MASTER SPECIFICATIONS

Division 23 - MECHANICAL

Release 2.0
April 2012

Released by:
Cleveland Clinic
Facilities and Construction
9500 Euclid Ave.
Cleveland OH 44195

Cleveland Clinic

Cleveland Clinic Master Specifications: Division 23 - Mechanical

This document contains the Master Specifications for the design and construction of new and renovated facilities for all domestic Cleveland Clinic locations. It is be used by A/E firms in the preparation of Construction Documents for all facility types.

The general purpose of each Specification is to provide minimum criteria for construction materials at Cleveland Clinic facilities regarding Code and FM Global compliance, warranty, approved products, execution and uniformity.

The Specifications are used to prepare specific project Contract Specifications. They are intended to be used to address system design aspects of equipment that Cleveland Clinic desires to standardize among facilities, and identify prohibited materials and construction practices. Use of these Specifications will help A/E's meet the Cleveland Clinic's primary goal of providing a safe, reliable, and energy efficient installations and ultimately successful patient outcomes.

The use of these Specifications is mandatory for all design or maintenance projects. Deviations are discouraged. If project conditions arise which require a deviation, it should be thoroughly documented by the user and submitted to the Cleveland Clinic for review and approval using the Design Standards Revision Request document. Additionally, all Cleveland Clinic staff, architects, engineers, and contractors are encouraged to participate in the ongoing development of these guidelines by communicating any suggestions by use of the Revision Request document.

USER NOTE: throughout the specifications, **bracketed, bold text** indicates optional requirements which may be deleted if project conditions permit.

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*** End of List ***

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 COORDINATION

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

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

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

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

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.

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

2.3 POLYPHASE MOTORS

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

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

C. Service Factor: 1.15.

D. Multispeed Motors: Separate winding for each speed.

E. Rotor: Random-wound, squirrel cage.

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

G. Temperature Rise: Match insulation rating.

H. Insulation: Class F.

I. Code Letter Designation:

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

J. Enclosure Material: Cast iron or extruded aluminum for motors greater than 1 hp; cast iron, extruded aluminum or rolled steel for motors 1 hp and smaller.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

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

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

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

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

2.5 SINGLE-PHASE MOTORS

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

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

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

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

SECTION 230514 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes separately enclosed, pre-assembled, combination VFDs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

B. Related Sections:

1. Section 262419 "Motor-Control Centers" for VFDs installed in motor-control centers.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. CE: Conformite Europeene (European Compliance).

C. CPT: Control power transformer.

D. EMI: Electromagnetic interference.

E. IGBT: Insulated-gate bipolar transistor.

F. LAN: Local area network.

G. LED: Light-emitting diode.

H. MCP: Motor-circuit protector.

I. NC: Normally closed.

J. NO: Normally open.

K. OCPD: Overcurrent protective device.

L. PCC: Point of common coupling.

M. PID: Control action, proportional plus integral plus derivative.

N. PWM: Pulse-width modulated.

O. RFI: Radio-frequency interference.

P. TDD: Total demand (harmonic current) distortion.

Q. THD(V): Total harmonic voltage demand.

R. VFD: Variable-frequency motor controller.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: VFDs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFD indicated. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, and furnished specialties and accessories.

B. LEED Submittals:

1. Product Data for Credit EA 5: For continuous metering equipment for energy consumption.

C. Shop Drawings: For each VFD indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Each installed unit's type and details.
b. Factory-installed devices.
c. Enclosure types and details.
d. Nameplate legends.
e. Short-circuit current (withstand) rating of enclosed unit.
f. Features, characteristics, ratings, and factory settings of each VFD and installed devices.
g. Specified modifications.
h. Outline dimensions, conduit entry locations and weight.
i. Customer connection and power wiring diagrams.
j. Complete technical product description include a complete list of options provided. Any portions of this specification not met must be clearly indicated or the supplier and contractor shall be liable to provide all additional components required to meet this specification.

2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFDs. Show VFD layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

B. Qualification Data: For qualified testing agency.

C. Seismic Qualification Certificates: For VFDs, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.

D. Product Certificates: For each VFD, from manufacturer.

E. Harmonic Analysis Study and Report: Comply with IEEE 399 and NETA Acceptance Testing Specification; identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze designated operating scenarios, including recommendations for VFD input filtering to limit TDD and THD(V) at each VFD to specified levels.

F. Source quality-control reports.

G. Field quality-control reports.

H. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.

I. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFDs to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and MCP trip settings.

2. Manufacturer's written instructions for setting field-adjustable overload relays.
3. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
4. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

1.8 MAINTENANCE MATERIAL SUBMITTALS

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

1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.9 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Comply with NFPA 70.

D. IEEE Compliance: Fabricate and test VFD according to IEEE 344 to withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

E. Referenced Standards and Guidelines:
1. Institute of Electrical and Electronic Engineers (IEEE)
   a. IEEE 519-1992, Guide for Harmonic Content and Control.
2. Underwriters Laboratories (as appropriate)
   a. UL508
   b. UL508A
   c. UL508C
3. National Electrical Manufacturer’s Association (NEMA)
   a. ICS 7.0, AC Adjustable Speed Drives
4. International Electrotechnical Commission (IEC)
   a. EN/IEC 61800-3
5. National Electric Code (NEC)
   a. NEC 430.120, Adjustable-Speed Drive Systems

6. International Building Code (IBC)
   a. IBC 2009 Seismic – referencing ASC 7-05 and ICC AC-156

F. Qualifications:
1. VFDs and options shall be UL508 listed as a complete assembly. The base VFD shall be UL listed for 100 kA SCCR without the need for input fuses. Base VFDs with red label UL stickers requiring additional branch circuit protection are not acceptable.
2. CE Mark – The base VFD shall conform to the European Union Electromagnetic Compatibility directive, a requirement for CE marking. The VFD shall meet product standard EN 61800-3 for the First Environment restricted level (Category C2). Base drives that only meet the Second Environment (Category C3, C4) shall be supplied with external filters to bring the drive in compliance with the First Environment levels.
3. The entire VFD assembly, including the bypass (if specified), shall be seismically certified and labeled as such in accordance with the 2009 International Building Code (IBC):
   a. VFD manufacturer shall provide Seismic Certification and Installation requirements at time of submittal.
   b. Seismic importance factor of 1.5 rating is required, and shall be based upon actual shake test data as defined by ICC AC-156.
   c. Seismic ratings based upon calculations alone are not acceptable. Certification of Seismic rating must be based on testing done in all three axis of motion.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Store in space that is permanently enclosed and air conditioned.

1.11 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than 14 deg F (minus 10 deg C) and not exceeding 104 deg F (40 deg C).
2. Ambient Storage Temperature: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C)
3. Humidity: Less than 95 percent (noncondensing).
4. Altitude: Not exceeding 3300 feet (1005 m).

B. Interruption of Existing Electrical Systems: Do not interrupt electrical systems in facilities occupied by Cleveland Clinic or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:

1. Notify the Cleveland Clinic no fewer than seven days in advance of proposed interruption of electrical systems.
2. Indicate method of providing temporary electrical service.
3. Do not proceed with interruption of electrical systems without the Cleveland Clinic's written permission.
4. Comply with NFPA 70E.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFDs, including clearances between VFDs, and adjacent surfaces and other items.

1.12 COORDINATION

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

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

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.13 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFDs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Five years from date of turnover to the Cleveland Clinic.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

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

1. ABB.

2.02 VARIABLE FREQUENCY DRIVES

A. The VFD package as specified herein shall be enclosed in a UL Listed Type enclosure, exceeding NEMA enclosure design criteria (enclosures with only NEMA ratings are not acceptable), completely assembled and tested by the manufacturer in an ISO9001 facility.

B. The VFD shall provide full rated output from a line of ±10% of nominal voltage. The VFD shall continue to operate without faulting from a line of +30% to -35% of nominal voltage.

1. VFDs shall be capable of continuous full load operation under the following environmental operating conditions:
   a. -15 to 40° C (5 to 104° F) ambient temperature. Operation to 50° C shall be allowed with a 10% reduction from VFD full load current.

b. Altitude 0 to 3300 feet above sea level Operation to 6600 shall be allowed with a 10% reduction from VFD full load current.
c. Humidity less than 95%, non-condensing.
d. Enclosure shall have a UL Type rating and shall be UL listed and available as a plenum rated VFD. VFDs without these ratings are not acceptable. Non UL Type enclosures (e.g. self-certified NEMA enclosures) are not acceptable.

C. All VFDs shall have the following standard features:
1. All circuit boards shall be coated. Drives that contain circuit boards that are not coated are not acceptable.
2. All VFDs shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple VFDs.
3. The keypad shall include Hand-Off-Auto selections and manual speed control. The drive shall incorporate “bumpless transfer” of speed reference when switching between “Hand” and “Auto” modes. There shall be fault reset and “Help” buttons on the keypad. The Help button shall include “on-line” assistance for programming and troubleshooting.
4. There shall be a built-in time clock in the VFD keypad. The clock shall have a battery backup with 10 years minimum life span. The clock shall be used to date and time stamp faults and record operating parameters at the time of fault. VFD programming shall be held in non-volatile memory and is not dependent on battery power
5. The VFD’s shall utilize pre-programmed application macros specifically designed to facilitate start-up. The Application Macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce programming time. The VFD shall have two user macros to allow the end-user to create and save custom settings.
6. The VFD shall have cooling fans that are designed for easy replacement. The fans shall be designed for replacement without requiring removing the VFD from the wall or removal of circuit boards. The VFD cooling fans shall operate only when required, based on the temperature of and run command to the drive. VFD protection shall be based on thermal sensing and not cooling fan operation.
7. The VFD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to set point without tripping or component damage (flying start).
8. The VFD shall have the ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable.
9. The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds every minute. The minimum FLA rating shall meet or exceed the values in the NEC/UL table 430.250 for 4-pole motors.
10. VFDs through 200 HP shall have internal swinging (non-linear) chokes providing impedance equivalent to 5% to reduce the harmonics to the power line. Swinging choke shall be required resulting in superior partial load harmonic reduction. Linear chokes are not acceptable. 5% impedance may be from dual (positive and negative DC bus) chokes, or 5% swinging AC line chokes. VFD’s with only one DC choke shall add an AC line choke.
11. The input current rating of the VFD shall not be greater than the output current rating. VFD’s with higher input current ratings require the upstream wiring, protection devices,

and source transformers to be oversized per NEC 430.122. Input and output current ratings must be shown on the VFD nameplate.

12. The VFD shall include a coordinated AC transient surge protection system consisting of 4 MOVs (phase to phase and phase to ground), a capacitor clamp, 1600 PIV Diode Bridge and internal chokes. VFDs that do not include coordinated AC transient surge protection shall include an external TVSS (Transient Voltage Surge Suppressor).
13. The VFD shall provide a programmable loss-of-load (broken belt / broken coupling) Form-C relay output. The drive shall be programmable to signal the loss-of-load condition via a keypad warning, Form-C relay output, and / or over the serial communications bus. The loss-of-load condition sensing algorithm shall include a programmable time delay that will allow for motor acceleration from zero speed without signaling a false loss-of-load condition.
14. The VFD shall include multiple “two zone” PID algorithms that allow the VFD to maintain PID control from two separate feedback signals (4-20mA, 0-10V, and / or serial communications). The two zone control PID algorithm will control motor speed based on a minimum, maximum, or average of the two feedback signals. All of the VFD PID controllers shall include the ability for “two zone” control.
15. If the input reference is lost, the VFD shall give the user the option of either (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) hold the VFD speed based on the last good reference received, or (4) cause a warning to be issued, as selected by the user. The drive shall be programmable to signal this condition via a keypad warning, Form-C relay output and / or over the serial communication bus.
16. The VFD shall have programmable “Sleep” and “Wake up” functions to allow the drive to be started and stopped from the level of a process feedback signal.

D. All VFDs to have the following adjustments:

1. Three (3) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed. The lockout range must be fully adjustable, from 0 to full speed.
2. Two (2) PID Set point controllers shall be standard in the drive, allowing pressure or flow signals to be connected to the VFD, using the microprocessor in the VFD for the closed-loop control. The VFD shall have 250 ma of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others. The PID set point shall be adjustable from the VFD keypad, analog inputs, or over the communications bus. There shall be two independent parameter sets for the PID controller and the capability to switch between the parameter sets via a digital input, serial communications or from the keypad. The independent parameter sets are typically used for night setback, switching between summer and winter set points, etc.
3. There shall be an independent, second PID loop that can utilize the second analog input and modulate one of the analog outputs to maintain the set point of an independent process (i.e. valves, dampers, etc.). All set points, process variables, etc. to be accessible from the serial communication network.
4. Two (2) programmable analog inputs shall accept current or voltage signals.
5. Two (2) programmable analog outputs (0-20ma or 4-20 ma). The outputs may be programmed to output proportional to Frequency, Motor Speed, Output Voltage, Output Current, Motor Torque, Motor Power (kW), DC Bus voltage, Active Reference, Active Feedback, and other data. Drives that have only one (1) analog output must provide an option card that provides additional analog outputs.

6. Six (6) programmable digital inputs for maximum flexibility in interfacing with external devices. All digital inputs shall be programmable to initiate upon an application or removal of 24VDC or 24VAC.
7. Three (3) programmable, digital Form-C relay outputs. The relay outputs shall include programmable on and off delay times and adjustable hysteresis. The relays shall be rated for maximum switching current 8 amps at 24 VDC and 0.4 A at 250 VAC; Maximum voltage 300 VDC and 250 VAC; continuous current rating of 2 amps RMS. Outputs shall be true Form-C type contacts; open collector outputs are not acceptable. Drives that have only two (2) relay outputs must provide an option card that provides additional relay outputs.
8. Run permissive circuit - There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad, input contact closure, time-clock control, or serial communications), the VFD shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a VFD digital input and allows VFD motor operation. Two separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop and the damper shall be commanded to close. The keypad shall display “start enable 1 (or 2) missing”. The safety input status shall also be transmitted over the serial communications bus.
9. The VFD control shall include a programmable time delay for VFD start and a keypad indication that this time delay is active. A Form C relay output provides a contact closure to signal the VAV boxes open. This will allow VAV boxes to be driven open before the motor operates. The time delay shall be field programmable from 0 – 120 seconds. Start delay shall be active regardless of the start command source (keypad command, input contact closure, time-clock control, or serial communications), and when switching from drive to bypass.
10. Seven (7) programmable preset speeds.
11. Two independently adjustable accel and decel ramps with 1 – 1800 seconds adjustable time ramps.
12. The VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and reduce audible motor noise. The VFD shall have selectable software for optimization of motor noise, energy consumption, and motor speed control.
13. The VFD shall include a carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows higher carrier frequency settings without derating the VFD.
14. The VFD shall include password protection against parameter changes.

E. The Keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (alpha-numeric codes are not acceptable). All VFD faults shall be displayed in English words. The keypad shall include a minimum of 14 assistants including:
   1. Start-up assistant
   2. Parameter assistants
      a. PID assistant
      b. Reference assistant
      c. I/O assistant
      d. Serial communications assistant
      e. Option module assistant
      f. Panel display assistant

g. Low noise set-up assistant
3. Maintenance assistant
4. Troubleshooting assistant
5. Drive optimizer assistants

F. All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of three operating values from the list below shall be capable of being displayed at all times. The display shall be in complete English words (alpha-numeric codes are not acceptable):
1. Output Frequency
2. Motor Speed (RPM, %, or Engineering units)
3. Motor Current
4. Motor Torque
5. Motor Power (kW)
6. DC Bus Voltage
7. Output Voltage

G. The VFD shall include a fireman's override input. Upon receipt of a contact closure from the fire / smoke control station, the VFD shall operate in one of two modes: 1) Operate at a programmed predetermined fixed speed ranging from -500Hz (reverse) to 500Hz (forward). 2) Operate in a specific fireman's override PID algorithm that automatically adjusts motor speed based on override set point and feedback. The mode shall override all other inputs (analog/digital, serial communication, and all keypad commands), except customer defined safety run interlocks, and force the motor to run in one of the two modes above. "Override Mode" shall be displayed on the keypad. Upon removal of the override signal, the VFD shall resume normal operation, without the need to cycle the normal digital input run command.

H. Serial Communications
1. The VFD shall have an EIA-485 port as standard. The standard protocols shall be Modbus, Johnson Controls N2, Siemens Building Technologies FLN, and BACnet. [Optional protocols for LonWorks, Profibus, EtherNet, BACnet IP, and DeviceNet shall be available.] Each individual drive shall have the protocol in the base VFD. The use of third party gateways and multiplexers is not acceptable. All protocols shall be "certified" by the governing authority (i.e. BTL Listing for BACnet). Use of non-certified protocols is not allowed.
2. The BACnet connection shall be an EIA-485, MS/TP interface operating at 9.6, 19.2, 38.4, or 76.8 Kbps. The connection shall be tested by the BACnet Testing Labs (BTL) and be BTL Listed. The BACnet interface shall conform to the BACnet standard device type of an Applications Specific Controller (B-ASC). The interface shall support all BIBBs defined by the BACnet standard profile for a B-ASC including, but not limited to:
   a. Data Sharing – Read Property – B.
   b. Data Sharing – Write Property – B.
   c. Device Management – Dynamic Device Binding (Who-Is; I-Am).
   d. Device Management – Dynamic Object Binding (Who-Has; I-Have).
   e. Device Management – Communication Control – B.
3. If additional hardware is required to obtain the BACnet interface, the VFD manufacturer shall supply one BACnet gateway per drive. Multiple VFDs sharing one gateway shall not be acceptable.
4. Serial communication capabilities shall include, but not be limited to; run-stop controls, speed set adjustment, and lock and unlock the keypad. The drive shall have the capability of allowing the BAS to monitor feedback such as process variable feedback,

output speed / frequency, current (in amps), % torque, power (kW), kilowatt hours (resettable), operating hours (resettable), and drive temperature. The BAS shall also be capable of monitoring the VFD relay output status, digital input status, and all analog input and analog output values. All diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote VFD fault reset shall be possible.

5. Serial communication in bypass (if bypass is specified) shall include, but not be limited to; bypass run-stop control, the ability to force the unit to bypass, and the ability to lock and unlock the keypad. The bypass shall have the capability of allowing the BAS to monitor feedback such as, current (in amps), kilowatt hours (resettable), operating hours (resettable), and bypass logic board temperature. The BAS shall also be capable of monitoring the bypass relay output status, and all digital input status. All bypass diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote bypass fault reset shall be possible.
6. The VFD / bypass shall allow the BAS to control the drive and bypass digital and analog outputs via the serial interface. This control shall be independent of any VFD function. The analog outputs may be used for modulating chilled water valves or cooling tower bypass valves. The drive and bypass' digital (Form-C relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. In addition, all of the drive and bypass' digital inputs shall be capable of being monitored by the BAS system. This allows for remote monitoring of which (of up to 4) safeties are open.
7. The VFD shall include an independent PID loop for customer use. The independent PID loop may be used for cooling tower bypass value control, chilled water value / hot water valve control, etc. Both the VFD PID control loop and the independent PID control loop shall continue functioning even if the serial communications connection is lost. As default, the VFD shall keep the last good set point command and last good DO & AO commands in memory in the event the serial communications connection is lost and continue controlling the process.

I. EMI / RFI filters. All VFD's shall include EMI/RFI filters. The onboard filters shall allow the VFD assembly to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level (Category C2) with up to 100 feet of motor cable. Second environment (Category C3, C4) is not acceptable, no Exceptions. Certified test reports shall be provided with the submittals confirming compliance to EN 61800-3, First Environment (C2).

J. DRIVE OPTIONS – Options shall be furnished and mounted by the drive manufacturer as defined by the VFD schedule. All optional features shall be UL Listed by the drive manufacturer as a complete assembly and carry a UL508 label.
1. Circuit Breaker - Door interlocked padlockable circuit breaker that will disconnect all input power from the drive and all internally mounted options. Circuit breaker option shall be available with or without systems requiring bypass.
2. Disconnect Switch with Fuses - Door interlocked, padlockable disconnect switch that will disconnect all input power from the drive and all internally mounted options. Drive input fusing is included.
3. Fieldbus adapters – The following optional fieldbus adapters shall be available as a plug in modules.
    a. LonWorks
    b. DeviceNet
    c. Ethernet IP

1) ControlNet over Ethernet & ModBus TCP

d. BACnet IP

e. Profibus

K. BYPASS

1. A complete factory wired and tested bypass system consisting of a door interlocked, padlockable circuit breaker, output contactor, bypass contactor, and fast acting VFD input fuses. UL Listed motor overload protection shall be provided in both drive and bypass modes.
2. The bypass enclosure door and VFD enclosure must be mechanically interlocked such that the disconnecting device must be in the “Off” position before either enclosure may be accessed.
3. The VFD and bypass package shall have a UL listed short circuit current rating (SCCR) of 100,000 Amps and this rating shall be indicated on the UL data label.
4. The drive and bypass package shall be seismic certified and labeled to the IBC:
   a. Seismic importance factor of 1.5 rating is required, and shall be based upon actual shake table test data as defined by ICC AC-156.
5. Drive Isolation Fuses - To ensure maximum possible bypass operation, fast acting fuses, exclusive to the VFD, shall be provided to allow the VFD to disconnect from the line prior to clearing upstream branch circuit protection. This maintains bypass operation capability in the event of a VFD failure. Bypass designs which have no such fuses, or that incorporate fuses common to both the VFD and the bypass, will not be accepted. Third contactor “isolation contactors” are not an acceptable alternative to fuses, as contactors could weld closed and are not an NEC recognized disconnecting device.
6. The bypass shall maintain positive contactor control through the voltage tolerance window of nominal voltage +30%, -35%. This feature is designed to avoid contactor coil failure during brown out / low line conditions and allow for input single phase operation when in the VFD mode. Designs that will not allow input single phase operation in the VFD mode are not acceptable.
7. Motor protection from single phase power conditions - the bypass system must be able to detect a single phase input power condition while running in bypass, disengage the motor in a controlled fashion, and give a single phase input power indication. Bypass systems not incorporating single phase protection in bypass mode are not acceptable.
8. The bypass system shall be designed for stand-alone operation and shall be completely functional in both Hand and Automatic modes even if the VFD has been removed from the system for repair / replacement. Serial communications shall remain functional even with the VFD removed. Bypass systems that do not maintain full functionality with the drive removed are not acceptable.
9. Serial communications – the bypass shall be capable of being monitored and / or controlled via serial communications. On-board communications protocols shall include ModBus RTU; Johnson Controls N2; Siemens Building Technologies FLN (P1); and BACnet MS/TP.
   a. Serial communication capabilities shall include, but not be limited to: bypass run-stop control, the ability to force the unit to bypass, and the ability to lock and unlock the keypad. The bypass shall have the capability of allowing the BAS to monitor feedback such as, current (in amps), kilowatt hours (resettable), operating hours (resettable), and bypass logic board temperature. The BAS shall also be capable of monitoring the bypass relay output status, and all digital input status. All bypass diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote bypass fault reset shall be possible. The

following additional status indications and settings shall be transmitted over the serial communications bus and / or via a Form-C relay output – keypad “Hand” or “Auto” selected, bypass selected, and broken belt indication. The BAS system shall also be able to monitor if the motor is running in the VFD mode or bypass mode over serial communications. A minimum of 50 field serial communications points shall be capable of being monitored in the bypass mode.

b. The bypass serial communications shall allow control of the drive/bypass (system) digital outputs via the serial interface. This control shall be independent of any bypass function or operating state. The system digital (relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. All system analog and digital I/O shall be capable of being monitored by the BAS system.

