tubing.
- C. Perform factory run test under normal operating conditions, water, and steam flow rates.
- D. Casing: Minimum 18 gage, 0.0478 inch thick sheet steel casing with threaded pipe connections for hanger rods for horizontal models and minimum 18 gage, 0.0478 inch thick sheet steel top and bottom plates for vertical projection models.

- E. Finish: Factory applied baked primer coat.
- F. Fan: Direct drive propeller type, statically and dynamically balanced, with fan guard; horizontal models with permanently lubricated sleeve bearings; vertical models with grease lubricated ball bearings.
- G. Air Outlet: Adjustable pattern diffuser on vertical projection models and two, four, or ____ way louvers on horizontal projection models.
- H. Totally Enclosed Motors: Permanently lubricated sleeve bearings on horizontal models, grease lubricated ball bearings on vertical models. Refer to Section 23 0513.
- I. Control: Local solid state disconnect switch.
- J. Electrical Characteristics:
 - 1. ____ hp.
 - 2. ____ volts, single phase, 60 Hz.

2.05 HYDRONIC CABINET UNIT HEATERS

- A. Manufacturers:
 - 1. Modine Manufacturing Company; ____: www.modineHVAC.com/#sle.
 - 2. Sterling Hydronics a Mestek Company; ____: www.sterlingheat.com/#sle.
 - 3. Trane, a brand of Ingersoll Rand; ____: www.trane.com/#sle.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to Authority Having Jurisdiction as suitable for the purpose indicated.
- C. Coils:
 - 1. Evenly spaced aluminum fins mechanically bonded to copper tubes.
 - 2. Heating Hot Water: Suitable for working temperatures up to a maximum not less than 200 degrees F.
- D. Cabinet: Minimum 16 gage, 0.0598 inch thick sheet steel front panel with exposed corners and edges rounded, easily removed panels, glass fiber insulation, integral air outlet, and inlet grilles.
- E. Finish: Factory applied baked primer coat on visible surfaces of enclosure or cabinet.
- F. Fans: Centrifugal forward-curved double-width wheels, statically and dynamically balanced, direct driven.
- G. Motor: Tap wound multiple speed permanent split capacitor with sleeve bearings, resiliently mounted.
- H. Control: Factory wired, solid state, infinite speed control, located in cabinet.
- I. Filter: Easily removed, 1 inch thick glass fiber throw-away type, located to filter air before coil.
- J. Electrical Characteristics:
 - 1. ____ W.
 - 2. ____ volts, single phase, 60 Hz.

2.06 FAN-COIL UNITS

- A. Manufacturers:
 - 1. Vertical Cabinet, Horizontal Exposed, or Horizontal Recessed:
 - a. Price
 - b. Daikin Applied; ____: www.daikinapplied.com/#sle.
 - c. Trane, a brand of Ingersoll Rand; ____: www.trane.com/#sle.
 - d. Substitutions: See Section 01 6000 - Product Requirements.
 - 2. Vertical Stack:
 - a. Trane
 - b. Daikin Applied; ____: www.daikinapplied.com/#sle.
 - c. Price

- d. Substitutions: See Section 01 6000 - Product Requirements.
- B. Performance Data and Safety Requirements:
 - 1. Unit capacities certified in accordance with AHRI 440.
 - 2. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to Authority Having Jurisdiction as suitable for the purpose indicated.
 - 3. Insulation to comply with NFPA 90A requirements for flame spread and smoke generation.
 - 4. Equipment wiring to comply with requirements of NFPA 70.
- C. Required Directory Listings: AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI).
- D. Coils:
 - 1. Evenly spaced aluminum fins mechanically bonded to copper tubes.
 - 2. Water Coil: Suitable for working temperatures not less than 200 degrees F.
 - 3. Provide drain pan under cooling coil easily removable for cleaning.
- E. Vertical Cabinet and Horizontal Exposed Units: Minimum 18 gage, 0.0478 inch thick sheet steel with exposed corners and edges rounded, easily removed panels, glass fiber insulation, integral air outlet, and inlet grilles.
- F. Horizontal Recessed Units:
 - 1. Provide with a galvanized steel cabinet, easily removed panels, glass fiber insulation, integral air outlet, and inlet grilles with minimum 18 gage, 0.0478 inch thick sheet steel bottom panel.
- G. Vertical Stack Units:
 - 1. Minimum 18 gage, 0.0478 inch thick sheet steel with exposed corners and edges rounded, easily removed panels, glass fiber insulation, aluminum double-deflection discharge grille, panel-type return grille, and _____.
 - 2. Provide maintenance access via return grille.
- H. Finish: Factory applied baked primer coat on visible surfaces of enclosure or cabinet.
- I. Fans: Centrifugal forward-curved double-width wheels, statically and dynamically balanced, direct driven.
- J. Motor: Tap wound multiple speed permanent split capacitor with sleeve bearings, resiliently mounted.
- K. Controls:
 - 1. Provide units with control valves furnished by the fan coil unit manufacturer.
 - 2. Controls Interface:
 - a. Trane Controls
- L. Filter: Easily removed 1 inch thick glass fiber throw-away type, located to filter air before coil.
- M. Electrical Characteristics:
 - 1. _____ W.
 - 2. _____ volts, single phase, 60 Hz.