10. There shall be an adjustable motor current sensing circuit for the bypass and VFD modes to provide proof of flow (broken belt) indication. The condition shall be indicated on the keypad display, transmitted over the BAS and / or via a Form-C relay output contact closure. The broken belt indication shall be programmable to be a system (drive and bypass) indication. The broken belt condition sensing algorithm shall be programmable to cause a warning or system shutdown.
11. The digital inputs for the system shall accept 24VAC or 24VDC. The bypass shall incorporate an internally sourced power supply and not require an external control power source. The bypass power board shall supply 250 mA of 24 VDC for use by others to power external devices.
12. There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad command, time-clock control, digital input, or serial communications) the bypass shall provide a dry contact closure that will signal the damper to open before the motor can run. When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a bypass system input and allows motor operation. Up to four separate safety interlock inputs shall be provided. When any safety is opened, the motor shall be commanded to coast to stop, and the damper shall be commanded to close. This feature will also operate in Fireman’s override / smoke control mode.
13. The bypass control shall monitor the status of the VFD and bypass contactors and indicate when there is a welded contactor contact or open contactor coil. This failed contactor condition shall be indicated on the bypass LCD display, programmed to activate a Form-C relay output, and / or over the serial communications protocol.
14. The bypass control shall include a programmable time delay bypass start including keypad indication of the time delay. A Form C relay output commands the VAV boxes open. This will allow VAV boxes to be driven open before the motor operates at full speed in the bypass mode. The time delay shall be field programmable from 0 – 120 seconds.
15. There shall be a keypad adjustment to select manual or automatic transfer to bypass. The user shall be able to select via keypad programming which drive faults will result in an automatic transfer to bypass mode and which faults require a manual transfer to bypass. The user may select whether the system shall automatically transfer from drive to bypass mode on the following drive fault conditions:
    a. Over current
    b. Over voltage
    c. Under voltage
    d. Loss of analog input
16. The following operators shall be provided:

a. Bypass Hand-Off-Auto
b. Drive mode selector
c. Bypass mode selector
d. Bypass fault reset

17. The bypass shall include a two line, 20 character LCD display. The display shall allow the user to access and view:
    a. Energy savings – in US dollars
    b. Bypass motor amps
    c. Bypass input voltage– average and individual phase voltage
    d. Bypass power (kW)
    e. Bypass faults and fault logs
    f. Bypass warnings
    g. Bypass operating time (resettable)
    h. Bypass energy (kilowatt hours – resettable)
    i. I/O status
    j. Parameter settings / programming
    k. Printed circuit board temperature
18. The following indicating lights (LED type) or keypad display indications shall be provided. A test mode or push to test feature shall be provided.
    a. Power-on (Ready)
    b. Run enable
    c. Drive mode selected
    d. Bypass mode selected
    e. Drive running
    f. Bypass running
    g. Drive fault
    h. Bypass fault
    i. Bypass H-O-A mode
    j. Automatic transfer to bypass selected
    k. Safety open
    l. Damper opening
    m. Damper end-switch made
19. The Bypass controller shall have six programmable digital inputs, and five programmable Form-C relay outputs. This I/O allows for a total System (VFD and Bypass) I/O count of 24 points as standard. The bypass I/O shall be available to the BAS system even with the VFD removed.
20. The on-board Form-C relay outputs in the bypass shall programmable for any of the following indications.
    a. System started
    b. System running
    c. Bypass override enabled
    d. Drive fault
    e. Bypass fault
    f. Bypass H-O-A position
    g. Motor proof-of-flow (broken belt)
    h. Overload
    i. Bypass selected
    j. Bypass run
    k. System started (damper opening)
    l. Bypass alarm

m. Over temperature

21. The bypass shall provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external safety interlocks shall remain fully functional whether the system is in VFD or Bypass mode. The remote start/stop contact shall operate in VFD and bypass modes. The terminal strip shall allow for independent connection of up to four (4) unique safety inputs.
22. The bypass shall include a supervisory control mode. In this bypass mode, the bypass shall monitor the value of the VFD's analog input (feedback). This feedback value is used to control the bypass contactor on and off state. The supervisory mode shall allow the user to maintain hysteresis control over applications such as cooling towers and booster pumps even with the VFD out of service.
23. The user shall be able to select the text to be displayed on the keypad when an external safety opens. Example text display indications include "FireStat", "FreezStat", "Over pressure" and "Low suction". The user shall also be able to determine which of the four (4) safety contacts is open over the serial communications connection.
24. Smoke Control Override Mode (Override 1) – The bypass shall include a dedicated digital input that will transfer the motor from VFD mode to Bypass mode upon receipt of a dry contact closure from the Fire / Smoke Control System. The Smoke Control Override Mode action is not programmable and will always function as described in the bypass User's Manual documentation. In this mode, the system will ignore low priority safeties and acknowledge high priority safeties. All keypad control, serial communications control, and normal customer start / stop control inputs will be disregarded. This Smoke Control Mode shall be designed to meet the intent of UL864/UUKL.
25. Fireman's Override Mode (Override 2) – the bypass shall include a second, programmable override input which will allow the user to configure the unit to acknowledge some digital inputs, all digital inputs, ignore digital inputs or any combination of the above. This programmability allows the user to program the bypass unit to react in whatever manner the local Authority Having Jurisdiction (AHJ) requires. The Override 2 action may be programmed for "Run-to-Destruction". The user may also force the unit into Override 2 via the serial communications link.
26. Class 10, 20, or 30 (programmable) electronic motor overload protection shall be included.

L. HARMONIC MITIGATION

1. *The engineer has completed a preliminary harmonic analysis showing that all drives below ___ HP shall be 6 pulse drives with swinging chokes and all drives ___ HP and above shall be Ultra Low Harmonic designs with an integral active front end. Drives with passive harmonic filters, 12 pulse, and 18 pulse drives shall not be acceptable. Compliance to IEEE 519 does not relieve the vendor from the requirement to provide active front end drives, as specified above.*

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFDs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance.

B. Examine VFD before installation. Reject VFDs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFD installation.

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

3.2 HARMONIC ANALYSIS STUDY

A. Perform a harmonic analysis study to identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze designated operating scenarios, including recommendations for VFD input filtering to limit TDD and THD(V) at each VFD to specified levels.

B. Prepare a harmonic analysis study and report complying with IEEE 399 and NETA Acceptance Testing Specification.

3.3 INSTALLATION

A. Coordinate layout and installation of VFDs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Wall-Mounting Controllers: Install VFDs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches (2000 mm) above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

C. Floor-Mounting Controllers: Install VFDs on 4-inch (100-mm) nominal thickness concrete base. Comply with requirements for concrete base specified in

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

D. Seismic Bracing: Comply with requirements specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

E. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

F. Install fuses in each fusible-switch VFD.

G. Install fuses in control circuits if not factory installed. Comply with requirements in Section 262813 "Fuses."

H. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

I. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

J. Comply with NECA 1.

3.4 IDENTIFICATION

A. Identify VFDs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each VFD with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFDs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFD units.

3.5 CONTROL WIRING INSTALLATION

A. Install wiring between VFDs and remote devices and facility's central-control system. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic control devices where applicable.

1. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Cleveland Clinic will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Acceptance Testing Preparation:

1. Test insulation resistance for each VFD element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

E. Tests and Inspections:

1. Inspect VFD, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFD element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFD locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify the Cleveland Clinic before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFD. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFD 11 months after date of Substantial Completion.
c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. VFDs will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies the VFD and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.8 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify the Cleveland Clinic before increasing settings.

D. Set the taps on reduced-voltage autotransformer controllers.

E. Set field-adjustable circuit-breaker trip ranges[as specified in Section 260573 "Overcurrent Protective Device Coordination Study."]

F. Set field-adjustable pressure switches.

3.9 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace VFDs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, reprogram, and maintain VFDs.

END OF SECTION 230514

SECTION 230516 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Flexible, ball-joint, packed expansion joints.
2. Slip-joint packed expansion joints.
3. Grooved-joint expansion joints.
4. Pipe loops and swing connections.
5. Alignment guides and anchors.

1.3 PERFORMANCE REQUIREMENTS

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

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

1.4 ACTION SUBMITTALS

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

B. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

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

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Product Certificates: For each type of expansion joint, from manufacturer.

1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For expansion joints to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.1 PACKED EXPANSION JOINTS

A. Flexible, Ball-Joint, Packed Expansion Joints:

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

a. Advanced Thermal Systems, Inc.
b. Hyspan Precision Products, Inc.

2. Standards: ASME Boiler and Pressure Vessel Code: Section II, "Materials"; and ASME B31.9, "Building Services Piping," for materials and design of pressure-containing parts and bolting.
3. Material: Carbon-steel assembly with asbestos-free composition packing.
4. Design: For 360-degree rotation and angular deflection.
5. Minimum Pressure Rating: **250 psig at 400 deg F (1725 kPa at 204 deg C)**.
6. Angular Deflection for NPS 6 (DN 150) and Smaller: 30 degree minimum.
7. Angular Deflection for NPS 8 (DN 200) and Larger: 15 degree minimum.
8. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
9. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.

B. Slip-Joint Packed Expansion Joints:

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

a. Adsco Manufacturing LLC.
b. Advanced Thermal Systems, Inc.
c. Hyspan Precision Products, Inc.

2. Standard: ASTM F 1007.
3. Material: Carbon steel with asbestos-free PTFE packing.

4. Design: With internal guide and injection device for repacking under pressure. Include drip connection if used for steam piping.
5. Configuration: [**Single joint**] [**Single joint with base**] [**and**] [**double joint with base**] class(es) unless otherwise indicated.
6. End Connections: Flanged or weld ends to match piping system.

2.2 GROOVED-JOINT EXPANSION JOINTS

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

1. Anvil International, Inc.
2. Shurjoint Piping Products.
3. Victaulic Company.

B. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.

C. Standard: AWWA C606, for grooved joints.

D. Nipples: [**Galvanized,**]ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.

E. Couplings: [**Five**] [**Seven**] [**10**] [**12**], flexible type for steel-pipe dimensions. Include ferrous housing sections, [**Buna-N gasket suitable for diluted acid, alkaline fluids, and cold and hot water**] [**EPDM gasket suitable for cold and hot water**], and bolts and nuts.

2.3 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides:

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

a. Adsco Manufacturing LLC.
b. Advanced Thermal Systems, Inc.
c. Flex-Hose Co., Inc.
d. Flexicraft Industries.
e. Flex-Weld, Inc.
f. Hyspan Precision Products, Inc.
g. Metraflex, Inc.
h. Senior Flexonics Pathway.
i. Unisource Manufacturing, Inc.
j. U.S. Bellows, Inc.

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

B. Anchor Materials:

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

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

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

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

PART 3 - EXECUTION

3.1 EXPANSION-JOINT INSTALLATION

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

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

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

D. Install rubber packless expansion joints according to FSA-NMEJ-702.

E. Install grooved-joint expansion joints to grooved-end steel piping

3.2 PIPE LOOP AND SWING CONNECTION INSTALLATION

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

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

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

3.3 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

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

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

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

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

E. Anchor Attachments:

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

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

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

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

END OF SECTION 230516

SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Sleeves.
2. Stack-sleeve fittings.
3. Sleeve-seal systems.
4. Sleeve-seal fittings.
5. Grout.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

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

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

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

D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

2.2 STACK-SLEEVE FITTINGS

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

1. Smith, Jay R. Mfg. Co.
2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.

B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL SYSTEMS

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

1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).
4. Pipeline Seal and Insulator, Inc.
5. Proco Products, Inc.

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

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

2.4 SLEEVE-SEAL FITTINGS

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

1. Presealed Systems.

B. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.5 GROUT

A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

B. Characteristics: Nonshrink; recommended for interior and exterior applications.

C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.

B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide **1-inch (25-mm)** annular clear space between piping and concrete slabs and walls.

C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.

1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
2. Cut sleeves to length for mounting flush with both surfaces.

    a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas **2 inches (50 mm)** above finished floor level.

3. Using sealant, seal the space outside of sleeves in slabs and walls without sleeve-seal system.

D. Install sleeves for pipes passing through interior partitions.

1. Cut sleeves to length for mounting flush with both surfaces.
2. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.
3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

A. Install stack-sleeve fittings in new slabs as slabs are constructed.

1. Install fittings that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation.

2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
3. Install section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level.
4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
5. Using grout, seal the space around outside of stack-sleeve fittings.

B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-SYSTEM INSTALLATION

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

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

3.4 SLEEVE-SEAL-FITTING INSTALLATION

A. Install sleeve-seal fittings in new walls and slabs as they are constructed.

B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.

C. Secure nailing flanges to concrete forms.

D. Using grout, seal the space around outside of sleeve-seal fittings.

3.5 SLEEVE AND SLEEVE-SEAL SCHEDULE

A. Use sleeves and sleeve seals for the following piping-penetration applications:

1. Exterior Concrete Walls above Grade:

a. Piping Smaller Than **NPS 6** **(DN 150)**: [**Cast-iron wall sleeves**] [**Galvanized-steel wall sleeves**] [**Galvanized-steel-pipe sleeves**] [**Sleeve-seal fittings**].
b. Piping **NPS 6** **(DN 150)** and Larger: [**Cast-iron wall sleeves**] [**Galvanized-steel wall sleeves**] [**Galvanized-steel-pipe sleeves**].

2. Exterior Concrete Walls below Grade:

a. Piping Smaller Than **NPS 6 (DN 150)**: [**Cast-iron wall sleeves with sleeve-seal system**] [**Galvanized-steel wall sleeves with sleeve-seal system**] [**Galvanized-steel-pipe sleeves with sleeve-seal system**] [**Sleeve-seal fittings**].

1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping **NPS 6 (DN 150)** and Larger: [**Cast-iron wall sleeves with sleeve-seal system**] [**Galvanized-steel wall sleeves with sleeve-seal system**] [**Galvanized-steel-pipe sleeves with sleeve-seal system**].

1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

3. Concrete Slabs-on-Grade:

a. Piping Smaller Than **NPS 6 (DN 150)**: [**Cast-iron wall sleeves with sleeve-seal system**] [**Galvanized-steel wall sleeves with sleeve-seal system**] [**Galvanized-steel-pipe sleeves with sleeve-seal system**] [**Sleeve-seal fittings**].

1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

b. Piping **NPS 6 (DN 150)** and Larger: [**Cast-iron wall sleeves with sleeve-seal system**] [**Galvanized-steel wall sleeves with sleeve-seal system**] [**Galvanized-steel-pipe sleeves with sleeve-seal system**] [**Galvanized-steel-pipe sleeves**].

1) Select sleeve size to allow for 1-inch (25-mm) annular clear space between piping and sleeve for installing sleeve-seal system.

4. Concrete Slabs above Grade:

a. Piping Smaller Than **NPS 6 (DN 150)**: [**Galvanized-steel-pipe sleeves**] [**Stack-sleeve fittings**] [**Sleeve-seal fittings**] [**Molded-PE or -PP sleeves**].
b. Piping **NPS 6 (DN 150)** and Larger: [**Galvanized-steel-pipe sleeves**] [**Stack-sleeve fittings**].

5. Interior Partitions:

a. Piping Smaller Than **NPS 6 (DN 150)**: Galvanized-steel-pipe sleeves.
b. Piping **NPS 6 (DN 150)** and Larger: Galvanized-steel-sheet sleeves.

END OF SECTION 230517

SECTION 230518 - ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Escutcheons.
2. Floor plates.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 ESCUTCHEONS

A. One-Piece, Cast-Brass Type: With polished, chrome-plated finish and setscrew fastener.

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

C. One-Piece, Stamped-Steel Type: With chrome-plated finish and spring-clip fasteners.

D. Split-Casting Brass Type: With polished, chrome-plated finish and with concealed hinge and setscrew.

E. Split-Plate, Stamped-Steel Type: With chrome-plated finish, [**concealed**] [**and**] [**exposed-rivet**] hinge, and spring-clip fasteners.

2.2 FLOOR PLATES

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

B. Split-Casting Floor Plates: Cast brass with concealed hinge.

PART 3 - EXECUTION

3.1 INSTALLATION

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

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

1. Escutcheons for New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Chrome-Plated Piping: One-piece, cast-brass[**or split-casting brass**] type with polished, chrome-plated finish.
c. Insulated Piping: One-piece, stamped-steel type[**or split-plate, stamped-steel type with concealed hinge**] [**or split-plate, stamped-steel type with exposed-rivet hinge**].
[Retain one of first two subparagraphs below.]
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass[**or split-casting brass**] type with polished, chrome-plated finish.
e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type[**or split-plate, stamped-steel type with concealed hinge**] [**or split-plate, stamped-steel type with exposed-rivet hinge**].
[Retain one of first two subparagraphs below.]
f. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, cast-brass[**or split-casting brass**] type with polished, chrome-plated finish.
g. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type[**or split-plate, stamped-steel type with concealed hinge**] [**or split-plate, stamped-steel type with exposed-rivet hinge**].
[Retain one of first two subparagraphs below.]
h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass[**or split-casting brass**] type with polished, chrome-plated finish.
i. Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type[**or split-plate, stamped-steel type with concealed hinge**] [**or split-plate, stamped-steel type with exposed-rivet hinge**].
j. ***[Retain one of first two subparagraphs below.]***
k. Bare Piping in Equipment Rooms: One-piece, cast-brass[**or split-casting brass**] type with polished, chrome-plated finish.
l. Bare Piping in Equipment Rooms: One-piece, stamped-steel type[**or split-plate, stamped-steel type with concealed hinge**] [**or split-plate, stamped-steel type with exposed-rivet hinge**].

2. Escutcheons for Existing Piping:

a. Chrome-Plated Piping: Split-casting brass type with polished, chrome-plated finish.
b. Insulated Piping: Split-plate, stamped-steel type with [**concealed**] [**or**] [**exposed-rivet**] hinge.
[Retain one of first two subparagraphs below.]

c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with [**concealed**] [**or**] [**exposed-rivet**] hinge.
[Retain one of first two subparagraphs below.]
e. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-casting brass type with polished, chrome-plated finish.
f. Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with [**concealed**] [**or**] [**exposed-rivet**] hinge.
[Retain one of first two subparagraphs below.]
g. Bare Piping in Unfinished Service Spaces: Split-casting brass type with polished, chrome-plated finish.
h. Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with [**concealed**] [**or**] [**exposed-rivet**] hinge.
i. ***[Retain one of two subparagraphs below.]***
j. Bare Piping in Equipment Rooms: Split-casting brass type with polished, chrome-plated finish.
k. Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with [**concealed**] [**or**] [**exposed-rivet**] hinge.

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

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

1. New Piping: One-piece, floor-plate type.
2. Existing Piping: Split-casting, floor-plate type.

3.2 FIELD QUALITY CONTROL

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

END OF SECTION 230518

SECTION 230519 - METERS AND GAGES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Filled-system thermometers.
2. Thermowells.
3. Dial-type pressure gages.
4. Gage attachments.
5. Test plugs.
6. Test-plug kits.
7. Sight flow indicators.
8. Orifice flowmeters.
9. Turbine flowmeters.
10. Venturi flowmeters.

B. Related Sections:

1. Section 231123 "Facility Natural-Gas Piping" for gas meters.
2. Section 232213 "Steam and Condensate Heating Piping" for steam and condensate meters.

1.3 ACTION SUBMITTALS

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

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

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage, from manufacturer.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 FILLED-SYSTEM THERMOMETERS

A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:

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

   a. Ashcroft Inc.
   b. Marsh Bellofram.
   c. Trerice, H. O. Co.
   d. Weiss Instruments, Inc.

2. Standard: ASME B40.200.
3. Case: Sealed type, [**cast aluminum or drawn steel**] **6-inch** **(152-mm)** nominal diameter.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, dampening type**,** with link to pressure element and connection to pointer.
6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: [**Metal**] [**Stainless steel**].
10. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

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

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

B. Remote-Mounted, Metal-Case, Vapor-Actuated Thermometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Ashcroft Inc.
   b. Marsh Bellofram.
   c. Trerice, H. O. Co.
   d. Weiss Instruments, Inc.

2. Standard: ASME B40.200.
3. Case: Sealed type, [**cast aluminum or drawn steel**] **6-inch** **(152-mm)** nominal diameter with [**back**] [**front**] flange and holes for panel mounting.
4. Element: Bourdon tube or other type of pressure element.
5. Movement: Mechanical, with link to pressure element and connection to pointer.

6. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
7. Pointer: Dark-colored metal.
8. Window: Glass.
9. Ring: [**Metal**] [**Stainless steel**].
10. Connector Type(s): Union joint, [**back**] [**bottom**]; with ASME B1.1 screw threads.
11. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.

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

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

2.2 DUCT-THERMOMETER MOUNTING BRACKETS

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

2.3 THERMOWELLS

[ASME B40.200 uses the following symbols for thermowell materials: "CNR" for copper nickel (90-10), "CUNI" for copper nickel (70-30), "CRES" for corrosion-resistant steel, "NICU" for nickel copper, "ALBR" for aluminum bronze, and "CSA" for steel.]

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: [**CNR**] [**or**] [**CUNI**].
4. Material for Use with Steel Piping: [**CRES**] [**CSA**].
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, (DN 15, DN 20, or NPS 25,) ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch (13, 19, and 25 mm), with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.4 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Ashcroft Inc.
    b. Marsh Bellofram.
    c. Noshok.
    d. Trerice, H. O. Co.
    e. Weiss Instruments, Inc.
2. Standard: ASME B40.100.
3. Case: [**Liquid-filled**] [**Sealed**] [**Open-front, pressure relief**] [**Solid-front, pressure relief**] type(s); [**cast aluminum or drawn steel**]; **4-1/2-inch (114-mm)** nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with [**NPS 1/4 (DN 8)**] [**NPS 1/4 or NPS 1/2 (DN 8 or DN 15)**] [**NPS 1/2 (DN 15)**], ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: [**Metal**] [**Brass**] [**Stainless steel**].
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

B. Remote-Mounted, Metal-Case, Dial-Type Pressure Gages:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Ashcroft Inc.
    b. Marsh Bellofram.
    c. Noshok.
    d. Trerice, H. O. Co.
    e. Weiss Instruments, Inc.
2. Standard: ASME B40.100.
3. Case: [**Liquid-filled**] [**Sealed**] type; [**cast aluminum or drawn steel**] [**metal**]; **4-1/2-inch (114-mm)** nominal diameter with [**back**] [**front**] flange and holes for panel mounting.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with [**NPS 1/4 (DN 8)**] [**NPS 1/4 or NPS 1/2 (DN 8 or DN 15)**] [**NPS 1/2 (DN 15)**], ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: [**Metal**] [**Stainless steel**].
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.5 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with [**NPS 1/4 (DN 8)**] [**NPS 1/4 or NPS 1/2 (DN 8 or DN 15)**] [**NPS 1/2 (DN 15)**], ASME B1.20.1 pipe threads and [**piston**] [**porous-metal**]-type surge-dampening device. Include extension for use on insulated piping.

B. Siphons: Loop-shaped section of [**stainless-steel**] [**steel**] pipe with [**NPS 1/4 (DN 8)**] [**NPS 1/4 or NPS 1/2 (DN 8 or DN 15)**] [**NPS 1/2 (DN 15)**] pipe threads.

C. Valves: Brass ball, with [**NPS 1/4 (DN 8)**] [**NPS 1/4 or NPS 1/2 (DN 8 or DN 15)**] [**NPS 1/2 (DN 15)**], ASME B1.20.1 pipe threads.

2.6 TEST PLUGS

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

1. Flow Design, Inc.
2. Miljoco Corporation.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
8. Weiss Instruments, Inc.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: [**NPS 1/4 (DN 8)**] [**or**] [**NPS 1/2 (DN 15)**], ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: **500 psig at 200 deg F (3450 kPa at 93 deg C)**.

F. Core Inserts: [**Chlorosulfonated polyethylene synthetic**] [**and**] [**EPDM**] self-sealing rubber.

2.7 TEST-PLUG KITS

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

1. Flow Design, Inc.
2. Miljoco Corporation.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.

8. Weiss Instruments, Inc.

B. Furnish two test-plug kit(s) containing two thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

***[Retain one of first two paragraphs below. If retaining both, indicate location of each on Drawings*.]**

C. Low-Range Thermometer: Small, bimetallic insertion type with **1- to 2-inch- (25- to 51-mm-)** diameter dial and tapered-end sensing element. Dial range shall be at least **25 to 125 deg F (minus 4 to plus 52 deg C)**.

D. High-Range Thermometer: Small, bimetallic insertion type with **1- to 2-inch- (25- to 51-mm-)** diameter dial and tapered-end sensing element. Dial range shall be at least **0 to 220 deg F (minus 18 to plus 104 deg C)**.

E. Pressure Gage: Small, Bourdon-tube insertion type with [**2- to 3-inch- (51- to 76-mm-)** diameter dial and probe. Dial range shall be at least **0 to 200 psig (0 to 1380 kPa)**.

F. Carrying Case: Metal or plastic, with formed instrument padding.

2.8 SIGHT FLOW INDICATORS

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

1. Archon Industries, Inc.
2. Dwyer Instruments, Inc.
3. Emerson Process Management; Brooks Instrument.
4. Ernst Co., John C., Inc.
5. Ernst Flow Industries.
6. KOBOLD Instruments, Inc. - USA; KOBOLD Messring GmbH.
7. OPW Engineered Systems; a Dover company.
8. Penberthy; A Brand of Tyco Valves & Controls - Prophetstown.

B. Description: Piping inline-installation device for visual verification of flow.

C. Construction: Bronze or stainless-steel body, with sight glass and ball, flapper, or paddle wheel indicator, and threaded or flanged ends.

D. Minimum Pressure Rating: **150 psig (1034 kPa)**.

E. Minimum Temperature Rating: **200 deg F (93 deg C)**.

F. End Connections for NPS 2 (DN 50) and Smaller: Threaded.

G. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.

2.9 FLOWMETERS

A. Orifice Flowmeters:

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

a. Badger.
b. Bell & Gossett; ITT Industries.
c. Meriam Process Technologies.
d. Preso Meters; a division of Racine Federated Inc.
e. S. A. Armstrong Limited; Armstrong Pumps Inc.

2. Description: Flowmeter with sensor, hoses or tubing, fittings, valves, indicator, and conversion chart.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Wafer-orifice-type, calibrated, flow-measuring element; for installation between pipe flanges.

a. Design: Differential-pressure-type measurement for [**gas**] [**oil**] [**steam**] [**water**].
b. Construction: Cast-iron body, brass valves with integral check valves and caps, and calibrated nameplate.
c. Minimum Pressure Rating: **300 psig (2070 kPa)**.
d. Minimum Temperature Rating: **250 deg F (121 deg C)**.

5. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected sensor and having 6-inch- (152-mm-) diameter, or equivalent, dial with fittings and copper tubing for connecting to sensor.

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

6. Display: Shows rate of flow**,** with register to indicate total volume in gallons (liters).
7. Conversion Chart: Flow rate data compatible with sensor and indicator.
8. Operating Instructions: Include complete instructions with each flowmeter.

B. Turbine Flowmeters:

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

a. ABB; Instrumentation and Analytical.
b. Data Industrial Corp.
c. EMCO Flow Systems; a division of Spirax Sarco, Inc.
d. ERDCO Engineering Corp.
e. Hoffer Flow Controls, Inc.
f. Liquid Controls; a unit of IDEX Corporation.
g. McCrometer, Inc.
h. Midwest Instruments & Controls Corp.
i. SeaMetrics, Inc.

j. Sponsler, Inc.; a unit of IDEX Corporation.

2. Description: Flowmeter with sensor and indicator.
3. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
4. Sensor: Impeller turbine; for inserting into pipe fitting or for installing in piping and measuring flow directly in gallons per minute (liters per second).

   a. Design: Device or pipe fitting with inline turbine and integral direct-reading scale for [**gas**] [**oil**] [**steam**] [**water**].
   b. Construction: Bronze or stainless-steel body, with plastic turbine or impeller.
   c. Minimum Pressure Rating: **150 psig (1035 kPa)**.
   d. Minimum Temperature Rating: **180 deg F (82 deg C)**.

5. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
6. Accuracy: Plus or minus 1-1/2 percent.
7. Display: Shows rate of flow, with register to indicate total volume in gallons (liters).
8. Operating Instructions: Include complete instructions with each flowmeter.

C. Venturi Flowmeters:

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

   a. ABB; Instrumentation and Analytical.
   b. Gerand Engineering Co.
   c. Hyspan Precision Products, Inc.
   d. Preso Meters; a division of Racine Federated Inc.
   e. S. A. Armstrong Limited; Armstrong Pumps Inc.
   f. Victaulic Company.

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

   a. Design: Differential-pressure-type measurement for [**gas**] [**oil**] [**steam**] [**water**].
   b. Construction: Bronze, brass, or factory-primed steel, with brass fittings and attached tag with flow conversion data.
   c. Minimum Pressure Rating: **250 psig (1725 kPa)**.
   d. Minimum Temperature Rating: **250 deg F (121 deg C)**.
   e. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
   f. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged or welded.
   g. Flow Range: Flow-measuring element and flowmeter shall cover operating range of equipment or system served.

5. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- (152-mm-) diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.

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

6. Display: Shows rate of flow, with register to indicate total volume in gallons (liters).
7. Conversion Chart: Flow rate data compatible with sensor.
8. Operating Instructions: Include complete instructions with each flowmeter.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending [**a minimum of 2 inches (51 mm) into fluid**] [**one-third of pipe diameter**] [**to center of pipe**] and in vertical position in piping tees.

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

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

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

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

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

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

I. Install remote-mounted pressure gages on panel.

J. Install valve and snubber in piping for each pressure gage for fluids (except steam).

K. Install valve and syphon fitting in piping for each pressure gage for steam.

L. Install test plugs in piping tees.

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

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

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

P. Install wafer-orifice flowmeter elements between pipe flanges.

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

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

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

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

U. Install thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler.
3. Two inlets and two outlets of each chiller.
4. Inlet and outlet of each hydronic coil in air-handling units.
5. Two inlets and two outlets of each hydronic heat exchanger.
6. Inlet and outlet of each thermal-storage tank.
7. Outside-, return-, supply-, and mixed-air ducts.

V. Install pressure gages in the following locations:

1. Discharge of each pressure-reducing valve.
2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
3. Suction and discharge of each pump.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

D. Connect thermal-energy meter transmitters to meters.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: [**0 to 100 deg F (Minus 20 to plus 50 deg C)**] [**0 to 100 deg F and minus 20 to plus 50 deg C**].

B. Scale Range for Condenser-Water Piping: [**0 to 150 deg F (Minus 20 to plus 70 deg C)**] [**0 to 150 deg F and minus 20 to plus 70 deg C**].

C. Scale Range for Heating, Hot-Water Piping: [**0 to 250 deg F (0 to 150 deg C)**] [**0 to 250 deg F and 0 to 150 deg C**].

D. Scale Range for Steam-Condensate Piping: [**0 to 250 deg F (0 to 150 deg C)**] [**0 to 250 deg F and 0 to 150 deg C**].

E. Scale Range for Air Ducts: [**0 to 100 deg F (Minus 20 to plus 50 deg C)**] [**0 to 100 deg F and minus 20 to plus 50 deg C**].

3.5 PRESSURE-GAGE SCALE-RANGE SCHEDULE

[Select appropriate range for applicable operating pressure.]

A. Scale Range for Chilled-Water Piping: [**30 in. Hg to 15 psi (minus 100 to 0 kPa)**] [**30 in. Hg to 15 psi and minus 100 to 0 kPa**].

B. Scale Range for Chilled-Water Piping: [**0 to 30 psi (0 to 240 kPa)**] [**0 to 30 psi and 0 to 240 kPa**].

C. Scale Range for Chilled-Water Piping: [**0 to 100 psi (0 to 600 kPa)**] [**0 to 100 psi and 0 to 600 kPa**].

D. Scale Range for Chilled-Water Piping: [**0 to 160 psi (0 to 1100 kPa)**] [**0 to 160 psi and 0 to 1100 kPa**].

E. Scale Range for Chilled-Water Piping: [**0 to 200 psi (0 to 1400 kPa)**] [**0 to 200 psi and 0 to 1400 kPa**].

F. Scale Range for Chilled-Water Piping: [**0 to 300 psi (0 to 2500 kPa)**] [**0 to 300 psi and 0 to 2500 kPa**].

G. Scale Range for Chilled-Water Piping: [**0 to 600 psi (0 to 4000 kPa)**] [**0 to 600 psi and 0 to 4000 kPa**].

[Select appropriate range for applicable operating pressure.]

H. Scale Range for Condenser-Water Piping: [**30 in. Hg to 15 psi (minus 100 to 0 kPa)**] [**30 in. Hg to 15 psi and minus 100 to 0 kPa**].

I. Scale Range for Condenser-Water Piping: [**0 to 30 psi (0 to 240 kPa)**] [**0 to 30 psi and 0 to 240 kPa**].

J. Scale Range for Condenser-Water Piping: [**0 to 100 psi (0 to 600 kPa)**] [**0 to 100 psi and 0 to 600 kPa**].

K. Scale Range for Condenser-Water Piping: [**0 to 160 psi (0 to 1100 kPa)**] [**0 to 160 psi and 0 to 1100 kPa**].

L. Scale Range for Condenser-Water Piping: [**0 to 200 psi (0 to 1400 kPa)**] [**0 to 200 psi and 0 to 1400 kPa**].

M. Scale Range for Condenser-Water Piping: [**0 to 300 psi (0 to 2500 kPa)**] [**0 to 300 psi and 0 to 2500 kPa**].

[Select appropriate range for applicable operating pressure.]

N. Scale Range for Heating, Hot-Water Piping: [**30 in. Hg to 15 psi (minus 100 to 0 kPa)**] [**30 in. Hg to 15 psi and minus 100 to 0 kPa**].

O. Scale Range for Heating, Hot-Water Piping: [**0 to 30 psi (0 to 240 kPa)**] [**0 to 30 psi and 0 to 240 kPa**].

P. Scale Range for Heating, Hot-Water Piping: [**0 to 100 psi (0 to 600 kPa)**] [**0 to 100 psi and 0 to 600 kPa**].

Q. Scale Range for Heating, Hot-Water Piping: [**0 to 160 psi (0 to 1100 kPa)**] [**0 to 160 psi and 0 to 1100 kPa**].

R. Scale Range for Heating, Hot-Water Piping: [**0 to 200 psi (0 to 1400 kPa)**] [**0 to 200 psi and 0 to 1400 kPa**].

S. Scale Range for Heating, Hot-Water Piping: [**0 to 300 psi (0 to 2500 kPa)**] [**0 to 300 psi and 0 to 2500 kPa**].

T. Scale Range for Heating, Hot-Water Piping: [**0 to 600 psi (0 to 4000 kPa)**] [**0 to 600 psi and 0 to 4000 kPa**].

[Select appropriate range for applicable operating pressure.]

U. Scale Range for Steam Piping: [**30 in. Hg to 15 psi (minus 100 to 0 kPa)**] [**30 in. Hg to 15 psi and minus 100 to 0 kPa**].

V. Scale Range for Steam Piping: [**0 to 30 psi (0 to 240 kPa)**] [**0 to 30 psi and 0 to 240 kPa**].

W. Scale Range for Steam Piping: [**0 to 100 psi (0 to 600 kPa)**] [**0 to 100 psi and 0 to 600 kPa**].

X. Scale Range for Steam Piping: [**0 to 160 psi (0 to 1100 kPa)**] [**0 to 160 psi and 0 to 1100 kPa**].

Y. Scale Range for Steam Piping: [**0 to 200 psi (0 to 1400 kPa)**] [**0 to 200 psi and 0 to 1400 kPa**].

Z. Scale Range for Steam Piping: [**0 to 300 psi (0 to 2500 kPa)**] [**0 to 300 psi and 0 to 2500 kPa**].

AA. Scale Range for Steam Piping: [**0 to 600 psi (0 to 4000 kPa)**] [**0 to 600 psi and 0 to 4000 kPa**].

3.6 FLOWMETER SCHEDULE

A. Flowmeters for Chilled-Water Piping: [**Orifice**] [**Turbine**] type.

B. Flowmeters for Condenser-Water Piping: [**Orifice**] [**Turbine**] type.

C. Flowmeters for Heating, Hot-Water Piping: [**Orifice**] [**Turbine**] type.

D. Flowmeters for Steam and Steam-Condensate Piping: [**Orifice**] [**Venturi**] type.

END OF SECTION 230519

SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Bronze angle valves.
2. Brass ball valves.
3. Bronze ball valves.
4. Iron, grooved-end butterfly valves.
5. High-performance butterfly valves.
6. Bronze lift check valves.
7. Bronze swing check valves.
8. Iron swing check valves.
9. Iron, grooved-end swing-check valves.
10. Bronze gate valves.
11. Iron gate valves.
12. Bronze globe valves.
13. Iron globe valves.
14. Chainwheels.

B. Related Sections:

1. Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

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

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

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

1.5 QUALITY ASSURANCE

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

B. ASME Compliance:

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

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

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

B. Use the following precautions during storage:

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

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

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

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

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

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

D. Valve Actuator Types:

1. Gear Actuator: For quarter-turn valves NPS 8 (DN 200) and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 (DN 150) and smaller[**except plug valves**].
4. Wrench: For plug valves with square heads. Furnish Cleveland Clinic with 1 wrench for every [**5**] [**10**] plug valves, for each size square plug-valve head.
5. 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.

E. Valves in Insulated Piping: With 2-inch (50-mm) stem extensions and the following features:

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

F. Valve-End Connections:

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

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

2.2 BRONZE ANGLE VALVES

A. Class 125, Bronze Angle Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig (1380 kPa).
   c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
   d. Ends: Threaded.
   e. Stem and Disc: Bronze.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron[**, bronze, or aluminum**].

B. Class 150, Bronze Angle Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Milwaukee Valve Company.
    b. Crane Co.; Crane Valve Group; Crane Valves.
    c. Conbraco Industries, Inc.; Apollo Valves.
    d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    e. DeZurik Water Controls.

2. Description:

    a. Standard: MSS SP-80, Type 2.
    b. CWP Rating: 300 psig (2070 kPa).
    c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
    d. Ends: Threaded.
    e. Stem and Disc: Bronze stem, TFE disc.
    f. Packing: Asbestos free.
    g. Handwheel: Malleable iron[**, bronze, or aluminum**].

2.3 BRASS BALL VALVES

A. Two-Piece, Full-Port, Brass Ball Valves with Brass Trim:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
    a. Milwaukee Valve Company.
    b. Crane Co.; Crane Valve Group; Crane Valves.
    c. Conbraco Industries, Inc.; Apollo Valves.
    d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    e. DeZurik Water Controls.

2. Description:

    a. Standard: MSS SP-110.
    b. SWP Rating: 150 psig (1035 kPa).
    c. CWP Rating: 600 psig (4140 kPa).
    d. Body Design: Two piece.
    e. Body Material: Forged brass, ASTM B283.
    f. Ends: Threaded.
    g. Seats: PTFE or TFE.
    h. Stem: Brass.
    i. Ball: Chrome-plated brass.
    j. Port: Full.

2.4 BRONZE BALL VALVES

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

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

a. Milwaukee Valve Company.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
e. DeZurik Water Controls.

2. Description:

a. Standard: MSS SP-110.
b. SWP Rating: 150 psig (1035 kPa).
c. CWP Rating: 600 psig (4140 kPa).
d. Body Design: Two piece.
e. Body Material: Bronze.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Bronze.
i. Ball: Chrome-plated brass, solid ball.
j. Port: Full.

2.5 IRON, GROOVED-END BUTTERFLY VALVES

A. 175 CWP, Iron, Grooved-End Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Milwaukee Valve Company.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
e. DeZurik Water Controls.

2. Description:

a. Standard: MSS SP-67, Type I.
b. CWP Rating: 175 psig (1200 kPa).
c. Body Material: Coated, ductile iron.
d. Stem: Two-piece stainless steel.
e. Disc: Coated, ductile iron.
f. Seal: EPDM.

B. 300 CWP, Iron, Grooved-End Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Milwaukee Valve Company.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-67, Type I.
   b. NPS 8 (DN 50) and Smaller CWP Rating: 300 psig (2070 kPa).
   c. NPS 10 (DN 250) and Larger CWP Rating: 200 psig (1380 kPa).
   d. Body Material: Coated, ductile iron.
   e. Stem: Two-piece stainless steel.
   f. Disc: Coated, ductile iron.
   g. Seal: EPDM.

2.6 HIGH-PERFORMANCE BUTTERFLY VALVES

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-68, and API609, Category B.
   b. CWP Rating: 285 psig (1965 kPa) at 100 deg F (38 deg C).
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange, double offset design.
   d. Body Material: Carbon steel, or stainless steel.
   e. Seat: Reinforced PTFE or metal.
   f. Stem: Stainless steel; offset from seat plane, one piece stem.
   g. Disc: Carbon steel.
   h. Service: Bidirectional.
   i. Packing: PTFE V-ring.

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-68, and API 609, Category B.
   b. CWP Rating: 720 psig (4965 kPa) at 100 deg F (38 deg C).

c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange, double offset design.
d. Body Material: Carbon steel, cast iron, or ductile iron.
e. Seat: Reinforced PTFE or metal.
f. Stem: Stainless steel; offset from seat plane.
g. Disc: Carbon steel.
h. Service: Bidirectional.

2.7 BRONZE LIFT CHECK VALVES

A. Class 125, Lift Check Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Milwaukee Valve Company.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
e. DeZurik Water Controls.

2. Description:

a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 250 psig (1380 kPa) wog.
c. Body Design: Vertical flow.
d. Body Material: ASTM B 61 or ASTM B 584, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

B. Class 125, Lift Check Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Milwaukee Valve Company.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
e. DeZurik Water Controls.