2.07 UNIT VENTILATORS

- A. Manufacturers:
 - 1. Price
 - 2. Daikin Applied; _____: www.daikinapplied.com/#sle.
 - 3. Trane, a brand of Ingersoll Rand; _____: www.trane.com/#sle.
- B. Performance Data and Safety Requirements:
 - 1. Unit capacities certified and tested in accordance with AHRI 840 and AHRI 350.
 - 2. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to Authority Having Jurisdiction as suitable for the purpose indicated.

- C. Required Directory Listings: AHRI Directory of Certified Product Performance - Air-Conditioning, Heating, and Refrigeration Institute (AHRI).
- D. Hydronic Coils:
 - 1. Copper tubes mechanically expanded or bonded into evenly spaced aluminum fins.
 - 2. Factory pressure tested, hydrostatically, to not less than 350 psi.
 - 3. Provide insulated drain pan under chilled water coils, to prevent sweating, with field convertible left or right hand drain connections.
- E. Cabinet: 14 gage, 0.0747 inch sheet steel on solid base pan with exposed edges rounded. Provide removable front panels with quick-acting, key-operated cam locks. Provide removable die-cast or fabricated steel discharge grilles. For units having cooling coils, insulate internal parts and surfaces exposed to conditioned air stream with moisture resistant insulation.
- F. Cabinet Accessories: Matching steel construction, reinforced, for use with unit ventilators or finned radiation, with steel alignment pins, adjustable kick plates with leveling bolts, shelves and sliding doors with locks as indicated, sinks, bubbler faucets and bowls, corner, end, and wall filler sections as required.
- G. Finish: Factory applied baked primer coat on visible surfaces of enclosure or cabinet.
- H. Fans: Centrifugal forward-curved double-width wheels, statically and dynamically balanced, direct driven, arranged to draw air through coil.
- I. Wall Louvers: Anodized aluminum wall intake box and louvers removable from frame with 1/2 inch square mesh galvanized screen in back of louver.
- J. Motor: Tap wound multiple speed permanent split capacitor with sleeve bearings, resiliently mounted.
- K. Controls:
 - 1. Provide units with control valves furnished by the automatic temperature controls manufacturer.
 - 2. Unit Ventilator Manufacturer's Controls:
 - a. Fan speed switch for unit mounting.
 - b. Disconnect switch.
 - c. Thermostats and controllers.
 - 3. Controls Interface:
 - a. Trane Controls.
 - b. 24-volt transformer.
 - 4. Provide ASHRAE Cycle I as defined in ASHRAE (HVACA) Handbook - HVAC Applications.
- L. Filter: Easily removed 1 inch thick glass fiber throw-away type, located to filter air before coil.
- M. Mixing Dampers: Multi-blade with compressible seal, capable of varying proportion of mixed air from 100 percent room air to 100 percent outside air.
- N. Electrical Characteristics:
 - 1. ____ kW.
 - 2. ____ volts, single phase, 60 Hz.

2.08 ELECTRIC BASEBOARD

- A. Manufacturers:
 - 1. Marley Engineered Products; ____: www.marleymep.com/#sle.
 - 2. Vulcan Radiator, a Mestek Company; ____: www.vulcanrad.com/#sle.

2.09 ELECTRIC UNIT HEATERS

- A. Manufacturers:
 - 1. INDEECO (Industrial Engineering and Equipment Company); ____: www.indeeco.com/#sle.
 - 2. Trane, a brand of Ingersoll Rand; ____: www.trane.com/#sle.

- B. Housing:
- C. Air Inlets and Outlets:
- D. Fan: Factory balanced, direct drive, axial type with fan guard.
- E. Motor: Totally enclosed, thermally protected, and provided with permanently lubricated bearings.
- F. Controls:
- G. Electrical Characteristics:

2.10 ELECTRIC CABINET UNIT HEATERS

- A. Manufacturers:
 - 1. INDEECO (Industrial Engineering and Equipment Company); _____: www.indeeco.com/#sle.
 - 2. Marley Engineered Products; _____: www.marleymep.com/#sle.
 - 3. Trane, a brand of Ingersoll Rand; _____: www.trane.com/#sle.

2.11 BLOWER-COIL UNITS

- A. Manufacturers:
 - 1. Price
 - 2. Trane, a brand of Ingersoll Rand; _____: www.trane.com/#sle.
 - 3. Substitutions: See Section 01 6000 - Product Requirements.
- B. Performance Data and Safety Requirements:
 - 1. Coils rated and tested in accordance with AHRI 410.
 - 2. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to Authority Having Jurisdiction as suitable for the purpose indicated.
 - 3. Comply with NFPA 90A for unit construction, including filters and related equipment, for protection of life and property from fire, smoke, and gases resulting from conditions having manifestations similar to fire.
- C. Unit Casing:
 - 1. Fabricate from heavy gage galvanized steel sheet.
 - 2. Insulate inside walls with 1 inch thick, fiberglass insulation for thermal and acoustical control.
 - 3. Provide access panels allowing servicing of coils, drain pan, fan, motor, and drive.
 - 4. Provide knockouts or hanger rod holes at all four corners for suspended units.
- D. Air Coils:
 - 1. Aluminum fins mechanically expanded or bonded to copper tubes having standard sweat connections.
 - a. Water: Manual, automatic or self-venting, designed to a working pressure and temperature of not less than 250 psig and 200 degrees F.
- E. Fans: Forward curved, centrifugal blower, dynamically balanced, adjustable speed V-belt drive with fan shaft supported by heavy-duty, permanently sealed ball bearings.
- F. Drain Pan: Cleanable, one-piece construction of polymer, galvanized steel, stainless steel, or _____; with drain connection and sloped for positive drainage.
- G. Filters: Fully accessible, flat filter rack with throw-away filters.
- H. Motors: Single speed with sleeve or ball bearings, 1750 rpm, wired to unit junction box, and mounted on a resilient motor base.
- I. Electrical Controls:
- J. Electrical Characteristics:

END OF SECTION 23 8200

**SECTION 23 8300
RADIANT HEATING AND COOLING UNITS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Hydronic radiant panel heaters.
- B. Electric radiant ceiling panel heaters.
- C. Radiant heating hydronic piping.
- D. Outdoor electric roof, gutter, and downspout deicing.
- E. Electric infrared radiant heaters.

1.02 RELATED REQUIREMENTS

- A. Section 03 3000 - Cast-in-Place Concrete.
- B. Section 07 8400 - Firestopping.
- C. Section 08 3100 - Access Doors and Panels.
- D. Section 23 0716 - HVAC Equipment Insulation.
- E. Section 23 0719 - HVAC Piping Insulation.
- F. Section 23 0913 - Instrumentation and Control Devices for HVAC.
- G. Section 23 0993 - Sequence of Operations for HVAC Controls.
- H. Section 23 2113 - Hydronic Piping.
- I. Section 23 2114 - Hydronic Specialties.
- J. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections. Installation of room thermostats. Electrical supply to units.

1.03 REFERENCE STANDARDS

- A. ASHRAE Std 138 - Method of Testing for Rated Ceiling Panels for Sensible Heating and Cooling; 2013.
- B. ASTM B75/B75M - Standard Specification for Seamless Copper Tube; 2011.
- C. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials; 2023d.
- D. ASTM F876 - Standard Specification for Crosslinked Polyethylene (PEX) Tubing; 2013a.
- E. ASTM F1281 - Standard Specification for Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene (PEX-AL-PEX) Pressure Pipe; 2011.
- F. ASTM F1807 - Standard Specification for Metal Insert Fittings Utilizing a Copper Crimp Ring for SDR9 Cross-Linked (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing; 2015.
- G. ASTM F1974 - Standard Specification for Metal Insert Fittings for Polyethylene/Aluminum/ Polyethylene and Crosslinked Polyethylene/Aluminum/ Crosslinked Polyethylene Composite Pressure Pipe; 2009 (Reapproved 2015).
- H. DIN EN 4726 - Warm Water Surface Heating Systems and Radiator Connecting Systems - Plastics Piping Systems and Multilayer Piping Systems; 2017.
- I. DIN EN 14037-2 - Free Hanging Heating and Cooling Surfaces for Water with a Temperature Below 120 Degrees C - Part 2: Pre-Fabricated Ceiling Mounted Radiant Panels for Space Heating - Test Method for Thermal Output; 2016.
- J. DIN EN 14037-3 - Free Hanging Heating and Cooling Surfaces for Water with a Temperature Below 120 Degrees C - Part 3: Prefabricated Ceiling Mounted Radiant Panels for Space Heating - Rating Method and Evaluation of Radiant Thermal Output; 2016.

- K. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- L. UL 2021 - Fixed and Location Dedicated Electric Room Heaters; Current Edition, Including All Revisions.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Preinstallation Meeting: Conduct a preinstallation meeting one week prior to the start of the work of this section; require attendance by all affected installers.
- B. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.05 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data for ceiling panel heaters.
- C. Shop Drawings: Indicate ceiling panel heater layout, electrical terminations, thermostats, controls, and branch circuit connections.
- D. Manufacturer's Installation Instructions: Indicate installation instructions and recommendations.
- E. Field Quality Control Submittals: Indicate test reports, inspection reports, and _____.
- F. Project Record Documents: Record actual locations of ceiling panel heaters.
- G. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions of equipment and controls, installation instructions, maintenance and repair data, and parts listings.
- H. Warranty: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.
- I. Maintenance Data:
 - 1. Include repair methods and parts list of components.
 - 2. See Section 01 6000 - Product Requirements, for additional provisions.

1.06 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing products specified in this section, with not less than three years of documented experience.
- B. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
- C. Copies of Documents at Project Site: Maintain at the project site a copy of each referenced document that prescribes execution requirements.

1.07 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide 5 year manufacturer's warranty.

PART 2 PRODUCTS

2.01 HYDRONIC RADIANT PANEL HEATERS

- A. Manufacturers:
 - 1. Barcol-Air USA Ltd; _____: www.barcolairusa.com/#sle.
 - 2. Price Industries; _____: www.price-hvac.com/#sle.
 - 3. TWA Panel Systems, inc; _____: www.twapanel.com.
 - 4. Substitutions: See Section 01 6000 - Product Requirements.
- B. Modular Radiant Ceiling Panels: Heat sinks located behind panel, transfer heat between copper tubes and panel face, and radiate heat to zone.
 - 1. Water Tubes:
 - a. ASTM B75/B75M copper tubing, 1/2 inch minimum nominal diameter.