2. Description:

a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 250 psig (1380 kPa).
c. Body Design: Vertical flow.
d. Body Material: ASTM B 61 or ASTM B 584, bronze.
e. Ends: Threaded.
f. Disc: Buna, or TFE.

2.8 BRONZE SWING CHECK VALVES

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-80, Type 3.
   b. CWP Rating: 200 psig (1380 kPa).
   c. Body Design: Horizontal flow.
   d. Body Material: ASTM B 62, bronze.
   e. Ends: Threaded.
   f. Disc: Bronze.

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-80, Type 4.
   b. CWP Rating: 200 psig (1380 kPa).
   c. Body Design: Horizontal flow.
   d. Body Material: ASTM B 62, bronze.
   e. Ends: Threaded.
   f. Disc: PTFE or TFE.

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

a. Standard: MSS SP-80, Type 3.
b. CWP Rating: 300 psig (2070 kPa).
c. Body Design: Horizontal flow.
d. Body Material: ASTM B 62, bronze.
e. Ends: Threaded.
f. Disc: Bronze.

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-80, Type 4.
   b. CWP Rating: 300 psig (2070 kPa).
   c. Body Design: Horizontal flow.
   d. Body Material: ASTM B 62, bronze.
   e. Ends: Threaded.
   f. Disc: PTFE or TFE.

2.9 IRON SWING CHECK VALVES

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
   c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 126, gray iron with bolted bonnet.
   f. Ends: Flanged.
   g. Trim: Bronze.
   h. Gasket: Asbestos free.

B. Class 250, Iron Swing Check Valves with Metal Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
   c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 126, gray iron with bolted bonnet.
   f. Ends: Flanged.
   g. Trim: Bronze.
   h. Gasket: Asbestos free.

2.10 IRON, GROOVED-END SWING CHECK VALVES

A. 300 CWP, Iron, Grooved-End Swing Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. CWP Rating: 300 psig (2070 kPa).
   b. Body Material: ASTM A 536, ductile iron.
   c. Seal: EPDM.
   d. Disc: Spring operated, ductile iron or stainless steel.

2.11 BRONZE GATE VALVES

A. Class 125, NRS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig (1380 kPa).
   c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
   d. Ends: Threaded[**or solder joint**].
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron[**, bronze, or aluminum**].

B. Class 125, RS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig (1380 kPa).
   c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
   d. Ends: Threaded[**or solder joint**].
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron[**, bronze, or aluminum**].

C. Class 150, NRS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 300 psig (2070 kPa).
   c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.

h. Handwheel: Malleable iron[**, bronze, or aluminum**].

D. Class 150, RS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig (2070 kPa).
   c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: Solid wedge; bronze.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron[**, bronze, or aluminum**].

2.12 IRON GATE VALVES

A. Class 125, NRS, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-70, Type I.
   b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
   c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
   d. Body Material: ASTM A 126, gray iron with bolted bonnet.
   e. Ends: Flanged.
   f. Trim: Bronze.
   g. Disc: Solid wedge.
   h. Packing and Gasket: Asbestos free.

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

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

a. Milwaukee Valve Company.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
e. DeZurik Water Controls.

2. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 200 psig (1380 kPa).
c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 150 psig (1035 kPa).
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

C. Class 250, NRS, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Milwaukee Valve Company.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. DeZurik Water ControlsDescription:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).
c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

D. Class 250, OS&Y, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Milwaukee Valve Company.
b. Crane Co.; Crane Valve Group; Crane Valves.
c. Conbraco Industries, Inc.; Apollo Valves.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
e. DeZurik Water Controls.

2. Description:

a. Standard: MSS SP-70, Type I.
b. NPS 2-1/2 to NPS 12 (DN 65 to DN 300), CWP Rating: 500 psig (3450 kPa).

c. NPS 14 to NPS 24 (DN 350 to DN 600), CWP Rating: 300 psig (2070 kPa).
d. Body Material: ASTM A 126, gray iron with bolted bonnet.
e. Ends: Flanged.
f. Trim: Bronze.
g. Disc: Solid wedge.
h. Packing and Gasket: Asbestos free.

2.13 BRONZE GLOBE VALVES

A. Class 125, Bronze Globe Valves with Bronze Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig (1380 kPa).
   c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
   d. Ends: Threaded[**or solder joint**].
   e. Stem and Disc: Bronze.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron[**, bronze, or aluminum**].

B. Class 150, Bronze Globe Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig (1380 kPa).
   c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
   d. Ends: Threaded[**or solder joint**].
   e. Stem: Bronze.
   f. Disc: PTFE or TFE.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron[**, bronze, or aluminum**].

C. Class 150, Bronze Globe Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig (2070 kPa).
   c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: PTFE or TFE.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron[**, bronze, or aluminum**].

2.14 IRON GLOBE VALVES

A. Class 125, Iron Globe Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. DeZurik Water Controls.

2. Description:

   a. Standard: MSS SP-85, Type I.
   b. CWP Rating: 200 psig (1380 kPa).
   c. Body Material: ASTM A 126, gray iron with bolted bonnet.
   d. Ends: Flanged.
   e. Trim: Bronze.
   f. Packing and Gasket: Asbestos free.

B. Class 250, Iron Globe Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Milwaukee Valve Company.
   b. Crane Co.; Crane Valve Group; Crane Valves.
   c. Conbraco Industries, Inc.; Apollo Valves.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

e. DeZurik Water Controls.

2. Description:

a. Standard: MSS SP-85, Type I.
b. CWP Rating: 500 psig (3450 kPa).
c. Body Material: ASTM A 126, gray iron with bolted bonnet.
d. Ends: Flanged.
e. Trim: Bronze.
f. Packing and Gasket: Asbestos free.

2.15 CHAINWHEELS

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

1. Babbitt Steam Specialty Co.
2. Roto Hammer Industries.
3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
2. Attachment: For connection to [**ball**] [**butterfly**] valve stems.
3. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve.[**Include zinc coating.**]
4. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

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

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

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

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

E. Install chainwheels on operators for [**ball**] [**butterfly**] [**gate**] [**globe**] valves **NPS 4 (DN 100)** and larger and more than **96 inches (2400 mm)** above floor. Extend chains to **60 inches (1520 mm)** above finished floor.

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

1. Swing Check Valves: In horizontal position with hinge pin level.
2. Lift Check Valves: With stem upright and plumb.

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

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

1. Shutoff Service:
   a. NPS 2 (DN 50) and Smaller: Ball
   b. NPS 2-1/2 (DN 65) and Larger: Butterfly
   c. Steam: Gate.
2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
3. Throttling Service except Steam: Globe valves.
4. Throttling Service, Steam: Globe valves.
5. Pump-Discharge Check Valves:

   a. NPS 2 (DN 50) and Smaller: Bronze swing check valves with bronze disc.
   b. NPS 2-1/2 (DN 65) and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, [**metal**] [**or**] [**resilient**]-seat check valves.

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

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

1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.

2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.
4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.
5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends except where threaded valve-end option is indicated in valve schedules below.
6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.
7. For Grooved-End [**Copper Tubing**] [**and**] [**Steel Piping**] except Steam and Steam Condensate Piping: Valve ends may be grooved.

3.5 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Ball Valves: **Two** piece, full port, **bronze** with **stainless-steel** trim.
3. Bronze Swing Check Valves: [**Class 125**] [**Class 150**], [**bronze**] disc.
4. Bronze Globe Valves: [**Class 125**] [**Class 150**], [**bronze**] disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): [**175**] [**300**] CWP.
2. High-Performance Butterfly Valves: [**Class 150**] [**Class 300**], single flange.
3. Iron Swing Check Valves: [**Class 125**] [**Class 250**], [**metal**] seats.
4. Iron, Grooved-End Check Valves, NPS 3 to NPS 12 (DN 80 to DN 300): 300 CWP.
5. Iron Globe Valves: [**Class 125**] [**Class 250**].

3.6 CONDENSER-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Ball Valves: Two piece, full port, **bronze** with **stainless-steel** trim.
3. Bronze Swing Check Valves: [**Class 125**] [**Class 150**], [**bronze**] disc.
4. Bronze Globe Valves: [**Class 125**] [**Class 150**], [**bronze**] disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:

1. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): [**175**] [**300**] CWP.
2. High-Performance Butterfly Valves: [**Class 150**] [**Class 300**], single flange.
3. Iron Swing Check Valves: [**Class 125**] [**Class 250**], metal seats.
4. Iron, Grooved-End Check Valves, NPS 3 to NPS 12 (DN 80 to DN 300): 300 CWP.
5. Iron Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): [**Class 125**] [**Class 250**].

3.7 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:

1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
2. Ball Valves: Two piece, full port, **bronze** with **stainless-steel** trim.
3. Bronze Swing Check Valves: [**Class 125**] [**Class 150**], [**bronze**] disc.
4. Bronze Globe Valves: [**Class 125**] [**Class 150**], [**bronze**] disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Iron, Grooved-End Butterfly Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): [**175**] [**300**] CWP.
2. High-Performance Butterfly Valves: [**Class 150**] [**Class 300**], single flange.
3. Iron Swing Check Valves: [**Class 125**] [**Class 250**], metal seats.
4. Iron, Grooved-End Check Valves, NPS 3 to NPS 12 (DN 80 to DN 300): 300 CWP.
5. Iron Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): [**Class 125**] [**Class 250**].

3.8 LOW-PRESSURE STEAM VALVE SCHEDULE (15 PSIG (104 kPa) OR LESS)

A. Pipe NPS 2 (DN 50) and Smaller:
1. Bronze Swing Check Valves: **Class 300**, **bronze** disc.
2. Cast Steel Gate Valves: **Class 300**] **RS**.
3. Bronze Globe Valves: [**Class 125**] [**Class 150**], [**bronze**] disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. .
2. Bronze Swing Check Valves: **Class 300**, bronze disc.
3. Cast Steel Gate Valves: **Class 300**, **OS&Y**.
4. Cast Steel Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **Class 300**.

3.9 MEDIUM-PRESSURE STEAM VALVE SCHEDULE (16-74 PSIG

A. Pipe NPS 2 (DN 50) and Smaller:
1. Cast Steel Gate Valves: **Class 300**, **RS**.
2. Cast Steel Globe Valves: Class **300**, stainless steel disc.

B. Pipe Sizes NPS 2-1/2 (DN 65) and Larger:

1. Cast Steel Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
2. Cast Steel Gate Valves: **Class 300**, **OS&Y**.
3. Cast Steel Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **Class 300, stainless steel disc**.

3.10 HIGH-PRESSURE STEAM VALVE SCHEDULE (75 PSIG (104 kPa) AND ABOVE)

A. Pipe NPS 2 (DN 50) and Smaller:
1. Bronze Swing Check Valves: **Class 300**, **bronze** disc.

2. Cast Steel Gate Valves: **Class 300**, **RS**.
3. Cast Steel Globe Valves: Class 300, bronze, stainless steel disc.

B. Pipe Sizes NPS 2-1/2 (DN 65) and Larger:

1. Cast Steel Valves, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): May be provided with threaded ends instead of flanged ends.
2. Bronze Swing Check Valves: **Class 300**, **metal** seats.
3. Cast Steel Gate Valves: **Class 300**, **OS&Y**.
4. Cast Steel Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **Class 300** .

3.11 STEAM-CONDENSATE VALVE SCHEDULE

A. Pipe NPS 2 (DN 50) and Smaller:
1. Bronze Swing Check Valves: **Class 300**, **bronze** disc.
2. Cast Steel Gate Valves: **Class 300**, **RS**.
3. Cast Steel Globe Valves: **Class 300**, stainless steel disc.

B. Pipe NPS 2-1/2 (DN 65) and Larger:
1. Bronze Swing Check Valves: **Class 300**, metal seats.
2. Cast Steel Gate Valves: **Class 300**, **OS&Y**.
3. Cast Steel Globe Valves, NPS 2-1/2 to NPS 12 (DN 65 to DN 300): **Class 300**.

END OF SECTION 230523

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

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

B. Related Sections:

1. Section 055000 "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
2. Section 230516 "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
3. Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation devices.
4. Section 233113 "Metal Ducts" for duct hangers and supports.

1.3 DEFINITIONS

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

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

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

1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
3. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

1.5 ACTION SUBMITTALS

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

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

1. Trapeze pipe hangers.
2. Metal framing systems.
3. Fiberglass strut systems.
4. Pipe stands.
5. Equipment supports.

C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of trapeze hangers.
2. Design Calculations: Calculate requirements for designing trapeze hangers.

1.6 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.7 QUALITY ASSURANCE

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

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

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
5. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**carbon steel**] [**stainless steel**].

B. Stainless-Steel Pipe Hangers and Supports:

1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
2. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.

C. Copper Pipe Hangers:

1. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
2. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**copper-coated steel**] [**stainless steel**].

2.2 TRAPEZE PIPE HANGERS

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

2.3 FIBERGLASS PIPE HANGERS

A. Clevis-Type, Fiberglass Pipe Hangers:

1. Description: Similar to MSS SP-58, Type 1, steel pipe hanger except hanger is made of fiberglass or fiberglass-reinforced resin.
2. Hanger Rods: Continuous-thread rod, washer, and nuts made of stainless steel.

B. Strap-Type, Fiberglass Pipe Hangers:

1. Description: Similar to MSS SP-58, Type 9 or Type 10, steel pipe hanger except hanger is made of fiberglass-reinforced resin.
2. Hanger Rod and Fittings: Continuous-thread rod, washer, and nuts made of stainless steel.

2.4 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

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

   a. Allied Tube & Conduit.
   b. Cooper B-Line, Inc.
   c. Powerstrut.
   d. Unistrut Corporation; Tyco International, Ltd.

2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with inturned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**carbon steel**] [**stainless steel**].
   [***Retain one of four subparagraphs below for coating.]***
7. Metallic Coating: [**Electroplated zinc**] [**Hot-dipped galvanized**] [**Mill galvanized**] [**In-line, hot galvanized**] [**Mechanically-deposited zinc**].
8. Paint Coating: [**Vinyl**] [**Vinyl alkyd**] [**Epoxy**] [**Polyester**] [**Acrylic**] [**Amine**] [**Alkyd**].
9. Plastic Coating: [**PVC**] [**Polyurethane**] [**Epoxy**] [**Polyester**].
10. Combination Coating: <**Insert coating materials in order of application**>.

2.5 FIBERGLASS STRUT SYSTEMS

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

1. Allied Tube & Conduit.
2. Champion Fiberglass, Inc.
3. Cooper B-Line, Inc.
4. SEASAFE, INC.; a Gibraltar Industries Company.

B. Description: Shop- or field-fabricated pipe-support assembly similar to MFMA-4 for supporting multiple parallel pipes.

1. Channels: Continuous slotted fiberglass[**or other plastic**] channel with inturned lips.
2. Channel Nuts: Fiberglass nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
3. Hanger Rods: Continuous-thread rod, nuts, and washer made of [**fiberglass**] [**stainless steel**].

2.6 THERMAL-HANGER SHIELD INSERTS

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

1. Carpenter & Paterson, Inc.
2. Clement Support Services.
3. ERICO International Corporation.
4. National Pipe Hanger Corporation.
5. PHS Industries, Inc.
6. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
7. Piping Technology & Products, Inc.
8. Rilco Manufacturing Co., Inc.
9. Value Engineered Products, Inc.

B. Insulation-Insert Material for Cold Piping: [**ASTM C 552, Type II cellular glass with 100-psig (688-kPa)**] [**or**] [**ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa)**] minimum compressive strength and vapor barrier.

C. Insulation-Insert Material for Hot Piping: [**Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa)**] [**ASTM C 552, Type II cellular glass with 100-psig (688-kPa)**] [**or**] [**ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa)**] minimum compressive strength.

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

E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.

F. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.7 FASTENER SYSTEMS

A. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

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

2.8 PIPE STANDS

A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

B. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.

C. Low-Type, Single-Pipe Stand: One-piece [**plastic**] [**stainless-steel**] base unit with plastic roller, for roof installation without membrane penetration.

D. High-Type, Single-Pipe Stand:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
2. Base: [**Plastic**] [**Stainless steel**].
3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

E. High-Type, Multiple-Pipe Stand:

1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
2. Bases: One or more; plastic.
3. Vertical Members: Two or more protective-coated-steel channels.
4. Horizontal Member: Protective-coated-steel channel.
5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

2.9 EQUIPMENT SUPPORTS

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

2.10 MISCELLANEOUS MATERIALS

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

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

1. Properties: Nonstaining, noncorrosive, and nongaseous.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.

B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.

C. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

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

E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.

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

G. Fastener System Installation:

1. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

H. Pipe Stand Installation:

1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
2. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Section 077200 "Roof Accessories" for curbs.

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

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

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

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

M. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, strainers, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

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

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

P. Insulated Piping:

1. Attach clamps and spacers to piping.

    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.

    a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
    b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
    c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
    d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.

e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.

5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 EQUIPMENT SUPPORTS

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

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

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

3.3 METAL FABRICATIONS

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

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

C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove welding flux immediately.
4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 ADJUSTING

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

B. Trim excess length of continuous-thread hanger and support rods to **1-1/2 inches (40 mm)**.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in [**Section 099113 "Exterior Painting"**] [**Section 099123 "Interior Painting"**] [**and**] [**Section 099600 "High Performance Coatings."**]

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

3.6 HANGER AND SUPPORT SCHEDULE

A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.

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

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

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

E. Use carbon-steel [**pipe hangers and supports**] [**metal trapeze pipe hangers**] [**and**] [**metal framing systems**] and attachments for general service applications.

F. Use [**stainless-steel pipe hangers**] [**and**] [**fiberglass pipe hangers**] [**and**] [**fiberglass strut systems**] and [**stainless-steel**] [**or**] [**corrosion-resistant**] attachments for hostile environment applications.

G. Use copper-plated pipe hangers and [**copper**] [**or**] [**stainless-steel**] attachments for copper piping and tubing.

H. Use padded hangers for piping that is subject to scratching.

I. Use thermal-hanger shield inserts for insulated piping and tubing.

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

1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1050 deg F (566 deg C), pipes NPS 4 to NPS 24 (DN 100 to DN 600), requiring up to 4 inches (100 mm) of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes NPS 3/4 to NPS 36 (DN 20 to DN 900), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.

4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes NPS 1/2 to NPS 24 (DN 15 to DN 600) if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.
6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes NPS 3/4 to NPS 8 (DN 20 to DN 200).
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes NPS 1/2 to NPS 8 (DN 15 to DN 200).
10. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 8 (DN 10 to DN 200).
11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes NPS 3/8 to NPS 3 (DN 10 to DN 80).
12. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
14. Pipe Saddle Supports (MSS Type 36): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes NPS 2-1/2 to NPS 36 (DN 65 to DN 900) if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
17. Single-Pipe Rolls (MSS Type 41): For suspension of pipes NPS 1 to NPS 30 (DN 25 to DN 750), from two rods if longitudinal movement caused by expansion and contraction might occur.
18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24 (DN 65 to DN 600), from single rod if horizontal movement caused by expansion and contraction might occur.
19. Complete Pipe Rolls (MSS Type 44): For support of pipes NPS 2 to NPS 42 (DN 50 to DN 1050) if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes NPS 2 to NPS 24 (DN 50 to DN 600) if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30 (DN 50 to DN 750) if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

K. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers NPS 3/4 to NPS 24 (DN 20 to DN 600) if longer ends are required for riser clamps.

L. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.
2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.
3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.

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

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

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

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

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

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

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

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

   a. Horizontal (MSS Type 54): Mounted horizontally.
   b. Vertical (MSS Type 55): Mounted vertically.
   c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

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

Q. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

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

END OF SECTION 230529

SECTION 230533 - HEAT TRACING FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes heat tracing for HVAC piping with the following electric heating cables:

1. Plastic insulated, series resistance.
2. Self-regulating, parallel resistance.

B. Related Requirements:

1. Section 210533 "Heat Tracing for Fire-Suppression Piping."
2. Section 220533 "Heat Tracing for Plumbing Piping."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
2. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.

B. Shop Drawings: For electric heating cable.

1. Include plans, elevations, sections, and attachment details.
2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.

1. Warranty Period: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PLASTIC-INSULATED, SERIES-RESISTANCE HEATING CABLES

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

1. Delta-Therm Corporation.
2. Raychem; a brand of Tyco Thermal Controls LLC.
3. Watts Radiant, Inc.; a subsidiary of Watts Water Technologies, Inc.

B. Comply with IEEE 515.1.

C. Heating Element: Single- or dual-stranded resistor wire. Terminate with waterproof, factory-assembled, nonheating leads with connectors at both ends.

D. Electrical Insulating Jacket: Minimum 4.0-mil (0.10-mm) Kapton with silicone, Tefzel, or polyolefin.

E. Cable Cover: Aluminum braid[**and silicone or Hylar outer jacket**].

F. Maximum Operating Temperature (Power On): **150 deg F (65 deg C)**.

G. Maximum Exposure Temperature (Power Off): **185 deg F (85 deg C)**.

H. 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.

I. Capacities and Characteristics:

1. Maximum Heat Output: [**6 W/ft. (19.7 W/m)**] [**7.5 W/ft. (24.6 W/m)**] maximum.
2. Piping Diameter: <**Insert NPS (DN)**>.
3. Number of Parallel Cables: <**Insert number**>.
4. Spiral Wrap Pitch: <**Insert inches (mm)**>.
5. Electrical Characteristics for Single-Circuit Connection:

a. Volts: [**120**] [**208**] [**240**] [**277**] [**480**].
b. Phase: <**Insert value**>.
c. Hertz: <**Insert value**>.
d. Full-Load Amperes: <**Insert value**>.
e. Minimum Circuit Ampacity: <**Insert value**>.
f. Maximum Overcurrent Protection: <**Insert amperage**>.

2.2 SELF-REGULATING, PARALLEL-RESISTANCE HEATING CABLES

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

1. Chromalox.
2. Delta-Therm Corporation.
3. Raychem; a brand of Tyco Thermal Controls LLC.

B. Comply with IEEE 515.1.

C. Heating Element: Pair of parallel [**No. 16**] [**No. 18**] AWG, [**tinned**] [**nickel-coated**], stranded copper bus wires embedded in crosslinked conductive polymer core, which varies heat output in response to temperature along its length. Terminate with waterproof, factory-assembled, nonheating leads with connectors at one end, and seal the opposite end watertight. Cable shall be capable of crossing over itself once without overheating.

D. Electrical Insulating Jacket: Flame-retardant polyolefin.

E. Cable Cover: [**Tinned-copper**] [**Stainless-steel**] braid[**and polyolefin outer jacket with ultraviolet inhibitor**].

F. Maximum Operating Temperature (Power On): **150 deg F (65 deg C)**.

G. Maximum Exposure Temperature (Power Off): **185 deg F (85 deg C)**.

H. 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.

I. Capacities and Characteristics:

1. Maximum Heat Output: [**3 W/ft. (9.8 W/m)**] [**5 W/ft. (16.4 W/m)**] [**8 W/ft. (26 W/m)**] [**10 W/ft. (32.8 W/m)**] [**12 W/ft. (39.4 W/m)**].
2. Piping Diameter: <**Insert NPS (DN)**>.
3. Number of Parallel Cables: <**Insert number**>.
4. Spiral Wrap Pitch: <**Insert inches (mm)**>.
5. Electrical Characteristics for Single-Circuit Connection:

   a. Volts: [**120**] [**208**] [**240**] [**277**] [**480**].
   b. Phase: <**Insert value**>.
   c. Hertz: <**Insert value**>.
   d. Full-Load Amperes: <**Insert value**>.
   e. Minimum Circuit Ampacity: <**Insert value**>.
   f. Maximum Overcurrent Protection: <**Insert amperage**>.

2.3 CONTROLS

A. Remote bulb unit with adjustable temperature range from **30 to 50 deg F (minus 1 to plus 10 deg C)**.

B. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.

C. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.

D. Corrosion-resistant, waterproof control enclosure.

2.4 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: Refer to Section 230553 "Identification for HVAC Piping and Equipment."

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils (0.08 mm) thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): 3/4 inch (19 mm) minimum.
2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches (150 mm) or Larger: 1-1/2 inches (38 mm) minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.

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

3.2 INSTALLATION

A. Install electric heating cable across expansion joints according to manufacturer's written instructions; use slack cable to allow movement without damage to cable.

B. Install electric heating cables after piping has been tested and before insulation is installed.

C. Install electric heating cables according to IEEE 515.1.

D. Install insulation over piping with electric cables according to Section 230719 "HVAC Piping Insulation."

E. Install warning tape on piping insulation where piping is equipped with electric heating cables.

F. Set field-adjustable switches and circuit-breaker trip ranges.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Cleveland Clinic will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
2. Test cables for electrical continuity and insulation integrity before energizing.
3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

D. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.

E. Cables will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 PROTECTION

A. Protect installed heating cables, including nonheating leads, from damage during construction.

B. Remove and replace damaged heat-tracing cables.

END OF SECTION 230533

SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Isolation pads.
2. Isolation mounts.
3. Restrained elastomeric isolation mounts.
4. [**Freestanding**] [**Restrained**] [**Freestanding and restrained**] spring isolators.
5. Housed spring mounts.
6. Elastomeric hangers.
7. Spring hangers.
8. Spring hangers with vertical-limit stops.
9. Pipe riser resilient supports.
10. Resilient pipe guides.
11. [**Freestanding**] [**Restrained**] [**Freestanding and restrained**] air-mounting system.
12. Restrained vibration isolation roof-curb rails.
13. Seismic snubbers.
14. Restraining braces and cables.
15. [**Steel**] [**Inertia**] [**Steel and inertia**], vibration isolation equipment bases.

1.3 DEFINITIONS

A. IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

C. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.4 PERFORMANCE REQUIREMENTS

A. Wind-Restraint Loading:

1. Basic Wind Speed: <**Insert value**>.
2. Building Classification Category: [**I**] [**II**] [**III**] [**IV**].

3. Minimum 10 lb/sq. ft. (48.8 kg/sq. m) multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

B. Seismic-Restraint Loading:

1. Site Class as Defined in the IBC: [**A**] [**B**] [**C**] [**D**] [**E**] [**F**].
2. Assigned Seismic Use Group or Building Category as Defined in the IBC: [**I**] [**II**] [**III**].

a. Component Importance Factor: [**1.0**] [**1.5**].
b. Component Response Modification Factor: [**1.5**] [**2.5**] [**3.5**] [**5.0**].
c. Component Amplification Factor: [**1.0**] [**2.5**].

3. Design Spectral Response Acceleration at Short Periods (0.2 Second): <**Insert percent**>.
4. Design Spectral Response Acceleration at 1-Second Period: <**Insert percent**>.

1.5 ACTION SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**].
b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic[**and wind**] forces required to select vibration isolators, seismic[**and wind**] restraints, and for designing vibration isolation bases.

a. Coordinate design calculations with wind load calculations required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.

2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.

3. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
4. Seismic[**- and Wind**]-Restraint Details:

    a. Design Analysis: To support selection and arrangement of seismic[**and wind**] restraints. Include calculations of combined tensile and shear loads.
    b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
    c. Coordinate seismic-restraint and vibration isolation details with wind-restraint details required for equipment mounted outdoors. Comply with requirements in other Sections for equipment mounted outdoors.
    d. Preapproval and Evaluation Documentation: By [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**], showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show coordination of seismic bracing for HVAC piping and equipment with other systems and equipment in the vicinity, including other supports and seismic restraints.

B. Qualification Data: For [**professional engineer**] [**and**] [**testing agency**].

C. Welding certificates.

D. Air-Mounting System Performance Certification: Include natural frequency, load, and damping test data[**performed by an independent agency**].

E. Field quality-control test reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-mounting systems to include in operation and maintenance manuals.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.

B. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

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

D. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

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

1. Kinetics Noise Control.
2. Mason Industries.
3. Vibro-Acoustics.

B. Pads <**Insert drawing designation**>: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant [**neoprene**] [**rubber**] [**hermetically sealed compressed fiberglass**].

C. Mounts <**Insert drawing designation**>: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

D. Restrained Mounts <**Insert drawing designation**>: All-directional mountings with seismic restraint.

1. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.

2. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.

E. Spring Isolators <**Insert drawing designation**>: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

F. Restrained Spring Isolators <**Insert drawing designation**>: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

G. Housed Spring Mounts <**Insert drawing designation**>: Housed spring isolator with integral seismic snubbers.

1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
2. Base: Factory drilled for bolting to structure.
3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch (6-mm) travel up or down before contacting a resilient collar.

H. Elastomeric Hangers <**Insert drawing designation**>: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

I. Spring Hangers <**Insert drawing designation**>: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

J. Spring Hangers with Vertical-Limit Stop <**Insert drawing designation**>: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
8. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

K. Pipe Riser Resilient Support <**Insert drawing designation**>: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig (3.45 MPa) and for equal resistance in all directions.

L. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of 1/2-inch- (13-mm-) thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.2 AIR-MOUNTING SYSTEMS

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

1. California Dynamics Corporation.
2. Firestone Industrial Products Company.
3. Kinetics Noise Control.
4. Mason Industries.
5. Vibration Eliminator Co., Inc.

B. Air Mounts <**Insert drawing designation**>: Freestanding, single or multiple, compressed-air bellows.

1. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows.
2. Maximum Natural Frequency: 3 Hz.
3. Operating Pressure Range: 25 to 100 psig (172 to 690 kPa).
4. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
5. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus 1/8 inch (3 mm).

C. Restrained Air Mounts <**Insert drawing designation**>: Housed compressed-air bellows.

1. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows and spring, with angle-iron frame having vertical-limit stops and channel-section top with leveling adjustment and attachment screws.
2. Maximum Natural Frequency: 3 Hz.
3. Operating Pressure Range: 25 to 100 psig (172 to 690 kPa).
4. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
5. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus 1/8 inch (3 mm).

2.3 RESTRAINED VIBRATION ISOLATION ROOF-CURB RAILS

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

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Isolation Technology, Inc.
4. Kinetics Noise Control.
5. Mason Industries.
6. Thybar Corporation.
7. Vibration Eliminator Co., Inc.
8. Vibration Isolation.
9. Vibration Mountings & Controls, Inc.

B. General Requirements for Restrained Vibration Isolation Roof-Curb Rails: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind forces.

C. Lower Support Assembly: Formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind forces. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of 2 inches (50 mm) of rigid, glass-fiber insulation on inside of assembly.

D. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on 1/4-inch- (6-mm-) thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.

1. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or wind restraint.

a. Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.
b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

a. Resilient Material: Oil- and water-resistant [**standard neoprene**] [**natural rubber**] [**hermetically sealed compressed fiberglass**].

E. Snubber Bushings: All-directional, elastomeric snubber bushings at least 1/4 inch (6 mm) thick.

F. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.

2.4 VIBRATION ISOLATION EQUIPMENT BASES

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

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Isolation Technology, Inc.
4. Kinetics Noise Control.
5. Mason Industries.
6. Vibration Eliminator Co., Inc.
7. Vibration Isolation.

8. Vibration Mountings & Controls, Inc.

B. Steel Base <**Insert drawing designation**>: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

    a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Inertia Base <**Insert drawing designation**>: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.

    a. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.5 SEISMIC-RESTRAINT DEVICES

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

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Hilti, Inc.
5. Kinetics Noise Control.
6. Loos & Co.; Cableware Division.
7. Mason Industries.
8. TOLCO Incorporated; a brand of NIBCO INC.
9. Unistrut; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**].

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
3. Maximum 1/4-inch (6-mm) air gap, and minimum 1/4-inch- (6-mm-) thick resilient cushion.

D. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

E. Restraint Cables: [**ASTM A 603 galvanized**] [**ASTM A 492 stainless**]-steel cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

F. Hanger Rod Stiffener: [**Steel tube or steel slotted-support-system sleeve with internally bolted connections**] [**Reinforcing steel angle clamped**] to hanger rod.

G. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.

H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.

I. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

J. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

K. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.6 FACTORY FINISHES

A. Finish: Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.
2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
3. Baked enamel or powder coat for metal components on isolators for interior use.
4. Color-code or otherwise mark vibration isolation and seismic- and wind-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic- and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

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

3.2 APPLICATIONS

A. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**].

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Comply with requirements in Section 077200 "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.

B. Equipment Restraints:

1. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
2. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
3. Install seismic-restraint devices using methods approved by [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**] providing required submittals for component.

C. Piping Restraints:

1. Comply with requirements in MSS SP-127.
2. Space lateral supports a maximum of **40 feet (12 m)** o.c., and longitudinal supports a maximum of **80 feet (24 m)** o.c.
3. Brace a change of direction longer than 12 feet (3.7 m).

D. Install cables so they do not bend across edges of adjacent equipment or building structure.

E. Install seismic-restraint devices using methods approved by [**an evaluation service member of ICC-ES**] [**OSHPD**] [**an agency acceptable to authorities having jurisdiction**] providing required submittals for component.

F. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

G. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

H. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

I. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Section 232113 "Hydronic Piping" for piping flexible connections.

3.5 FIELD QUALITY CONTROL

A. Testing Agency: Cleveland Clinic will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
2. Schedule test with Cleveland Clinic, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
5. Test to 90 percent of rated proof load of device.
6. Measure isolator restraint clearance.
7. Measure isolator deflection.
8. Verify snubber minimum clearances.
9. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
10. Air-Mounting System Operational Test: Test the compressed-air leveling system.
11. Test and adjust air-mounting system controls and safeties.
12. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

D. Remove and replace malfunctioning units and retest as specified above.

E. Prepare test and inspection reports.

3.6 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust air-spring leveling mechanism.

D. Adjust active height of spring isolators.

E. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Section 017900 "Demonstration and Training."

3.8 HVAC VIBRATION-CONTROL AND SEISMIC-RESTRAINT DEVICE SCHEDULE

A. Supported or Suspended Equipment: <**Insert name and drawing designation**>.

1. Equipment Location: <**Insert room number**>.
2. Pads:

    a. Material: [**Neoprene**] [**Rubber**] [**Hermetically sealed compressed fiberglass**].
    b. Thickness: <**Insert inches (mm)**>.
    c. Number of Pads: <**Insert number**> thick.

3. Isolator Type: <**Insert generic name or designation used in Part 2**>.
4. Base Type: <**Insert generic name or designation used in Part 2**>.
5. Minimum Deflection: <**Insert inches (mm)**>.
6. Component Importance Factor: [**1.0**] [**1.5**].
7. Component Response Modification Factor: [**1.5**] [**2.5**] [**3.5**] [**5.0**].
8. Component Amplification Factor: [**1.0**] [**2.5**].

END OF SECTION 230548

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

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

1.3 ACTION SUBMITTALS

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

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

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

D. Valve numbering scheme.

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

1.4 COORDINATION

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

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

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

1.5 WORK INCLUDED

A. Furnish and install nameplates, valve tags, valve charts, stencils and pipe markers on all Mechanical equipment, piping and ductwork.

B. Provide nameplates with the unit number and service designation on all mechanical equipment.

C. Indicate all valve tag numbers on Record Drawings and submit framed under glass valve tag charts including valve service and location.

D. Install color coded ceiling tacks in acoustical tile ceilings or color coded tape on ceiling grid to identify location of equipment, valves and dampers that require regular maintenance or are part of a life safety system (fire dampers, smoke dampers, sprinkler valves or main isolation valves). Concealed fire protection valves shall be marked by red label triangles (3" equilateral) and circle dots (1" diameter). Triangles shall be placed on the wall nearest the valve with the apex pointing toward the ceiling tile. Dots shall be placed on border of ceiling tile.

E. Provide underground plastic pipe markers 6 to 8 inches below finish grade, directly above buried pipes.

F. Provide manufactured pipe and ductwork identification stencils with flow arrows and service indicated. All backgrounds of the stencils shall be color coded with specific service designation

G. Prepare valve charts and frame under glass. All valves and the tag numbers shall be shown on the Record As-Built Drawings.

H. Provide valve computer data base to match chart.

I. Prepare and install exterior protected brass plaques indicating underground service entrances.

PART 2 - PRODUCTS

2.1 GENERAL

A. Acceptable manufactures contingent on compliance with the specification.
   1. Seton
   2. W. H. Bradey Company
   3. Marning Services Incorporated

2.2 PIPE IDENTIFICATION AND VALVE TAGS

A. All piping, except that piping which is within inaccessible chases, shall be identified with semi-rigid plastic identification markers equal to Seton Setmark pipe markers.
   1. Direction of flow arrows are to be included on each marker.
   2. Each marker background shall be appropriately color coded with a clearly printed legend to identify the contents of the pipe in conformance with the “Scheme for the Identification of Piping Systems” (ASME A13.1-1981).

3. Setmark snap-around markers shall be used for overall diameters up to 6” and strap-around markers shall be used above 6” overall diameters.
4. Markers shall be located:
   a. Adjacent to each valve
   b. At each branch
   c. At each cap for future
   d. At each riser takeoff,
   e. At each pipe passage through wall (each side)
   f. At each pipe passage at 20’ – 0” intervals maximum.
   g. At each piece of equipment.
   h. At all access doors.
   i. A minimum of one (1) marker shall be provided at each room.
5. Under ground pipe markers:
   a. Provide detectable tape on all underground piping:
   b. Labels shall be color coded and labeled the same as indoors.

B. Valve tags
1. All valves shall be designated by distinguishing numbers and letters carefully coordinated with a valve chart. Valve tags shall include what room(s) the valve serves and piece of equipment served.
2. Valve tags shall be color coded 0.097” ABS plastic tags, with engraved letters similar to Seton S Type 250-BL or approved equal.
   a. HVAC tags shall be round 2” diameter, similar to Seton 15426.
   b. Plumbing tags shall be square 2” x 2” similar to Seton 42769.
   c. Fire Protection tags shall be square 2” x 2” similar to Seton 42769 RED.
   d. Lettering shall be ¼” high for type service and ½” for valve number. Tag shall indicate service and valve number.
   e. Each service shall be a different color.
3. Tag shall be attached to valves with chain similar to Seton No 16 stainless steel jack chain.
4. Whenever a valve is above a hung ceiling, the valve tag shall be located immediately above the hung ceiling.
5. Provide a tag for every valve except:
   a. Perimeter radiation shut-off valves that are located at the finned tube radiation element within the accessible (from the space) heating enclosure

C. Furnish a minimum of two (2) typed valve lists
1. Each framed under glass or Plexiglas. Each chart shall be enclosed in an approved 0.015” thick plastic closure for permanent protection.
2. Valve numbers shall correspond to those indicated on the Record Drawings and on the printed valve lists.
3. The printed list shall include the valve number, location and purpose of each valve.
4. It shall state other necessary information such as the required opening or closing of another valve when one valve is to be opened or closed.
5. Printed framed valve lists shall be displayed in each Mechanical Room or in a location designated by Cleveland Clinic.

D. Valve data base.
1. Provide a valve data base for all valves to operate on the building computer.

2. Every valve shall include:
   a. Tag Number
   b. Service (Hot water, Chilled water, Sprinkler, etc.)
   c. Size
   d. Operation
   e. Location
   f. Manufacture
   g. Model number
   h. Submittal reference

2.3 DUCTWORK IDENTIFICATION

A. All ductwork (supply, return, exhaust, etc.) serving multiple spaces or floors shall be identified with directional flow arrows and unit identification numbers (AHU-1, EX-1, etc.) on the side of each duct (or bottom if abutting other systems or obstructions).

B. All flow arrows and labels shall be similar to Seton Name Plate Company vinyl labels or stencil painted.

C. The kitchen hood exhaust system shall also have identified access doors with numbers of specific doors identified on the Record As-Built Drawings.

D. All duct access doors.

2.4 EQUIPMENT NAMEPLATES

A. Equipment nameplates shall be 3” x 6” long, 0.02” aluminum with a black enamel background with engraved natural aluminum letters similar to Seton Style 2065-20. Nameplate shall have pressure sensitive taped backing.

B. The nameplate shall contain the unit or equipment designation (“AHU” for air handling unit, “P” for circulating pump, etc.), unit number and area or system served.

C. Nameplates for exterior equipment shall be applied with waterproof adhesive.

2.5 UTILITY ENTRANCE DESIGNATIONS

A. Provide a brass wall plaque, minimum 0.020” thickness, secured to the exterior wall just above the grade line for all buried service entrances or exits. Samples are: Water Service Below; Gas Service Below; Sanitary Sewer Below; Storm Sewer Below; Irrigation Water Below; etc.

B. Ceiling Tacks or Tape.

C. Provide steel color coded 3/4 inch diameter ceiling tacks in acoustical tile ceilings or color coded tape applied to ceiling grid to locate equipment, valves or dampers that require regular maintenance or are part of a Life Safety System.

D. The tacks or tapes shall be color codes as follows:
   1. Yellow – HVAC
   2. Red – Life Safety (fire dampers, sprinkler valves, etc.)
   3. Green - Plumbing Valves.
   4. Blue – Heating/Cooling Valves.

PART 3 - EXECUTION

3.1 PREPARATION

A. All surfaces shall be cleaned and insulated (if applicable) prior to installing any identification.

B. Exterior surfaces of outdoor equipment shall be dry and prepared to accept the specified identification.

3.2 INSTALLATION

A. Install nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion. Seal with clear lacquer.

B. Install valve tags with chain.

C. Install duct markers in accordance with manufacturer’s instructions.

D. Install plastic pipe markers in accordance with manufacturer’s Instructions.

E. Install plastic tape markers complete around pipe in accordance with manufacturer’s instructions.

F. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.

G. Identify air handling units, pumps, domestic hot water heaters, fire pumps, heat transfer equipment tanks, water treatment devices, etc. with plastic nameplates. Small devices, such as in-line pumps, may be identified with tags.

H. Identify control panels and major control components outside panels with plastic nameplates.

I. Install detector tape on all under ground services in accordance with the manufactures recommendations.

J. Identify thermostats relating to air handling equipment serving multiple spaces.

K. Identify valves in main and branch piping with valve tags.

L. Tag automatic controls, instruments and relays. Key to control schematic.

M. Identify piping, concealed or exposed, with pipe markers or where buried using plastic tape pipe markers. Use tags on piping ¾ inch diameter and smaller. Identify service, flow direction and pressure. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.

N. Identify ductwork with plastic nameplates and flow arrows. Identify with air handling unit or fan identification number and area served. Locate identification at air handling unit or fan, at each side of penetration of structure or enclosure, and at each obstruction.

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Balancing Air Systems:

   a. Constant-volume air systems.
   b. Dual-duct systems.
   c. Variable-air-volume systems.
   d. Multizone systems.
   e. Induction-unit systems.

2. Balancing Hydronic Piping Systems:

   a. Constant-flow hydronic systems.
   b. Variable-flow hydronic systems.
   c. Primary-secondary hydronic systems.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

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

E. TAB Specialist: An entity engaged to perform TAB Work.

1.4 ACTION SUBMITTALS

A. LEED Submittals:

1. Air-Balance Report for Prerequisite IEQ 1: Documentation of work performed for ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

2. TAB Report for Prerequisite EA 2: Documentation of work performed for ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within [**15**] [**30**] [**45**] days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within [**15**] [**30**] [**45**] days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within [**30**] [**60**] [**90**] days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. Certified TAB reports.

E. Sample report forms.

F. Instrument calibration reports, to include the following:

1. Instrument type and make.
2. Serial number.
3. Application.
4. Dates of use.
5. Dates of calibration.

1.6 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by [**AABC**] [**NEBB**] [**or**] [**TABB**].

1. TAB Field Supervisor: Employee of the TAB contractor and certified by [**AABC**] [**NEBB**] [**or**] [**TABB**].
2. TAB Technician: Employee of the TAB contractor and who is certified by [**AABC**] [**NEBB**] [**or**] [**TABB**] as a TAB technician.