- b. Water Connections:
 - 1) Same end only.
 - 2) Suitable for solder, compression fittings, push-on fittings, or threaded connection.
 - 3) Protect with removable seals. Prevent introduction of dirt and dust during shipping.
- 2. Heat Sink Construction:
 - a. Mechanically fasten extruded aluminum and copper pipe to heat sink.
 - b. Provide non-hardening heat transfer paste between tubing, heat sink, and panel.
- 3. Panel Face: Construct of minimum 18 gage (0.0403 inches) thick aluminum.
- 4. Finish:
 - a. Apply polyester paint, manufacture's standard finish, or _____.
 - b. Color: As selected by Architect from manufacturer's standard range.
 - c. Maintain optimal radiative properties, durability, and cleanability.
- 5. Water Pressure Drop and Heating Output Data: Derive from factory testing in accordance with ASHRAE Std 138 or DIN EN 14037, Parts 2 and 3.
- 6. Accessories:
 - a. 18 inch stainless steel braided hose with isolation ball valves for supply and return connections.

2.02 ELECTRIC RADIANT CEILING PANEL HEATERS

- A. Manufacturers:
 - 1. INDEECO (Industrial Engineering and Equipment Company); _____: www.indeeco.com/#sle.
 - 2. Marley Engineered Products; _____: www.marleymep.com/#sle.
- B. Provide products listed, classified, and labeled under UL 2021 as suitable for the purpose indicated.
- C. Suitable for surface mounting installation.
- D. Ceiling Panel Construction:
 - 1. Exposed-Side Panel Finish: Silk-screened finish matching appearance of ceiling tile.
- E. Heating Elements: Materials to consist of powdered graphite sandwiched between sheets of insulation, insulated resistive wires, enclosed and insulated solid state element with uniform resistance, or _____.
- F. Electrical Connections: Non-heating, high-temperature, insulated copper leads, factory connected to heating element.
- G. Electrical Characteristics:

2.03 RADIANT-HEATING HYDRONIC PIPING

- A. Applications:
 - 1. Provide the following types of hydronic, radiant heating piping for the applications described:
 - a. Piping in Exterior Pavement: PEX.
 - b. Piping in Interior Reinforced Concrete Floors: PEX.
 - c. Piping in Level Fill Concrete Floors (Not Reinforced): PEX.
 - d. Piping in Ceilings: PEX.
 - e. Piping in Subfloors: PEX.
- B. Crosslinked Polyethylene (PEX) Pipe and Fittings:
 - 1. Manufacturers:
 - a. Heat Innovations Inc; _____: www.heatinnovations.com/#sle.
 - b. IPEX Inc; _____: www.ipexamerica.com/#sle.
 - c. Substitutions: See Section 01 6000 - Product Requirements.
 - 2. Pipe Material: PEX plastic according to ASTM F876.

3. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.000044 grains per cu ft/day at 104 degrees F according to DIN 4726.
 4. Fittings: ASTM F1807, metal insert and copper crimp rings.
 5. Pressure/Temperature Rating: Minimum 100 psig and 180 degrees F.
- C. Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene (PEX/AL/PEX) Pipe and Fittings:
1. Manufacturers:
 - a. Heat Innovations Inc; _____: www.heatinnovations.com/#sle.
 - b. IPEX Inc; _____: www.ipexamerica.com/#sle.
 - c. Viega LLC; _____: www.viega.com/#sle.
 - d. Substitutions: See Section 01 6000 - Product Requirements.
 2. Pipe Material: PEX plastic bonded to the inside and outside of a welded aluminum tube according to ASTM F1281.
 3. Oxygen Barrier: Limit oxygen diffusion through the pipe to maximum 0.0000436996 grains per cu ft/day at 104 degrees F according to DIN 4726.
 4. Fittings: ASTM F1974, metal insert fittings with split ring and compression nut (compression joint) or metal insert fittings with copper crimp rings (crimp joint).
 5. Flame Spread and Smoke Developed Indexes: 25 and 50 or less, respectively, when tested in accordance with ASTM E84.
 6. Pressure/Temperature Rating: Minimum 100 psig and 210 degrees F.
- D. Distribution Manifolds (Manufacturer's Standard):
1. Manifold: Minimum 1 inch, brass, copper, or stainless steel.
 2. Main Shutoff Valves:
 - a. Factory installed on supply and return connections.
 - b. Two-piece brass, bronze, or _____ body.
 - c. Ball: Chrome-plated bronze.
 - d. Seals: PTFE.
 - e. CWP Rating: 150 psig.
 - f. Maximum Operating Temperature: 225 degrees F.
 3. Manual Air Vents:
 - a. Body to consist of bronze, brass, or _____.
 - b. Internal Parts: Nonferrous.
 - c. Operator: Key furnished with valve or screwdriver bit.
 - d. Inlet Connection: 1/2 inch.
 - e. Discharge Connection: 1/8 inch.
 - f. CWP Rating: 150 psig.
 - g. Maximum Operating Temperature: 225 degrees F.
 4. Balancing Valves:
 - a. Body: Provide bronze, plug or globe.
 - b. _____
 - c. Globe Cartridge and Washer: Brass with EPDM composition washer.
 - d. Seat: PTFE.
 - e. Visual Flow Indicator: Flowmeter with visible indication in a clear plastic cap at top of valve.
 - f. Differential Pressure Gauge Connections: Integral seals for portable meter to measure loss across calibrated orifice.
 - g. Handle Style: Knob, with memory stop to retain set position if used for shutoff.
 - h. CWP Rating: Minimum 125 psig.
 - i. Maximum Operating Temperature: 250 degrees F.
 5. Zone Control Valves: Belimo
 - a. Body: Provide brass, bronze, or _____, plug, globe, or _____ cartridge type.
 - b. Plug: EPDM.
 - c. Globe Cartridge and Washer: Brass with EPDM composition washer.

- d. Seat: PTFE.
- e. Actuator: Replaceable electric motor.
- f. CWP Rating: Minimum 125 psig.
- g. Maximum Operating Temperature: 250 degrees F.
- 6. Thermometers:
 - a. Mounted on supply and return connections.
 - b. Case: Dry type, metal or plastic, 2 inch diameter.
 - c. Element: Bi-metallic coil.
 - d. Movement: Mechanical, connecting element and pointer.
 - e. Dial: Satin-faced, non-reflective aluminum with permanently etched scale markings.
 - f. Pointer: Black metal.
 - g. Window: Plastic.
 - h. Connector: Rigid, back type.
 - i. Thermal System: Bi-metallic coil.
 - j. Accuracy: Plus or minus 1 percent of range, 1 scale division, or _____ to maximum of 1.5 percent of range.
- 7. Mounting Brackets: Provide copper, plastic, rubber-clad steel, or _____, where in contact with manifold.
- E. Piping Specialties (Manufacturer's Standard):
 - 1. Cable Ties:
 - a. Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
 - b. Minimum Width: 1/8 inch.
 - c. Minimum Tensile Strength: 20 lb.
 - d. Temperature Range: Minus 40 degrees F to plus 185 degrees F.
 - 2. Floor Mounting Staples:
 - a. Steel, with corrosion-resistant coating and smooth finish without sharp edges.
 - b. Minimum Thickness: 3/32 inch.
 - c. Width: Minimum, wider than tubing.
 - 3. Floor Mounting Clamps:
 - a. Two bolts, steel, with corrosion-resistant coating and smooth finish without sharp edges.
 - b. Minimum Thickness: 3/32 inch.
 - c. Width: Minimum, wider than tubing.
 - 4. Floor Mounting Tracks:
 - a. Aluminum or plastic channel track with smooth finish and no sharp edges.
 - b. Minimum Thickness: 1/16 inch.
 - c. Slot Width: Snap fit to hold tubing.
 - 5. Heat-Emission Plates:
 - a. Formed aluminum suitable for radiant-heating piping.
 - b. Minimum Thickness: 1/16 inch.
 - c. Slot Width: Snap fit to maintain pressure fit on tubing.

2.04 OUTDOOR ELECTRIC ROOF, GUTTER, AND DOWNSPOUT DEICING

- A. Manufacturers:
 - 1. Danfoss; _____: www.danfoss.com/#sle.
 - 2. Delta-Therm Corporation; _____: www.delta-therm.com/#sle.
- B. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to authority having jurisdiction as suitable for the purpose indicated.
- C. Assembly:
 - 1. Factory designed specifically for outdoor applications.

2. Conductors(s): Factory insulated, copper, copper alloy, or _____ heating cable with standard factory coating or plating.
 3. Provide factory or field spliced and sealed cold lead with single point connection of sufficient length to reach designated junction boxes or power panel.
- D. Controls:
1. Sensing to be based on ambient, moisture, roof, and _____ detection.
 2. Controls to be stand-alone.
- E. Accessories:
1. Roof clips, hooks, and downspout hangers.
 2. Outdoor heating system marker for outdoor electric snow and ice melting system in accordance with NFPA 70, Article 426.
- F. Electrical Characteristics:

2.05 ELECTRIC INFRARED RADIANT HEATERS

- A. Manufacturers:
1. INDEECO (Industrial Engineering and Equipment Company); _____: www.indeeco.com/#sle.
 2. Marley Engineered Products; _____: www.marleymep.com/#sle.
- B. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to authority having jurisdiction as suitable for the purpose indicated.
- C. Factory assembled including heating element, reflector, heater housing, mounting brackets, element holders, wire guards, and high temperature internal wiring for non-residential, indoor use only.
- D. Heating Element:
1. Minimum 3/8 inch diameter quartz tube with coiled resistor wire.
 2. Element operating temperature range: 1200 to 1800 degrees F.
- E. Heater Housing:
1. Factory fabricated from aluminum clad steel, stainless steel, or aluminum for indoor use as indicated.
 2. Provide with baked enamel finish over corrosion-resistant primer.
 3. Furnish stainless steel wire guard designed to protect heating elements from damage.
- F. Reflector: Polished stainless steel.
- G. Wiring:
1. Fully enclosed internal wiring.
 2. Provide minimum 6 inch slack fixture (heater) wire for connection to branch circuit wiring.
- H. Accessories:
- I. Electrical Characteristics:

PART 3 EXECUTION

3.01 EXAMINATION

- A. Hydronic Radiant Ceiling Panel Heaters:
1. Examine areas to receive radiant heating units for compliance with requirements for installation tolerances and other conditions affecting performance.
 2. Examine roughing-in for hydronic piping connections to verify actual locations prior to installation.
 3. Ensure surfaces in contact with radiant heating panels are free of burrs and sharp protrusions.
 4. Ensure surfaces are level and plumb.
 5. Proceed with installation only after unsatisfactory conditions have been corrected.