B. TAB Conference: Meet with the Cleveland Clinic on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide seven days advance notice of scheduled meeting time and location.

1. Agenda Items:

a. The Contract Documents examination report.
b. The TAB plan.
c. Coordination and cooperation of trades and subcontractors.
d. Coordination of documentation and communication flow.

C. Certify TAB field data reports and perform the following:

1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard TAB contractor's forms approved by Cleveland Clinic.

E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

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

1.7 PROJECT CONDITIONS

[Retain one of two paragraphs below. Delete article if there will be no occupancy during TAB Work.]

A. Full Owner Occupancy: Cleveland Clinic will occupy the site and existing building during entire TAB period. Cooperate with Cleveland Clinic during TAB operations to minimize conflicts with Cleveland Clinic operations.

[Retain paragraph below if Owner might occupy completed areas of building.]

B. Partial Owner Occupancy: Cleveland Clinic may occupy completed areas of building before Substantial Completion. Cooperate with Cleveland Clinic during TAB operations to minimize conflicts with Cleveland Clinic operations.

1.8 COORDINATION

A. Notice: Provide seven days advance notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on [**air**] [**and**] [**water**] distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 TAB SPECIALISTS

A. Subject to compliance with requirements, engage one of the following:

1. Cleveland Clinic selected and contracted

3.2 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to report any observed issues that would prevent from meeting the leakage class of connected ducts as specified in Section 233113 "Metal Ducts" and that the plenums are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.

1. Include in test report Project conditions and observed system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
2. Test and report HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine test reports specified in individual system and equipment Sections.

H. Observe and report HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

I. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

J. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

K. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

M. Examine system pumps to ensure absence of entrained air in the suction piping.

N. Observe and report any deficiencies in operating safety interlocks and controls on HVAC equipment.

O. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.3 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare progress reports weekly. Verify the following:

1. Permanent electrical-power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Automatic temperature-control systems are operational.
4. Equipment and duct access doors are securely closed.
5. Balance, smoke, and fire dampers are open.
6. Isolating and balancing valves are open and control valves are operational.
7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.4 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in [**AABC's "National Standards for Total System Balance"**] [**ASHRAE 111**] [**NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems"**] [**SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing"**] and in this Section.

1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
2. After testing and balancing, verify and report any problems with test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
3. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.5 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. For variable-air-volume systems, develop a plan to simulate diversity.

C. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

D. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.

E. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

F. Verify that motor starters are equipped with properly sized thermal protection.

G. Check dampers for proper position to achieve desired airflow path.

H. Check for airflow blockages.

I. Check condensate drains for proper connections and functioning.

J. Report any observed problems and verify leakage calculations done by others for proper sealing of air-handling-unit components.

K. Report any observed issues associated with the sealing of the air duct system.

3.6 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

a. Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.

2. Measure fan static pressures as follows to determine actual static pressure:

   a. Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
   b. Measure static pressure directly at the fan outlet or through the flexible connection.
   c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
   d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

   a. Report the cleanliness status of filters and the time static pressures are measured.

4. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
5. Review Record Documents to determine variations in design static pressures versus actual static pressures. Recommend adjustments to accommodate actual conditions.
6. Obtain approval from the Cleveland Clinic for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in HVAC Sections for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
7. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, smoke evacuation (if applicable) and any other specified operating mode to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure airflow of submain and branch ducts.

   a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
3. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure air outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.7 PROCEDURES FOR DUAL-DUCT SYSTEMS

A. Verify that the cooling coil is capable of full-system airflow, and set mixing boxes at full-cold airflow position for fan volume.

B. Measure static pressure in both hot and cold ducts at the end of the longest duct run to determine that sufficient static pressure exists to operate controls of mixing boxes and to overcome resistance in the ducts and outlets downstream from mixing boxes.

1. If insufficient static pressure exists, increase airflow at the fan.

C. Test and adjust the constant-volume mixing boxes as follows:

1. Verify both hot and cold operations by adjusting the thermostat and observing changes in air temperature and volume.
2. Verify sufficient inlet static pressure before making volume adjustments.
3. Adjust mixing boxes to indicated airflows within specified tolerances. Measure airflow by Pitot-tube traverse readings or by measuring static pressure at mixing-box taps if provided by mixing-box manufacturer.

D. Do not overpressurize ducts.

E. Remeasure static pressure in both hot and cold ducts at the end of the longest duct run to determine that sufficient static pressure exists to operate controls of mixing boxes and to overcome resistance in the ducts and outlets downstream from mixing boxes.

F. Adjust variable-air-volume, dual-duct systems in the same way as constant-volume, dual-duct systems; adjust maximum- and minimum-airflow setting of each mixing box.

3.8 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

    a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record final fan-performance data.

C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Balance variable-air-volume systems the same as described for constant-volume air systems.
2. Set terminal units and supply fan at full-airflow condition.
3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
4. Readjust fan airflow for final maximum readings.
5. Measure operating static pressure at the sensor that controls the supply fan if one is installed, and verify operation of the static-pressure controller.
6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.

a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
3. Set terminal units at full-airflow condition.
4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Adjust terminal units for minimum airflow.
6. Measure static pressure at the sensor.
7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

3.9 PROCEDURES FOR MULTIZONE SYSTEMS

A. Set unit at maximum airflow through the cooling coil.

B. Adjust each zone's balancing damper to achieve indicated airflow within the zone.

3.10 PROCEDURES FOR INDUCTION-UNIT SYSTEMS

A. Balance primary-air risers by measuring static pressure at the nozzles of the top and bottom units of each riser to determine which risers must be throttled. Adjust risers to indicated airflow within specified tolerances.

B. Adjust each induction unit.

3.11 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 10 percent.

B. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check liquid level in expansion tank.
3. Check makeup water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation, and set at indicated flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
6. Set system controls so automatic valves are wide open to heat exchangers.
7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

C. Verify correct expansion tank charge.

3.12 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.

   a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from the Cleveland Clinic and comply with requirements in Section 232123 "Hydronic Pumps."

2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.

   a. Monitor motor performance during procedures and do not operate motors in overload conditions.

3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Report flow rates that are not within plus or minus 10 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

D. Set calibrated balancing valves, if installed, at calculated presettings.

E. Measure flow at all stations and adjust, where necessary, to obtain first balance.

1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

G. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:

1. Determine the balancing station with the highest percentage over indicated flow.
2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
3. Record settings and mark balancing devices.

H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.

3.13 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

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

3.14 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first and then balance the secondary circuits.

3.15 PROCEDURES FOR HEAT EXCHANGERS

A. Measure water flow through all circuits.

B. Adjust water flow to within specified tolerances.

C. Measure inlet and outlet water temperatures.

D. Measure inlet steam pressure.

E. Check settings and operation of safety and relief valves. Record settings.

3.16 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.17 PROCEDURES FOR CHILLERS

A. Balance water flow through each evaporator[**and condenser**] to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
2. For water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
3. Capacity: Calculate in tons of cooling.
4. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.18 PROCEDURES FOR COOLING TOWERS

A. Shut off makeup water for the duration of the test, and verify that makeup and blowdown systems are fully operational after tests and before leaving the equipment. Perform the following tests and record the results:

1. Measure condenser-water flow to each cell of the cooling tower.
2. Measure entering- and leaving-water temperatures.
3. Measure wet- and dry-bulb temperatures of entering air. (At owner’s request).
4. Measure wet- and dry-bulb temperatures of leaving air. (At owner’s request).
5. Measure cooling-tower spray pump discharge pressure. (At owner’s request).

3.19 PROCEDURES FOR BOILERS

A. Hydronic Boilers: Measure and record entering- and leaving-water temperatures and water flow.

B. Steam Boilers: Measure and record entering-water temperature and flow.

3.20 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Dry-bulb temperature of entering and leaving air.
5. Wet-bulb temperature of entering and leaving air for cooling coils. (At owner's request).
6. Airflow.
7. Air pressure drop.

3.21 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is indicated on the drawings to remain and be reused.

1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check the refrigerant charge.
4. Check the condition of filters.
5. Check the condition of coils.
6. Check the operation of the drain pan and condensate-drain trap.
7. Check bearings and other lubricated parts for proper lubrication.
8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment indicated on drawings to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:

1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.
4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.

1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the air flow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.

4. Balance each air outlet.

3.22 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Heating-Water Flow Rate: Plus or minus 10 percent.
4. Cooling-Water Flow Rate: Plus or minus 10 percent.

3.23 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.24 FINAL REPORT

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

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

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

1. Pump curves.
2. Fan curves.
3. Manufacturers' test data.
4. Field test reports prepared by system and equipment installers.
5. Other information relative to equipment performance; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB contractor.
3. Project name.

4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
11. Summary of contents including the following:
    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of testing conditions system operation sequence if it varies from the Contract Documents.
12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:
    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions (as requested by Cleveland Clinic).
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

1. Unit Data:
    a. Unit identification.
    b. Location.
    c. Make and type.
    d. Model number and unit size.
    e. Manufacturer's serial number.
    f. Unit arrangement and class.
    g. Discharge arrangement.
    h. Sheave make, size in inches (mm), and bore.
    i. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
    j. Number, make, and size of belts.
    k. Number, type, and size of filters.
2. Motor Data:
    a. Motor make, and frame type and size.
    b. Horsepower and rpm.
    c. Volts, phase, and hertz.
    d. Full-load amperage and service factor.

e. Sheave make, size in inches (mm), and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).

3. Test Data (Indicated and Actual Values):

a. Total air flow rate in cfm (L/s).
b. Total system static pressure in inches wg (Pa).
c. Fan rpm.
d. Discharge static pressure in inches wg (Pa).
e. Filter static-pressure differential in inches wg (Pa).
f. Preheat-coil static-pressure differential in inches wg (Pa).
g. Cooling-coil static-pressure differential in inches wg (Pa).
h. Heating-coil static-pressure differential in inches wg (Pa).
i. Minimum outdoor airflow in cfm (L/s).
j. Return airflow in cfm (L/s).
k. Outdoor-air damper position.
l. Return-air damper position.
m. Vortex damper position.

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

1. Fan Data:

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

2. Motor Data:

a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches (mm), and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm (L/s).
b. Total system static pressure in inches wg (Pa).
c. Fan rpm.
d. Discharge static pressure in inches wg (Pa).
e. Suction static pressure in inches wg (Pa).

F. Round, Flat-Oval, and Rectangular Duct Traverse Reports:

1. Report Data:

    a. System and air-handling-unit number.
    b. Location and zone.
    c. Traverse air temperature in deg F (deg C).
    d. Duct static pressure in inches wg (Pa).
    e. Duct size in inches (mm).
    f. Duct area in sq. ft. (sq. m).
    g. Indicated air flow rate in cfm (L/s).
    h. Indicated velocity in fpm (m/s).
    i. Actual air flow rate in cfm (L/s).
    j. Actual average velocity in fpm (m/s).
    k. Barometric pressure in psig (Pa) or corrected to location.

G. Air-Terminal-Device Reports:

1. Unit Data:

    a. System and air-handling unit identification.
    b. Location and zone.
    c. Apparatus used for test.
    d. Area served.
    e. Number from system diagram.
    f. Type and model number.
    g. Size.
    h. Effective area in sq. ft. (sq. m).

2. Test Data (Indicated and Actual Values):

    a. Air flow rate in cfm (L/s).
    b. Air velocity in fpm (m/s).
    c. Preliminary air flow rate as needed in cfm (L/s).
    d. Preliminary velocity as needed in fpm (m/s).
    e. Final air flow rate in cfm (L/s).
    f. Final velocity in fpm (m/s).

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

1. Unit Data:

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

2. Test Data (Indicated and Actual Values):

    a. Air flow rate in cfm (L/s).
    b. Water flow rater in gpm.

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

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and size.
e. Model number.
f. Water flow rate in gpm (L/s).
g. Water pressure differential in feet of head or psig (kPa).
h. Pump rpm.
i. Impeller diameter in inches (mm).
j. Motor make and frame size.
k. Motor horsepower and rpm.
l. Voltage at each connection.
m. Amperage for each phase.
n. Full-load amperage and service factor.

2. Test Data (Indicated and Actual Values):

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

J. Instrument Calibration Reports:

1. Report Data:

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

3.25 INSPECTIONS

A. Refer to commissioning specification.

3.26 ADDITIONAL TESTS

A. (If requested by Cleveland Clinic) Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. (If requested by Cleveland Clinic) Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following duct services:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
6. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
7. Indoor, concealed oven and warewash exhaust.
8. Indoor, exposed oven and warewash exhaust.
9. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
10. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
11. Outdoor, concealed supply and return.
12. Outdoor, exposed supply and return.

B. Related Sections:

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

1.3 ACTION SUBMITTALS

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

B. LEED Submittals:

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

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

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

2. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.
3. Detail application of field-applied jackets.
4. Detail application at linkages of control devices.

D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Sheet Form Insulation Materials: 12 inches (300 mm) square.
2. Sheet Jacket Materials: 12 inches (300 mm) square.
3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

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

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

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

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

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

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.

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

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

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

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

F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, [**Type I**] [**Type II with factory-applied vinyl jacket**] [**Type III with factory-applied FSK jacket**] [**Type III with factory-applied FSP jacket**]. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

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

G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation [**without factory-applied jacket**] [**with factory-applied ASJ**] [**with factory-applied FSK jacket**]. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

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

H. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied [**ASJ**] [**FSK jacket**] complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

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

2.2 FIRE-RATED INSULATION SYSTEMS

A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F (927 deg C). Comply with ASTM C 656, Type II, Grade 6. Tested and certified to provide a [**1**] [**2**]-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

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

a. Johns Manville; Super Firetemp M.

B. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a [**1**] [**2**]-hour fire rating by an NRTL acceptable to authorities having jurisdiction.

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

   a. CertainTeed Corp.; FlameChek.
   b. Johns Manville; Firetemp Wrap.
   c. Nelson Fire Stop Products; Nelson FSB Flameshield Blanket.
   d. Thermal Ceramics; FireMaster Duct Wrap.
   e. 3M; Fire Barrier Wrap Products.
   f. Unifrax Corporation; FyreWrap.

2.3 ADHESIVES

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

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

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

   a. Aeroflex USA, Inc.; Aeroseal.
   b. Armacell LLC; Armaflex 520 Adhesive.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.K-Flex USA; R-373 Contact Adhesive.

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

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

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

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.Eagle Bridges - Marathon Industries; 225.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.Mon-Eco Industries, Inc.; 22-25.

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

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

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

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
   b. Eagle Bridges - Marathon Industries; 225.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.Mon-Eco Industries, Inc.; 22-25.

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

E. PVC Jacket Adhesive: Compatible with PVC jacket.

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

a. Dow Corning Corporation; 739, Dow Silicone.
b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
c. P.I.C. Plastics, Inc.; Welding Adhesive.
d. Speedline Corporation; Polyco VP Adhesive.

2. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

2.4 MASTICS

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

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

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.

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

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
b. Eagle Bridges - Marathon Industries; 501.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
d. Mon-Eco Industries, Inc.; 55-10.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
3. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
b. Eagle Bridges - Marathon Industries; 570.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
b. Eagle Bridges - Marathon Industries; 550.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
d. Mon-Eco Industries, Inc.; 55-50.
e. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
b. Vimasco Corporation; 713 and 714.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct insulation.
4. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
5. Color: White.

2.6 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.Eagle Bridges - Marathon Industries; 405.
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
c. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.7 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. (203 g/sq. m) with a thread count of 5 strands by 5 strands/sq. in. (2 strands by 2 strands/sq. mm) for covering ducts.

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas No. 5.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for ducts.

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

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.
b. Vimasco Corporation; Elastafab 894.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).

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

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

2.10 FIELD-APPLIED JACKETS

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

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

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

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

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

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.

D. Metal Jacket:

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
c. RPR Products, Inc.; Insul-Mate.

2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. [**Sheet and roll stock ready for shop or field sizing**] [**Factory cut and rolled to size**].
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: [**1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper**] [**3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**] [**2.5-mil- (0.063-mm-) thick polysurlyn**].
d. Moisture Barrier for Outdoor Applications: [**3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**] [**2.5-mil- (0.063-mm-) thick polysurlyn**].

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

a. [**Sheet and roll stock ready for shop or field sizing**] [**Factory cut and rolled to size**].
b. Material, finish, and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: [**1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper**] [**3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**] [**2.5-mil- (0.063-mm-) thick polysurlyn**].
d. Moisture Barrier for Outdoor Applications: [**3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**] [**2.5-mil- (0.063-mm-) thick polysurlyn**].

E. Self-Adhesive Outdoor Jacket: 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with [**white**] [**stucco-embossed**] aluminum-foil facing.

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

   a. Polyguard Products, Inc.; Alumaguard 60.

2.11 TAPES

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

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

      a. ABI, Ideal Tape Division; 428 AWF ASJ.
      b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
      c. Compac Corporation; 104 and 105.
      d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

   2. Width: 3 inches (75 mm).
   3. Thickness: 11.5 mils (0.29 mm).
   4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   5. Elongation: 2 percent.
   6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

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

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

      a. ABI, Ideal Tape Division; 491 AWF FSK.
      b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
      c. Compac Corporation; 110 and 111.
      d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

   2. Width: 3 inches (75 mm).
   3. Thickness: 6.5 mils (0.16 mm).
   4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   5. Elongation: 2 percent.
   6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

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

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

      a. ABI, Ideal Tape Division; 370 White PVC tape.
      b. Compac Corporation; 130.
      c. Venture Tape; 1506 CW NS.

   2. Width: 2 inches (50 mm).

3. Thickness: 6 mils (0.15 mm).
4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

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

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

a. ABI, Ideal Tape Division; 488 AWF.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
c. Compac Corporation; 120.
d. Venture Tape; 3520 CW.

2. Width: 2 inches (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

2.12 SECUREMENTS

A. Bands:

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

a. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, [**Type 304**] [**or**] [**Type 316**]; 0.015 inch (0.38 mm) thick, [**1/2 inch (13 mm)**] [**3/4 inch (19 mm)**] wide with [**wing seal**] [**or**] [**closed seal**].
3. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, [**1/2 inch (13 mm)**] [**3/4 inch (19 mm)**] wide with [**wing seal**] [**or**] [**closed seal**].
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, [**0.106-inch- (2.6-mm-)**] [**0.135-inch- (3.5-mm-)**] diameter shank, length to suit depth of insulation indicated.

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

1) AGM Industries, Inc.; CWP-1.
2) GEMCO; CD.
3) Midwest Fasteners, Inc.; CD.
4) Nelson Stud Welding; TPA, TPC, and TPS.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, [**0.106-inch- (2.6-mm-)**] [**0.135-inch- (3.5-mm-)**] diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.

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

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

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

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

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

   b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   c. Spindle: [**Copper- or zinc-coated, low-carbon steel**] [**Aluminum**] [**Stainless steel**], fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

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

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

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

   b. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
   c. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
   d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

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

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

      1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers.
      2) GEMCO; Peel & Press.
      3) Midwest Fasteners, Inc.; Self Stick.

   b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
   c. Spindle: [**Copper- or zinc-coated, low-carbon steel**] [**Aluminum**] [**Stainless steel**], fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   d. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, [**galvanized-steel**] [**aluminum**] [**stainless-steel**] sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

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

      1) AGM Industries, Inc.; RC-150.
      2) GEMCO; R-150.
      3) Midwest Fasteners, Inc.; WA-150.
      4) Nelson Stud Welding; Speed Clips.

   b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

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

      1) GEMCO.
      2) Midwest Fasteners, Inc.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

D. Wire: [**0.080-inch (2.0-mm) nickel-copper alloy**] [**0.062-inch (1.6-mm) soft-annealed, stainless steel**] [**0.062-inch (1.6-mm) soft-annealed, galvanized steel**].

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

a. C & F Wire.

2.13 CORNER ANGLES

A. PVC Corner Angles: **30 mils (0.8 mm)** thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: **0.040 inch (1.0 mm)** thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: **0.024 inch (0.61 mm)** thick, minimum 1 by 1 inch (25 by 25 mm), stainless steel according to ASTM A 167 or ASTM A 240/A 240M, [**Type 304**] [**or**] [**Type 316**].

PART 3 - EXECUTION

3.1 EXAMINATION

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

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

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

3.3 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

F. Keep insulation materials dry during application and finishing.

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

H. Install insulation with least number of joints practical.

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

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

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

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

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at [**2 inches (50 mm)**] o.c.

   a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

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

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

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

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
4. Seal jacket to wall flashing with flashing sealant.

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

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches (50 mm).

1. Comply with requirements in Section 078413 "Penetration Firestopping"irestopping and fire-resistive joint sealers.

E. Insulation Installation at Floor Penetrations:

1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches (50 mm).
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 INSTALLATION OF MINERAL-FIBER INSULATION

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

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

    a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
    b. On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    d. Do not overcompress insulation during installation.
    e. Impale insulation over pins and attach speed washers.
    f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

    a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches (75 mm).

5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

3.6 FIELD-APPLIED JACKET INSTALLATION

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

1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

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

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

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

D. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.

3.7 FIRE-RATED INSULATION SYSTEM INSTALLATION

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

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

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

3.8 FINISHES

A. Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

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

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

3.9 FIELD QUALITY CONTROL

A. Testing Agency: Cleveland Clinic will engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

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

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

3.10 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
6. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
7. Indoor, concealed oven and warewash exhaust.
8. Indoor, exposed oven and warewash exhaust.
9. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
10. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
11. Outdoor, concealed supply and return.
12. Outdoor, exposed supply and return.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.

3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Flexible connectors.
6. Vibration-control devices.
7. Factory-insulated access panels and doors.

3.11 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, or non-occupied space supply-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: **2 inches (50 mm)** thick and **0.75-lb/cu. ft. (12-kg/cu. m)** nominal density.

B. Concealed, or non-occupied space outdoor-air duct insulation shall be the following:
   1. Mineral-Fiber Blanket: **2 inches (50 mm)** thick and **0.75-lb/cu. ft. (12-kg/cu. m)** nominal density.

C. Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated double wall, Metalbestos style, as required to achieve 2-hour fire rating.

3.12 ABOVEGROUND, OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

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

B. All exterior supply and return ductwork shall be double wall duct insulated to meet ASHRAE 90.1.

3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

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

C. Ducts and Plenums, Exposed:

   1. [**PVC**] [**PVC, Color-Coded by System**]: [**20 mils (0.5 mm)**] [**30 mils (0.8 mm)**] thick.
   2. Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch (0.41 mm)**] [**0.020 inch (0.51 mm)**] [**0.024 inch (0.61 mm)**] [**0.032 inch (0.81 mm)**] [**0.040 inch (1.0 mm)**] thick.

3.14 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

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

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

C. Ducts and Plenums, Concealed:

1. [**PVC**] [**PVC, Color-Coded by System**]: [**20 mils (0.5 mm)**] [**30 mils (0.8 mm)**] thick.
2. Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch (0.41 mm)**] [**0.020 inch (0.51 mm)**] [**0.024 inch (0.61 mm)**] [**0.032 inch (0.81 mm)**] [**0.040 inch (1.0 mm)**] thick.

D. Ducts and Plenums, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):

1. Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch (0.41 mm)**] [**0.020 inch (0.51 mm)**] [**0.024 inch (0.61 mm)**] [**0.032 inch (0.81 mm)**] [**0.040 inch (1.0 mm)**] thick.
2. Painted Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch (0.41 mm)**] [**0.020 inch (0.51 mm)**] [**0.024 inch (0.61 mm)**] [**0.032 inch (0.81 mm)**] thick.
3. Stainless Steel, [**Type 304**] [**or**] [**Type 316**], [**Smooth 2B Finish**] [**Corrugated**] [**Stucco Embossed**]: [**0.010 inch (0.25 mm)**] [**0.016 inch (0.41 mm)**] [**0.020 inch (0.51 mm)**] [**0.024 inch (0.61 mm)**] thick.

E. Ducts and Plenums, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):

1. [**Painted**]Aluminum, [**Smooth**] [**Stucco Embossed**] with [**1-1/4-Inch- (32-mm-) Deep Corrugations**] [**2-1/2-Inch- (65-mm-) Deep Corrugations**] [**4-by-1-Inch (100-by-25-mm) Box Ribs**]: [**0.032 inch (0.81 mm)**] [**0.040 inch (1.0 mm)**] thick.
2. Stainless Steel, [**Type 304**] [**or**] [**Type 316**], [**Smooth**] [**Stucco Embossed**], with [**1-1/4-Inch- (32-mm-) Deep Corrugations**] [**2-1/2-Inch- (65-mm-) Deep Corrugations**] [**4-by-1-Inch (100-by-25-mm) Box Ribs**]: [**0.020 inch (0.51 mm)**] [**0.024 inch (0.61 mm)**] thick.

END OF SECTION 230713

SECTION 230716 - HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following HVAC equipment that is not factory insulated:

1. Chillers.
2. Heat exchangers.
3. Converters.
4. Chilled-water pumps.
5. Condenser-water pumps.
6. Dual-service heating and cooling pumps.
7. Heating, hot-water pumps.
8. Heat-recovery pumps.
9. Steam condensate pumps.
10. Expansion/compression tanks.
11. Air separators.
12. Thermal storage tanks.
13. Deaerators.
14. Steam condensate tanks.
15. Steam flash tanks, flash separators, moisture separators, and blow-off tanks.
16. Piping system filtration unit housings.
17. Outdoor, aboveground, heated, fuel-oil storage tanks.

B. Related Sections:

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

1.3 ACTION SUBMITTALS

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

B. LEED Submittals:

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

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

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

D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

1. Preformed Pipe Insulation Materials: 12 inches (300 mm) long by NPS 2 (DN 50).
2. Sheet Form Insulation Materials: 12 inches (300 mm) square.
3. Sheet Jacket Materials: 12 inches (300 mm) square.
4. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

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

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

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

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with equipment Installer for equipment insulation application.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

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

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Breeching Insulation Schedule" and "Equipment Insulation Schedule" articles for where insulating materials shall be applied.

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

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

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

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

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

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

a. Aeroflex USA, Inc.; Aerocel.

b. Armacell LLC; AP Armaflex.
c. K-Flex USA; Insul-Sheet and K-FLEX LS.

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

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

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

H. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.

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

a. Industrial Insulation Group (IIG); MinWool-1200 Flexible Batt.
b. Johns Manville; HTB 26 Spin-Glas.
c. Roxul Inc.; Roxul RW.

I. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. Provide insulation [**without factory-applied jacket**] [**with factory-applied ASJ**] [**with factory-applied FSK jacket**]. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

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

J. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.

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

a. Fibrex Insulations Inc.; FBX.Industrial Insulation Group (IIG); MinWool-1200 Industrial Board.
b. Rock Wool; Delta Board.
c. Roxul Inc.; RHT and RockBoard.
d. Thermafiber, Inc.; Thermafiber Industrial Felt.

K. Mineral-Fiber, Preformed Pipe Insulation:

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

   a. Fibrex Insulations Inc.; Coreplus 1200.
   b. Johns Manville; Micro-Lok.
   c. Knauf Insulation; 1000-Degree Pipe Insulation.
   d. Manson Insulation Inc.; Alley-K.
   e. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 Deg F (454 Deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, [**without factory-applied jacket**] [**with factory-applied ASJ**] [**with factory-applied ASJ-SSL**]. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
3. Type II, 1200 Deg F (649 Deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, [**without factory-applied jacket**] [**with factory-applied ASJ**] [**with factory-applied ASJ-SSL**]. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

L. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied [**ASJ**] [**FSK jacket**] complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

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

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

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

   a. Ramco Insulation, Inc.; Super-Stik.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

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

   a. Ramco Insulation, Inc.; Thermokote V.

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

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

    a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 ADHESIVES

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

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

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

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

    a. Aeroflex USA, Inc.; Aeroseal.
    b. Armacell LLC; Armaflex 520 Adhesive.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
    d. K-Flex USA; R-373 Contact Adhesive.

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

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

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

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
    b. Eagle Bridges - Marathon Industries; 225.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
    d. Mon-Eco Industries, Inc.; 22-25.

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

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

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

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
    b. Eagle Bridges - Marathon Industries; 225.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
    d. Mon-Eco Industries, Inc.; 22-25.

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

E. PVC Jacket Adhesive: Compatible with PVC jacket.

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

   a. Dow Corning Corporation; 739, Dow Silicone.
   b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
   c. P.I.C. Plastics, Inc.; Welding Adhesive.
   d. Speedline Corporation; Polyco VP Adhesive.

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

2.4 MASTICS

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

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

B. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

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

   a. Foster Brand, Specialty Construction Brands, Inc., a business of H .B. Fuller Company; 30-80/30-90.
   b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.

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

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
   b. Eagle Bridges - Marathon Industries; 501.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
   d. Mon-Eco Industries, Inc.; 55-10.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
3. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.

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

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
   b. Eagle Bridges - Marathon Industries; 570.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

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

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
   b. Eagle Bridges - Marathon Industries; 550.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
   d. Mon-Eco Industries, Inc.; 55-50.
   e. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of <**Insert value**> g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, provide one of the following:

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
c. Vimasco Corporation; 713 and 714.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment insulation.
4. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
5. Color: White.

2.6 SEALANTS

A. Joint Sealants:

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

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

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-70.
b. Eagle Bridges - Marathon Industries; 405.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
d. Mon-Eco Industries, Inc.; 44-05.

3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
6. Color: White or gray.
7. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK and Metal Jacket Flashing Sealants:

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
b. Eagle Bridges - Marathon Industries; 405.

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
d. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.7 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm (0.013 metric perm) when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

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

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

6. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm (0.007 metric perm) when tested

according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

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

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

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

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

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

8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perm) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 6 oz./sq. yd. (203 g/sq. m) with a thread count of 5 strands by 5 strands/sq. in. (2 strands by 2 strands/sq. mm) for covering equipment.

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas No. 5.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for equipment.

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

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.
b. Vimasco Corporation; Elastafab 894.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).

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

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

2.10 FIELD-APPLIED JACKETS

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

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

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

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

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

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
4. Factory-fabricated tank heads and tank side panels.

D. Metal Jacket:

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
c. RPR Products, Inc.; Insul-Mate.

2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. [**Sheet and roll stock ready for shop or field sizing**] [**Factory cut and rolled to size**].
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: [**1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper**] [**3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**] [**2.5-mil- (0.063-mm-) thick polysurlyn**].
d. Moisture Barrier for Outdoor Applications: [**3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**] [**2.5-mil- (0.063-mm-) thick polysurlyn**].
e. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.

8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

a. [**Sheet and roll stock ready for shop or field sizing**] [**Factory cut and rolled to size**].
b. Material, finish, and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: [**1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper**] [**3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**] [**2.5-mil- (0.063-mm-) thick polysurlyn**].
d. Moisture Barrier for Outdoor Applications: [**3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**] [**2.5-mil- (0.063-mm-) thick polysurlyn**].
e. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed two-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Self-Adhesive Outdoor Jacket: 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with [**white**] [**stucco-embossed**] aluminum-foil facing.

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

a. Polyguard Products, Inc.; Alumaguard 60.

F. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm (0.013 metric perm) when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

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

a. Dow Chemical Company (The), Saran 540 Vapor Retarder Film.

G. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm (0.007 metric perm) when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

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

a. Dow Chemical Company (The), Saran 560 Vapor Retarder Film.

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

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

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

2.11 TAPES

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

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

a. ABI, Ideal Tape Division; 428 AWF ASJ.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
c. Compac Corporation; 104 and 105.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches (75 mm).
3. Thickness: 11.5 mils (0.29 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

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

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

a. ABI, Ideal Tape Division; 491 AWF FSK.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
c. Compac Corporation; 110 and 111.
d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches (75 mm).
3. Thickness: 6.5 mils (0.16 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

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

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

a. ABI, Ideal Tape Division; 370 White PVC tape.
b. Compac Corporation; 130.
c. Venture Tape; 1506 CW NS.

2. Width: 2 inches (50 mm).
3. Thickness: 6 mils (0.15 mm).
4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

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

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

a. ABI, Ideal Tape Division; 488 AWF.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
c. Compac Corporation; 120.
d. Venture Tape; 3520 CW.

2. Width: 2 inches (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

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

a. Dow Chemical Company (The); Saran 540 Vapor Retarder Tape.

2. Width: 3 inches (75 mm).
3. Film Thickness: 4 mils (0.10 mm).
4. Adhesive Thickness: 1.5 mils (0.04 mm).
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

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

a. Dow Chemical Company (The); Saran 560 Vapor Retarder Tape.

2. Width: 3 inches (75 mm).
3. Film Thickness: 6 mils (0.15 mm).
4. Adhesive Thickness: 1.5 mils (0.04 mm).
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

2.12 SECUREMENTS

A. Bands:

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

a. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, [**Type 304**] [**or**] [**Type 316**]; 0.015 inch (0.38 mm) thick, [**1/2 inch (13 mm)**] [**3/4 inch (19 mm)**] wide with [**wing seal**] [**or**] [**closed seal**].
3. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, [**1/2 inch (13 mm)**] [**3/4 inch (19 mm)**] wide with [**wing seal**] [**or**] [**closed seal**].
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:

1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, [**0.106-inch- (2.6-mm-)**] [**0.135-inch- (3.5-mm-)**] diameter shank, length to suit depth of insulation indicated.

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

1) AGM Industries, Inc.; CWP-1.
2) GEMCO; CD.
3) Midwest Fasteners, Inc.; CD.
4) Nelson Stud Welding; TPA, TPC, and TPS.

2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, [**0.106-inch- (2.6-mm-)**] [**0.135-inch- (3.5-mm-)**] diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.

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

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

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

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

1) AGM Industries, Inc.; Tactoo Perforated Base Insul-Hangers.
2) GEMCO; Perforated Base.

3) Midwest Fasteners, Inc.; Spindle.

b. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
c. Spindle: [**Copper- or zinc-coated, low-carbon steel**] [**Aluminum**] [**Stainless steel**], fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

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

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

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

b. Baseplate: Perforated, nylon sheet, 0.030 inch (0.76 mm) thick by 1-1/2 inches (38 mm) in diameter.
c. Spindle: Nylon, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated, up to 2-1/2 inches (63 mm).
d. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.

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

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

1) AGM Industries, Inc.; Tactoo Self-Adhering Insul-Hangers, Series.
2) GEMCO; Peel & Press.
3) Midwest Fasteners, Inc.; Self Stick.

b. Baseplate: Galvanized carbon-steel sheet, 0.030 inch (0.76 mm) thick by 2 inches (50 mm) square.
c. Spindle: [**Copper- or zinc-coated, low-carbon steel**] [**Aluminum**] [**Stainless steel**], fully annealed, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
d. Adhesive-backed base with a peel-off protective cover.

6. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, [**galvanized-steel**] [**aluminum**] [**stainless-steel**] sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

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

1) AGM Industries, Inc.; RC-150.
2) GEMCO; R-150.
3) Midwest Fasteners, Inc.; WA-150.
4) Nelson Stud Welding; Speed Clips.

b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

7. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.

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

1) GEMCO.
2) Midwest Fasteners, Inc.

C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

D. Wire: **0.062-inch (1.6-mm)** soft-annealed, stainless steel.

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

a. C & F Wire.

2.13 CORNER ANGLES

A. PVC Corner Angles: **30 mils (0.8 mm)** thick, minimum 1 by 1 inch (25 by 25 mm), PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

B. Aluminum Corner Angles: **0.040 inch (1.0 mm)** thick, minimum 1 by 1 inch (25 by 25 mm), aluminum according to ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14.

C. Stainless-Steel Corner Angles: **0.024 inch (0.61 mm)** thick, minimum 1 by 1 inch (25 by 25 mm), stainless steel according to ASTM A 167 or ASTM A 240/A 240M, [**Type 304**] [**or**] [**Type 316**].

PART 3 - EXECUTION

3.1 EXAMINATION

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

1. Verify that systems and equipment to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.

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

3.2 PREPARATION

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

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

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

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

3.3 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

F. Keep insulation materials dry during application and finishing.

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

H. Install insulation with least number of joints practical.

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

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

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

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

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at [**2 inches (50 mm)**] [**4 inches (100 mm)**] o.c.

   a. For below ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

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

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

3.4 INSTALLATION OF EQUIPMENT, TANK, AND VESSEL INSULATION

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

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

a. Do not weld anchor pins to ASME-labeled pressure vessels.
b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
c. On tanks and vessels, maximum anchor-pin spacing is 3 inches (75 mm) from insulation end joints, and 16 inches (400 mm) o.c. in both directions.
d. Do not overcompress insulation during installation.
e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
f. Impale insulation over anchor pins and attach speed washers.
g. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

5. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches (150 mm) from each end. Install wire or cable between two circumferential girdles 12 inches (300 mm) o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches (1200 mm) o.c. Use this network for securing insulation with tie wire or bands.
7. Stagger joints between insulation layers at least 3 inches (75 mm).
8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

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

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

C. Insulation Installation on Pumps:

1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch (150-mm) centers, starting at corners. Install 3/8-inch- (10-mm-) diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
2. Fabricate boxes from [**galvanized steel**] [**aluminum**] [**stainless steel**], at least [**0.040 inch (1.0 mm)**] [**0.050 inch (1.3 mm)**] [**0.060 inch (1.6 mm)**] thick.
3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.5 FIELD-APPLIED JACKET INSTALLATION

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

1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

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

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

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

D. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.

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

1. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
2. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.6 FINISHES

A. Equipment Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

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

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

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Cleveland Clinic will engage a qualified testing agency to perform tests and inspections.

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

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

3.8 BREECHING INSULATION SCHEDULE

1. Manufacturer provided, pre-fabricated, factory-insulated.

3.9 EQUIPMENT INSULATION SCHEDULE

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

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

C. Chillers: Insulate cold surfaces on chillers, including, but not limited to, evaporator bundles, condenser bundles, suction piping, compressor inlets, tube sheets, water boxes, and nozzles with one of the following:

1.
2. Flexible Elastomeric: **1 inch (25 mm)** thick.
3. Mineral-Fiber Board: **1 inch (25 mm)** thick and **6-lb/cu. ft. (96-kg/cu. m)** nominal density.
4. Mineral-Fiber Pipe and Tank: **1 inch (25 mm)** thick.

D. Heat-exchanger (water-to-water for cooling service) insulation shall be one of the following:
1. Flexible Elastomeric: **1 inch (25 mm)** thick.
2. Mineral-Fiber Board: **1 inch (25 mm)** thick and **6-lb/cu. ft. (96-kg/cu. m)** nominal density.
3. Mineral-Fiber Pipe and Tank: [**1 inch (25 mm)**] thick.

E. Heat-exchanger (water-to-water for heating service) insulation shall be one of the following:
1. Mineral-Fiber Board: **2 inches (50 mm)** thick and **6-lb/cu. ft. (96-kg/cu. m)** nominal density.
2. Mineral-Fiber Pipe and Tank: [**2 inches (50 mm)**] thick.

F. Steam-to-hot-water converter insulation shall be one of the following:

1. Calcium Silicate: **3 inches (75 mm)** thick.
2. Cellular Glass: **3 inches (75 mm)** thick.
3. Mineral-Fiber Board: **2 inches (50 mm)** thick and **6-lb/cu. ft. (96-kg/cu. m)** nominal density.
4. Mineral-Fiber Pipe and Tank: **2 inches (50 mm)** thick.

G. Hot-water-to-steam converter insulation shall be one of the following:
1. Mineral-Fiber Board: **2 inches (50 mm)** thick and **6-lb/cu. ft. (96-kg/cu. m)** nominal density.
2. Mineral-Fiber Pipe and Tank: **2 inches (50 mm)** thick.

H. Chilled-water pump insulation shall be one of the following:
1. Flexible Elastomeric: **1 inch (25 mm)** thick.

I. Condenser-water pump insulation shall be one of the following:
1. Mineral-Fiber Board: **1 inch (25 mm)** thick and **6-lb/cu. ft. (96-kg/cu. m)** nominal density.

J. Dual-service heating and cooling pump insulation shall be one of the following:
1. Mineral-Fiber Board: **2 inches (50 mm)** thick and **6-lb/cu. ft. (96-kg/cu. m)** nominal density.

K. Heating-hot-water pump insulation shall be one of the following:
   1. Mineral-Fiber Board: **2 inches (50 mm)** thick and **6-lb/cu. ft. (96-kg/cu. m)** nominal density.

L. Heat-recovery pump insulation shall be one of the following:
   1. Mineral-Fiber Board: **2 inches (50 mm)** thick and **6-lb/cu. ft. (96-kg/cu. m)** nominal density.

M. Steam condensate pump and boiler feedwater pump insulation shall be one of the following:
   1. Mineral-Fiber Board: **2 inches (50 mm)** thick and **6-lb/cu. ft. (96-kg/cu. m)** nominal density.

N. Chilled-water expansion/compression tank insulation shall be one of the following:
   1. Flexible Elastomeric: **1 inch (25 mm)** thick.

O. Condenser-water expansion/compression tank insulation shall be one of the following:
   1. Mineral-Fiber Board: **1 inch (25 mm)** thick and **6-lb/cu. ft. (96-kg/cu. m)** nominal density.

P. Dual-service heating and cooling expansion/compression tank insulation shall be one of the following:
   1. Flexible Elastomeric: **1 inch (25 mm)** thick.
   2. **6-lb/cu. ft. (96-kg/cu. m)** nominal density.

Q. Heat-recovery expansion/compression tank insulation shall be one of the following:
   1. Mineral-Fiber Board: **1 inch (25 mm)** thick and **6-lb/cu. ft. (96-kg/cu. m)** nominal density.

R. Chilled-water air-separator insulation shall be one of the following:
   1. Flexible Elastomeric: **1 inch (25 mm)** thick.

S. Condenser-water air-separator insulation shall be one of the following:
   1. Flexible Elastomeric: **1 inch (25 mm)** thick.

T. Dual-service heating and cooling air-separator insulation shall be one of the following:
   1. Flexible Elastomeric: **1 inch (25 mm)** thick.

U. Heating-hot-water air-separator insulation shall be one of the following:
   1. Flexible Elastomeric: **1 inch (25 mm)** thick.

V. Heat-recovery air-separator insulation shall be one of the following:
   1. Flexible Elastomeric: **1 inch (25 mm)** thick.

W. Thermal storage tank (brine, water, ice) insulation shall be one of the following:
   1. Mineral-Fiber Board: **3 inches (75 mm)** thick and **6-lb/cu. ft. (96-kg/cu. m)** nominal density.

X. Deaerator insulation shall be one of the following:
   1. Mineral-Fiber Board: **2 inches (50 mm)** thick and **6-lb/cu. ft. (96-kg/cu. m)** nominal density.

Y. Steam condensate tank and receiver insulation shall be one of the following:
 1. Mineral-Fiber Board: **2 inches (50 mm)** thick and **6-lb/cu. ft. (96-kg/cu. m)** nominal density.

Z. Steam flash-tank, flash-separator, moisture-separator, and blow-off-tank insulation shall be one of the following:
 1. Mineral-Fiber Pipe and Tank: **2 inches (50 mm)** thick.

AA. Piping system filter-housing insulation shall be one of the following:
 1. Mineral-Fiber Pipe and Tank: **2 inches (50 mm)** thick.

3.10 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

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

C. Equipment, Concealed:
 1. Aluminum, **Stucco Embossed**: **0.016 inch (0.41 mm)** thick.

D. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
 1. Aluminum, **Stucco Embossed**: **0.016 inch (0.41 mm)** thick.

E. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
 1. Aluminum, **Stucco Embossed** : **0.032 inch (0.81 mm)** thick.