- B. Hydronic Radiant Heating Piping:
 - 1. Examine surfaces and substrates to receive radiant heating piping for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 - a. Ensure that surfaces and pipes in contact with radiant heating piping are free of burrs and sharp protrusions.
 - b. Ensure that surfaces and substrates are level and plumb.
 - 2. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. Outdoor Roof, Gutter, and Downspout Deicing:
 - 1. Verify field measurements are as indicated on shop drawings.
 - 2. Any revisions needed to shop drawings, or product provided, must be implemented prior to proceeding with installation.
 - 3. Verify the availability of required power, in proper location, and ready for use.

3.02 PREPARATION

- A. Clean all surfaces prior to installation.

3.03 INSTALLATION

- A. Install in accordance with manufacturer's recommendations.
- B. Hydronic Radiant Ceiling Panel Heaters:
 - 1. Install level and plumb.
 - 2. Suspend from structure.
 - 3. Support in grid-type suspended ceiling using grid as support element as follows:
 - a. Install a minimum of four ceiling support system rods or wires for each panel, located not more than 6 inches from panel corners.
 - b. Fasten support clips to panel and to ceiling grid members at or near each panel corner with clips designed for the application.
 - c. For panels of sizes less than ceiling grid, install as indicated on reflected ceiling plan(s) or center of acoustical panel, and support panels independently with at least two 3/4 inch metal channels spanning and secured to ceiling tees.
 - d. Install at least one independent support rod or wire from structure to tab on panel with breaking strength of the weight of panel at a safety factor of 3.
 - 4. Unless otherwise indicated, install shutoff valve and union or flange at each connection.
 - 5. Provide tamper-proof, balancing valve with memory stop on return piping.
 - 6. Provide float operated automatic air vents with stop valve.
- C. Hydronic Radiant Panel Heaters: Consult manufacturer's installation manual for panels not installed in ceiling systems.
- D. Hydronic Radiant Heating Piping:
 - 1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
 - 2. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
 - 3. Install piping as indicated unless deviations to layout are approved on shop drawings or coordination drawings.
 - 4. Install radiant heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.
 - 5. Connect radiant piping to manifold in a reverse-return arrangement.
 - 6. Do not bend pipes in radius smaller than manufacturer's minimum bend radius dimension.
 - 7. Install manifolds accessible locations, or install access panels to provide maintenance access as required in Section 08 3100.
 - 8. Comply with requirements in Sections 23 2113 and 23 2114 for pipes and connections to hydronic systems and for glycol-solution fill requirements.
 - 9. Fire and Smoke Barrier Penetrations:

- a. Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations.
 - b. Seal pipe penetrations with firestop materials according to Section 07 8400.
- 10. Piping in Exterior Pavement:
 - a. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
 - b. Space cable ties a maximum of 18 inches and at center of turns or bends.
 - c. Maintain 3 inch minimum cover.
 - d. Install a sleeve of 3/8 inch thick, foam-type insulation or PE pipe around tubing and extending for a minimum of 10 inches on each side of slab joints to protect the tubing passing through expansion or control joints.
 - 1) Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
 - e. Maintain minimum 40 psig pressure in piping during concrete placement and continue for 24 hours after placement.
- 11. Piping in Interior Reinforced Concrete Floors:
 - a. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
 - b. Space cable ties a maximum of 18 inches and at center of turns or bends.
 - c. Maintain 2 inch minimum cover.
 - d. Install a sleeve of 3/8 inch thick, foam type insulation or PE pipe around tubing and extending for a minimum of 10 inches on each side of slab joints to protect the tubing passing through expansion or control joints.
 - e. Maintain minimum 40 psig pressure in piping during concrete placement and continue for 24 hours after placement.
- 12. Piping in Level Fill Concrete Floors (Not Reinforced):
 - a. Secure piping in concrete floors by attaching pipes to subfloor using tracks, clamps, or staples.
 - b. Space tracks, clamps, or staples a maximum of 18 inches on center and at center turn of bends.
 - c. Maintain 3/4 inch minimum cover.
 - d. Install a sleeve of 3/8 inch thick, foam type insulation or PE pipe around tubing and extending for a minimum of 10 inches on each side of slab joints to protect the tubing passing through expansion or control joints.
 - e. Maintain minimum 40 psig pressure in piping during the concrete pour and continue for 24 hours during curing.
- 13. Piping in Ceiling:
 - a. Secure piping by attaching pipes to ceiling substrate using clamps or staples.
 - b. Space clamps or staples a maximum of 18 inches and at center of turns or bends.
 - c. Maintain 1-1/2 inch minimum plaster cover.
 - d. Maintain minimum 40 psig pressure in piping during the plaster application and continue for 24 hours during curing.
- 14. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Architect.
- 15. After system balancing has been completed, mark balancing valves to permanently indicate final position.
- 16. Perform the following adjustments before operating the system:
 - a. Open valves to fully open position.
 - b. Check operation of automatic valves.
 - c. Set temperature controls so all zones call for full flow.
 - d. Purge air from piping.
- 17. After concrete or plaster heating panel has cured as recommended by concrete or plaster supplier, operate radiant-heating system as follows:
 - a. Start system heating at a maximum of 10 degrees F above the ambient radiant panel temperature and increase 10 degrees F each following day until design temperature is achieved.

- b. For freeze protection, operate at a minimum of 60 degrees F supply-water temperature.
- E. Outdoor Roof, Gutter, and Downspout Deicing with Electric Cable:
 - 1. Install in accordance with manufacturer's instructions.
 - 2. Comply with applicable codes.
 - 3. Cable to be laid in gutters, suspended in downspouts as a loop with downspout hanger, suspended in downspouts as a single length with downspout hanger, and attached to the roof with clips in accordance with engineered layout drawings.
 - 4. Cut self regulating cable to length as required.
 - 5. Make self regulating cable connections with kits supplied by the manufacturer and specifically approved by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to authority having jurisdiction as suitable for the purpose indicated.
 - 6. Pull stranded wire (cold leads) through conduit from condulets to junction boxes.
- F. Electric Infrared Radiant Heaters:
 - 1. Install in accordance with manufacturer's instructions.
 - 2. Comply with applicable codes.
 - 3. Maintain minimum distances from all combustibles in accordance with manufacturer's instructions and applicable codes.

3.04 FIELD QUALITY CONTROL

- A. See Section 01 4000 - Quality Requirements, for additional requirements.
- B. Provide manufacturer's field representative to test, inspect, instruct, and observe.
- C. Hydronic Radiant Ceiling Panel Heaters:
 - 1. Inspect for damage to finish.
 - 2. Repair damaged finish to match original finish.
 - 3. Perform the following field tests, inspections, and prepare test reports:
 - a. Leak Test:
 - 1) After installation, fill water tubes and test for leaks.
 - 2) Repair leaks and retest until no leaks exist.
 - b. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation.
 - c. Test and adjust controls and safeties.
 - 4. Manufacturer's Field Service:
 - a. Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing.
 - b. Report any findings in writing.
 - 5. Remove and replace damaged and malfunctioning controls and equipment and retest as specified above.
- D. Hydronic Radiant Heating Piping
 - 1. Prepare radiant heating piping for testing as follows:
 - a. Open all isolation valves and close bypass valves.
 - b. Open and verify operation of zone control valves.
 - c. Flush with clean water and clean strainers.
 - 2. Perform the following tests and inspections with the assistance of a factory authorized service representative:
 - a. Leak Test:
 - 1) After installation, charge system and test for leaks.
 - 2) Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than 100 psig.
 - 3) Repair leaks and retest until no leaks exist.

3. Radiant heating piping will be considered defective if it does not pass tests and inspections.
 4. Prepare test and inspection reports.
 5. Protect hydronic piping system from damage during construction.
- E. Outdoor Roof, Gutter, and Downspout Deicing with Electric Cable:
1. Test continuity of heating cable.
 2. Perform insulation resistance (megger) test on each heater section.
 3. Minimum acceptable megger reading to be based on recommendations of cable manufacturer.
 4. Measure voltage and current at each unit after installation is completed.

3.05 CLEANING

- A. Radiant Ceiling Panel Heaters: Remove paint splatters, other spots, dirt, and debris.
- B. Outdoor Roof, Gutter, and Downspout Deicing with Electric Cable: Keep automatic control system's sensor(s) clean of dirt and debris.

3.06 CLOSEOUT ACTIVITIES

- A. See Section 01 7800 - Closeout Submittals.
- B. See Section 01 7900 - Demonstration and Training, for additional requirements.
- C. Demonstrate Operation of Controls for the following Equipment:
 1. Hydronic Radiant Ceiling Panel Heaters.
 2. Outdoor Roof, Gutter, and Downspout Deicing.

3.07 PROTECTION

- A. Protect installed products from damage until Date of Substantial Completion.
- B. Outdoor Equipment: Touch-up, repair, or replace damaged products before Date of Substantial Completion.

END OF SECTION 23 8300

SECTION 23 8415 STEAM HUMIDIFIERS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Direct Plant Steam-Injection humidifiers.
- B. Electrode steam humidifiers.
- C. Self-Contained Packaged humidifiers

1.02 RELATED REQUIREMENTS

- A. Section 22 1005 - Plumbing Piping.
- B. Section 23 0913 - Instrumentation and Control Devices for HVAC: Humidistats.
- C. Section 23 2213 - Steam and Condensate Heating Piping.
- D. Section 23 2214 - Steam and Condensate Heating Specialties.
- E. Section 26 0583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. AHRI 610 (I-P) - Performance Rating Of Central System Humidifiers for Residential Applications; 2014.
- B. AHRI 611 (SI) - Performance Rating Of Central System Humidifiers for Residential Applications; 2014.

1.04 SUBMITTALS

- A. See Section 01 3000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide catalog data indicating rated capacity, dimensions, duct and service connections, electric nameplate data and wiring diagrams.
- C. Shop Drawings: Indicate layout of system and components.
- D. Manufacturer's Instructions: Indicate installation instructions and recommendations.
- E. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- F. Warranty: Submit manufacturer's warranty and ensure forms have been completed in Owner's name and registered with manufacturer.
- G. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 01 6000 - Product Requirements, for additional provisions.
 - 2. Extra Humidifier Cylinders: One of each type and size.

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

1.06 WARRANTY

- A. See Section 01 7800 - Closeout Submittals, for additional warranty requirements.
- B. Provide two year manufacturer warranty for humidifier unit except the cylinder.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Armstrong International, Inc; _____: www.armstronginternational.com/#sle.
- B. Dri-Steem Corporation; _____: www.dristeem.com/#sle.

- C. Condair Inc. (previously Nortec)

2.02 DIRECT PLANT STEAM-INJECTION HUMIDIFIERS

- A. Humidifier: Steam separator type receiving steam at supply pressure and providing separation ahead of control valve, discharging through internal drying and silencing chambers, and distribution manifold at atmospheric pressure; complying with AHRI 610 (I-P).
- B. Body: Cast iron with integral metering valve, separating and drying chambers, and silencing chamber with stainless steel silencing medium.
- C. Separating Chamber: To disengage and remove water droplets and particle matter when operated at maximum capacity.
- D. Control Valve: Steam jacketed parabolic plug, capable of modulating flow of steam over entire stroke of operator with modulating electric operator.
- E. Internal Drying and Silencing Chambers: To receive steam at atmospheric pressure and jacketed by steam at supply pressure.
- F. Distribution Manifold: To provide uniform distribution over entire length, and jacketed by steam at supply pressure, with full length stainless steel internal silencing screen.
- G. Controls: Temperature switch before steam trap to prevent humidifier from operating before start-up condensate is drained.

2.03 ELECTRODE STEAM HUMIDIFIERS

- A. Humidifier: Self-contained, disposable cylinder, microprocessor controlled electrode steam generating unit AHRI 610 (I-P).
- B. Cylinders: Disposable, polypropylene plastic with field adjustable stainless steel electrodes.
- C. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing. Incorporate water fill with 1 inch air gap and integral air gap on drain. Fill solenoid valve shall incorporate built-in strainer, pressure reducing and flow regulating orifice.
- D. Cabinet: Steel, 0.058 inches with enamel finish, with hinged and lockable access door.
- E. Electric Service: Unit protected by internal fusing on line voltage leads and automatic emergency drain trigger. Incorporate electrical terminals for installation of humidistat, duct high-limit humidistat, interlock to fan or air flow switch.
- F. Control: Fully modulating control to provide gradual 0 to 100 percent capacity. Maximum capacity shall be field adjustable for 0 to 100 percent. High water probe shall prevent overfilling. Multiple cylinder humidifiers shall have duplicate internal control circuitry to allow each cylinder to be independently controlled.
- G. Drain Cycle: Field adjustable with drain duration range of 2 to 128 seconds and drain interval range of 0.25 to 16 hours, with one drain valve for each generator. Drain system shall include manufacturer provided subcooling components to reduce drain waste discharge temperature to below 140F prior to discharge in sanitary sewer.
- H. Steam Distributor: Stainless steel steam dispersion tube suitable for insertion in duct with condensate separator and return leg to remove condensate from distributor and return to humidifier fill. Steam hose from generator to dispersion tube shall be 1-1/2 inch diameter reinforced rubber.
- I. Display: Digital, providing select monitoring of unit amperage draw, percentage demand from humidistat, steam output, and manually set capacity adjustment. Lamps to indicate full cylinder.
- J. Humidistat:
 - 1. Wall mounted, solid state electronic sensor, 24 volt.
 - 2. Refer to Section 23 0913.

2.04 SELF-CONTAINED PACKAGED HUMIDIFIERS

- A. MANUFACTURERS

Armstrong International, Inc; _____: www.armstronginternational.com/#sle.
Dri-Steem Corporation; _____: www.dristeem.com/#sle.
Condair Inc. (previously Nortec)

B. MANUFACTURED UNITS

1. Units: AHRI 610 (I-P); evaporative pan with stand, cabinet enclosure, heating coil, humidistat, pre-wired except for humidistat, for use with heating hot water.

C. COMPONENTS

1. Pan, Cover, Screws and Bolts: Stainless steel with duct collar.
2. Overflow and Drainage Fittings: Copper or Brass.
3. Float Valve Mechanism: Stainless steel or brass with 1/4 inch fill connection.
4. Coil: Shielded electric immersion heating element with safety cut-out switch (set at 225 degrees F) to disconnect electric heating element on low water level in pan;
5. Floor Stand: Extruded aluminum.
6. Cabinet Enclosure: Galvanized sheet metal with baked enamel finish.
7. Control: Humidistat cycles blower fan and opens inlet solenoid valve.
8. Flush Cycle: Timers allow one to four flushes per day of three to 120 minutes duration by shutting off power to heating element and opening drain valve. Flush cycle to be interlocked with integral sub-cooling unit to maintain discharge water temperature below 140F prior to entering sanitary sewer system piping.
9. Disconnect Switch: Factory mount disconnect switch in control panel.

D. ACCESSORIES

1. Manufacturer provided drain-flush sub-cooling system
2. Humidistats: Refer to Section 23 0913.
3. Provide Water Softener/Reverse Osmosis (RO) water treatment system for Humidifier scale control.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. All Steam Distribution devices installed in ductwork shall be installed in Stainless Steel duct section with appropriate upsstream/downstream length (as recommended by manufacturer). Stainless Steel ductwork to be sloped to low-point to drain through a trapped drain opening.
- C. Provide Stainless Steel rods to support distribution manifolds and mount in air system plenums.
- D. Connect dry steam humidifiers to steam supply and to condensate piping. Provide gate valve, inlet strainer, and inverted bucket steam trap. Refer to Section 23 2213 and Section 23 2214.

END OF SECTION 23 8415