3.11 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

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

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

C. Equipment, Concealed:
 1. Aluminum, **Stucco Embossed**: **0.016 inch (0.41 mm)** thick.

D. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):

 1. Aluminum, **Stucco Embossed**: **0.016 inch (0.41 mm)** thick.

E. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):

 1. Aluminum, **Stucco Embossed** with [: **0.032 inch (0.81 mm)** thick.

END OF SECTION 230716

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Condensate drain piping, [**indoors**] [**and**] [**outdoors**].
2. Chilled-water and brine piping, [**indoors**] [**and**] [**outdoors**].
3. Condenser-water piping, [**indoors when used for water-side economizer or for condensate control**] [**and**] [**outdoors**].
4. Heating hot-water piping, [**indoors**] [**and**] [**outdoors**].
5. Steam and steam condensate piping, [**indoors**] [**and**] [**outdoors**].
6. Refrigerant suction and hot-gas piping, [**indoors**] [**and**] [**outdoors**].
7. Dual-service heating and cooling piping, [**indoors**] [**and**] [**outdoors**].
8. Heat-recovery piping, [**indoors**] [**and**] [**outdoors**].
9. Heated fuel-oil piping, [**indoors**] [**and**] [**outdoors**].

B. Related Sections:

1. Section 230713 "Duct Insulation."
2. Section 230716 "HVAC Equipment Insulation."
3. Section 232113.13 "Underground Hydronic Piping" for loose-fill pipe insulation in underground piping outside the building.
4. Section 336313 "Underground Steam and Condensate Distribution Piping" for loose-fill pipe insulation in underground piping outside the building.

1.3 ACTION SUBMITTALS

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

B. LEED Submittals:

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

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

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

D. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.

1. Preformed Pipe Insulation Materials: 12 inches (300 mm) long by NPS 2 (DN 50).
2. Sheet Form Insulation Materials: 12 inches (300 mm) square.
3. Jacket Materials for Pipe: 12 inches (300 mm) long by NPS 2 (DN 50).
4. Sheet Jacket Materials: 12 inches (300 mm) square.
5. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

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

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

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

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

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

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

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

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

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

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

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

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

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

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

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

F. Calcium Silicate:

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

   a. Industrial Insulation Group (IIG); Thermo-12 Gold.

2. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
3. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
4. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

G. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

   a. Pittsburgh Corning Corporation; Foamglas.

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

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

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

   a. Aeroflex USA, Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

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

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

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

J. Mineral-Fiber, Preformed Pipe Insulation:

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

   a. Fibrex Insulations Inc.; Coreplus 1200.
   b. Johns Manville; Micro-Lok.
   c. Knauf Insulation; 1000-Degree Pipe Insulation.
   d. Manson Insulation Inc.; Alley-K.
   e. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 deg F (454 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, [**without factory-applied jacket**] [**with factory-applied ASJ**] [**with factory-applied ASJ-SSL**]. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
3. Type II, 1200 deg F (649 deg C) Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, [**without factory-applied jacket**] [**with factory-applied ASJ**] [**with factory-applied ASJ-SSL**]. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

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

   a. Knauf Insulation; Permawick Pipe Insulation.
   b. Owens Corning; VaporWick Pipe Insulation.

L. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied [**ASJ**] [**FSK jacket**] complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. (40 kg/cu. m) or more. Thermal conductivity (k-value) at 100 deg F (55 deg C) is 0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K) or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

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

M. Phenolic:

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

a. Kingspan Tarec Industrial Insulation NV; Koolphen K.
b. Resolco International BV; Insul-phen.

2. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
3. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
4. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
5. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.

a. Preformed Pipe Insulation: [**None**] [**ASJ**].

N. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.

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

a. Dow Chemical Company (The); Trymer 2000 XP.
b. Duna USA Inc.; Corafoam.
c. Dyplast Products; ISO-25.
d. Elliott Company of Indianapolis; Elfoam.

2. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed 0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K) at 75 deg F (24 deg C) after 180 days of aging.
3. Flame-spread index shall be 25 or less, and smoke-developed index shall be 50 or less for thickness up to 1 inch (25 mm) as tested by ASTM E 84.
4. Fabricate shapes according to ASTM C 450 and ASTM C 585.
5. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.

a. Pipe Applications: [**None**] [**ASJ**] [**ASJ-SSL**] [**PVDC**] [**PVDC-SSL**].

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

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

a. Armacell LLC; Tubolit.
b. Nomaco Insulation; IMCOLOCK, IMCOSHEET, NOMALOCK, and NOMAPLY.

P. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed 0.26 Btu x in./h x sq. ft. x deg F (0.038 W/m x K) after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585.

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

a. Dow Chemical Company (The); Styrofoam.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

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

a. Ramco Insulation, Inc.; Super-Stik.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

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

a. Ramco Insulation, Inc.; Thermokote V.

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

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

a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 ADHESIVES

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

B. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of 50 to 800 deg F (10 to 427 deg C).

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-97.
b. Eagle Bridges - Marathon Industries; 290.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-27.
d. Mon-Eco Industries, Inc.; 22-30.
e. Vimasco Corporation; 760.

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

C. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F (minus 73 to plus 93 deg C).

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

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.

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

D. Phenolic and Polyisocyanurate Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F (minus 59 to plus 149 deg C).

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-96.
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-33.

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

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

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

a. Aeroflex USA, Inc.; Aeroseal.
b. Armacell LLC; Armaflex 520 Adhesive.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
d. K-Flex USA; R-373 Contact Adhesive.

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

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

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
b. Eagle Bridges - Marathon Industries; 225.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
d. Mon-Eco Industries, Inc.; 22-25.

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

G. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of minus 20 to plus 140 deg F (29 to plus 60 deg C).

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-96.
b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60.

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

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
b. Eagle Bridges - Marathon Industries; 225.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
d. Mon-Eco Industries, Inc.; 22-25.

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

I. PVC Jacket Adhesive: Compatible with PVC jacket.

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

a. Dow Corning Corporation; 739, Dow Silicone.
b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
c. P.I.C. Plastics, Inc.; Welding Adhesive.
d. Speedline Corporation; Polyco VP Adhesive.

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

2.4 MASTICS

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

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

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

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

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.

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

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
   b. Eagle Bridges - Marathon Industries; 501.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
   d. Mon-Eco Industries, Inc.; 55-10.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.03 metric perm) at 35-mil (0.9-mm) dry film thickness.
3. Service Temperature Range: 0 to 180 deg F (Minus 18 to plus 82 deg C).
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.

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

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
   b. Eagle Bridges - Marathon Industries; 570.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

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

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
   b. Eagle Bridges - Marathon Industries; 550.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
   d. Mon-Eco Industries, Inc.; 55-50.
   e. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms (1.2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, provide one of the following:

   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
   c. Vimasco Corporation; 713 and 714.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
4. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
5. Color: White.

2.6 SEALANTS

A. Joint Sealants:

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

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

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

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

c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
d. Mon-Eco Industries, Inc.; 44-05.

3. Materials shall be compatible with insulation materials, jackets, and substrates.
4. Permanently flexible, elastomeric sealant.
5. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
6. Color: White or gray.
7. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK and Metal Jacket Flashing Sealants:

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
b. Eagle Bridges - Marathon Industries; 405.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
d. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.7 FACTORY-APPLIED JACKETS

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

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
4. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
5. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perm (0.013 metric perm) when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

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

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

6. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm (0.007 metric perm) when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

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

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

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

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

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

8. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perms) when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 FIELD-APPLIED FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.

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

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas Number 10.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm), in a Leno weave, for pipe.

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

a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Mast-A-Fab.
b. Vimasco Corporation; Elastafab 894.

2.9 FIELD-APPLIED CLOTHS

A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).

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

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

2.10 FIELD-APPLIED JACKETS

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

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

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

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

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

2. Adhesive: As recommended by jacket material manufacturer.
3. Color: [**White**] [**Color-code jackets based on system. Color as selected by Architect**].
4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.

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

D. Metal Jacket:

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
c. RPR Products, Inc.; Insul-Mate.

2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.

a. [**Sheet and roll stock ready for shop or field sizing**] [**Factory cut and rolled to size**].
b. Finish and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: [**1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper**] [**3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**] [**2.5-mil- (0.063-mm-) thick polysurlyn**].
d. Moisture Barrier for Outdoor Applications: [**3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**] [**2.5-mil- (0.063-mm-) thick polysurlyn**].
e. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.
8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

3. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.

a. [**Sheet and roll stock ready for shop or field sizing**] [**Factory cut and rolled to size**].
b. Material, finish, and thickness are indicated in field-applied jacket schedules.
c. Moisture Barrier for Indoor Applications: [**1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper**] [**3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**] [**2.5-mil- (0.063-mm-) thick polysurlyn**].
d. Moisture Barrier for Outdoor Applications: [**3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper**] [**2.5-mil- (0.063-mm-) thick polysurlyn**].
e. Factory-Fabricated Fitting Covers:

1) Same material, finish, and thickness as jacket.
2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
3) Tee covers.
4) Flange and union covers.
5) End caps.
6) Beveled collars.
7) Valve covers.

8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

E. Underground Direct-Buried Jacket: 125-mil- (3.2-mm-) thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

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

a. Pittsburgh Corning Corporation; Pittwrap.
b. Polyguard Products, Inc.; Insulrap No Torch 125.

F. Self-Adhesive Outdoor Jacket: 60-mil- (1.5-mm-) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with [**white**] [**stucco-embossed**] aluminum-foil facing.

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

a. Polyguard Products, Inc.; Alumaguard 60.

G. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

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

a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film.

H. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms (0.007 metric perms) when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

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

a. Dow Chemical Company (The); Saran 560 Vapor Retarder Film.

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

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

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

2.11 TAPES

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

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

   a. ABI, Ideal Tape Division; 428 AWF ASJ.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
   c. Compac Corporation; 104 and 105.
   d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches (75 mm).
3. Thickness: 11.5 mils (0.29 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

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

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

   a. ABI, Ideal Tape Division; 491 AWF FSK.
   b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
   c. Compac Corporation; 110 and 111.
   d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches (75 mm).
3. Thickness: 6.5 mils (0.16 mm).
4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

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

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

   a. ABI, Ideal Tape Division; 370 White PVC tape.
   b. Compac Corporation; 130.
   c. Venture Tape; 1506 CW NS.

2. Width: 2 inches (50 mm).
3. Thickness: 6 mils (0.15 mm).
4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
5. Elongation: 500 percent.
6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

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

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

a. ABI, Ideal Tape Division; 488 AWF.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
c. Compac Corporation; 120.
d. Venture Tape; 3520 CW.

2. Width: 2 inches (50 mm).
3. Thickness: 3.7 mils (0.093 mm).
4. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

E. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

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

a. Dow Chemical Company (The); Saran 540 Vapor Retarder Tape.

2. Width: 3 inches (75 mm).
3. Film Thickness: 4 mils (0.10 mm).
4. Adhesive Thickness: 1.5 mils (0.04 mm).
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

F. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.

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

a. Dow Chemical Company (The); Saran 560 Vapor Retarder Tape.

2. Width: 3 inches (75 mm).
3. Film Thickness: 6 mils (0.15 mm).
4. Adhesive Thickness: 1.5 mils (0.04 mm).
5. Elongation at Break: 145 percent.
6. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

2.12 SECUREMENTS

A. Bands:

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

a. ITW Insulation Systems; Gerrard Strapping and Seals.
b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.

2. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, [**Type 304**] [**or**] [**Type 316**]; 0.015 inch (0.38 mm) thick, [**1/2 inch (13 mm)**] [**3/4 inch (19 mm)**] wide with [**wing seal**] [**or**] [**closed seal**].
3. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, [**1/2 inch (13 mm)**] [**3/4 inch (19 mm)**] wide with [**wing seal**] [**or**] [**closed seal**].
4. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

C. Wire: **0.062-inch (1.6-mm)** soft-annealed, stainless steel.

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

a. C & F Wire.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

3.2 PREPARATION

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

1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils (0.127 mm) thick and an epoxy finish 5 mils (0.127 mm) thick if operating in a temperature range between 140 and 300 deg F (60 and 149 deg C). Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

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

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

3.3 GENERAL INSTALLATION REQUIREMENTS

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

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

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

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

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

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

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

I. Install insulation with least number of joints practical.

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

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

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

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

1. Draw jacket tight and smooth.

2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at [**2 inches (50 mm)**] [**4 inches (100 mm)**] o.c.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

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

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

3.4 PENETRATIONS

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

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

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

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

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
4. Seal jacket to wall flashing with flashing sealant.

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

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

1. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

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

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

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.

4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

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

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

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover

and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.

5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CALCIUM SILICATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.
2. Install two-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.
3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Finish flange insulation same as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
3. Finish fittings insulation same as pipe insulation.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
2. Install insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation same as pipe insulation.

3.7 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.8 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.

4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

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

3.9 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.

2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

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

3.10 INSTALLATION OF PHENOLIC INSULATION

A. General Installation Requirements:

1. Secure single-layer insulation with stainless-steel bands at 12-inch (300-mm) intervals and tighten bands without deforming insulation materials.
2. Install 2-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with 0.062-inch (1.6-mm) wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.

B. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets with vapor retarders on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

C. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.

D. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

E. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.11 INSTALLATION OF POLYISOCYANURATE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.

C. Insulation Installation on Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of polyisocyanurate insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.12 INSTALLATION OF POLYOLEFIN INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of polyolefin pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install cut sections of polyolefin pipe and sheet insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.13 INSTALLATION OF POLYSTYRENE INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3- and 9-o'clock positions on the pipe.
2. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
3. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, and make thickness same as adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm).
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed section of polystyrene insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.14 FIELD-APPLIED JACKET INSTALLATION

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

1. Draw jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

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

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch (38-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

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

D. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.

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

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches (50 mm) over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches (850 mm) or less. The 33-1/2-inch- (850-mm-) circumference limit allows for 2-inch- (50-mm-) overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.15 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

   a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

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

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

3.16 FIELD QUALITY CONTROL

A. Testing Agency: Cleveland Clinic will engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:

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

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

3.17 PIPING INSULATION SCHEDULE, GENERAL

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

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.18 PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):

1. All Pipe Sizes: Insulation shall be one of the following:
   a. Flexible Elastomeric: **1 inch (25 mm)** thick.

B. Chilled Water and Brine, 40 Deg F (5 Deg C) and below:

1. **NPS 6 (DN 150)** and Smaller: Insulation shall be one of the following:
   a. Mineral-Fiber, **Preformed Pipe, Type I**: **1 inch (25 mm)** thick.

2. **NPS 8 (DN 200)** and Larger: Insulation shall be one of the following:
   a. Mineral-Fiber, **Preformed Pipe, Type I,** : **2 inches (50 mm)** thick.

C. Chilled Water and Brine, above 40 Deg F (5 Deg C):

1. **NPS 12 (DN 300)** and Smaller: Insulation shall be one of the following:
   a. Mineral-Fiber, **Preformed Pipe, Type I**: **1 inch (25 mm)** thick.

2. **NPS 14 (DN 350)** and Larger: Insulation shall be one of the following:
   a. Mineral-Fiber **Preformed Pipe, Type I,** : **1-1/2 inches (38 mm)** thick.

D. Condenser-Water Supply and Return:

1. **NPS 12** **(DN 300)** and Smaller: Insulation shall be one of the following:
    a. Mineral-Fiber, Preformed Pipe, Type I: **1 inch** **(25 mm)** thick.

2. **NPS 14** **(DN 350)** and Larger: Insulation shall be one of the following:

    a. Cellular Glass: [**2 inches** **(50 mm)**] [**3 inches** **(75 mm)**] thick.
    b. Mineral-Fiber, [**Preformed Pipe, Type I**] [**or**] [**Pipe and Tank Insulation**]: [**1-1/2 inches** **(38 mm)**] [**2 inches** **(50 mm)**] [**3 inches** **(75 mm)**] thick.
    c. Phenolic: [**1-1/2 inches** **(38 mm)**] [**2 inches** **(50 mm)**] [**3 inches** **(75 mm)**] thick.

E. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and Below:

1. **NPS 12** **(DN 300)** and Smaller: Insulation shall be one of the following:

    a. Cellular Glass: [**1-1/2 inches** **(38 mm)**] [**2 inches** **(50 mm)**] thick.
    b. Mineral-Fiber, Preformed Pipe, Type I: [**1 inch** **(25 mm)**] [**2 inches** **(50 mm)**] thick.
    c. Phenolic: [**1 inch** **(25 mm)**] [**1-1/2 inches** **(38 mm)**] [**2 inches** **(50 mm)**] [**3 inches** **(75 mm)**] thick.
    d. Polyisocyanurate: **1 inch** **(25 mm)** thick.

2. **NPS 14** **(DN 350)** and Larger: Insulation shall be one of the following:

    a. Cellular Glass: [**2 inches** **(50 mm)**] [**3 inches** **(75 mm)**] thick.
    b. Mineral-Fiber, [**Preformed Pipe, Type I**] [**or**] [**Pipe and Tank Insulation**]: [**1-1/2 inches** **(38 mm)**] [**2 inches** **(50 mm)**] [**3 inches** **(75 mm)**] thick.
    c. Phenolic: [**1-1/2 inches** **(38 mm)**] [**2 inches** **(50 mm)**] [**3 inches** **(75 mm)**] thick.

F. Heating-Hot-Water Supply and Return, above 200 Deg F (93 Deg C):

1. **NPS 3/4** **(DN 20)** and Smaller: Insulation shall be one of the following:

    a. Calcium Silicate: [**2 inches** **(50 mm)**] [**3 inches** **(75 mm)**] thick.
    b. Cellular Glass: [**2 inches** **(50 mm)**] [**3 inches** **(75 mm)**] thick.
    c. Mineral-Fiber, Preformed Pipe, Type I or II: [**1-1/2 inches** **(38 mm)**] [**2 inches** **(50 mm)**] thick.

2. **NPS 1** **(DN 25)** and Larger: Insulation shall be one of the following:

    a. Calcium Silicate: [**3 inches** **(75 mm)**] [**4 inches** **(100 mm)**] thick.
    b. Cellular Glass: [**3 inches** **(75 mm)**] [**4 inches** **(100 mm)**] thick.
    c. Mineral-Fiber, Preformed Pipe, Type I or II: [**3 inches** **(75 mm)**] [**4 inches** **(100 mm)**] thick.

G. Steam and Steam Condensate, 350 Deg F (177 Deg C) and Below:

1. **NPS 3/4** **(DN 20)** and Smaller: Insulation shall be one of the following:

a. Calcium Silicate: [**2 inches (50 mm)**] [**3 inches (75 mm)**] thick.
b. Cellular Glass: [**2 inches (50 mm)**] [**3 inches (75 mm)**] thick.
c. Mineral-Fiber, Preformed Pipe, Type I or II: [**1-1/2 inches (38 mm)**] [**2 inches (50 mm)**] thick.

2. **NPS 1 (DN 25)** and Larger: Insulation shall be one of the following:

a. Calcium Silicate: [**3 inches (75 mm)**] [**4 inches (100 mm)**] thick.
b. Cellular Glass: [**3 inches (75 mm)**] [**4 inches (100 mm)**] thick.
c. Mineral-Fiber, [**Preformed Pipe, Type I or II**] [**or**] [**Pipe and Tank Insulation**]: [**3 inches (75 mm)**] [**4 inches (100 mm)**] thick.

H. Steam and Steam Condensate, above 350 Deg F (177 Deg C):

1. **NPS 3/4 (DN 20)** and Smaller: Insulation shall be one of the following:

a. Calcium Silicate: [**2 inches (50 mm)**] [**3 inches (75 mm)**] thick.
b. Cellular Glass: [**2 inches (50 mm)**] [**3 inches (75 mm)**] thick.
c. Mineral-Fiber, Preformed Pipe, Type I or II: [**1-1/2 inches (38 mm)**] [**2 inches (50 mm)**] thick.

2. **NPS 1 (DN 25)** and Larger: Insulation shall be one of the following:

a. Calcium Silicate: [**3 inches (75 mm)**] [**4 inches (100 mm)**] thick.
b. Cellular Glass: [**3 inches (75 mm)**] [**4 inches (100 mm)**] thick.
c. Mineral-Fiber, [**Preformed Pipe, Type I or II**] [**or**] [**Pipe and Tank Insulation**]: [**3 inches (75 mm)**] [**4 inches (100 mm)**] thick.

I. Refrigerant Suction and Hot-Gas Piping:

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

a. Cellular Glass: **1-1/2 inches (38 mm)** thick.
b. Flexible Elastomeric: **1 inch (25 mm)** thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: **1 inch (25 mm)** thick.
d. Phenolic: **1 inch (25 mm)** thick.
e. Polyisocyanurate: **1 inch (25 mm)** thick.
f. Polyolefin: **1 inch (25 mm)** thick.

J. Refrigerant Suction and Hot-Gas Flexible Tubing:

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

a. Flexible Elastomeric: **1 inch (25 mm)** thick.
b. Polyolefin: **1 inch (25 mm)** thick.

K. Dual-Service Heating and Cooling, 40 to 200 Deg F (5 to 93 Deg C):

1. **NPS 12 (DN 300)** and Smaller: Insulation shall be one of the following:

a. Cellular Glass: [1-1/2 inches (38 mm)] [2 inches (50 mm)] thick.
b. Mineral-Fiber, Preformed Pipe, Type I: [1 inch (25 mm)] [1-1/2 inches (38 mm)] [2 inches (50 mm)] thick.
c. Phenolic: [1 inch (25 mm)] [1-1/2 inches (38 mm)] [2 inches (50 mm)] [3 inches (75 mm)] thick.
d. Polyisocyanurate: 1 inch (25 mm) thick.

2. NPS 14 (DN 350) and Larger: Insulation shall be one of the following:

a. Cellular Glass: [2 inches (50 mm)] [3 inches (75 mm)] thick.
b. Mineral-Fiber, [**Preformed Pipe, Type I**] [**or**] [**Pipe and Tank Insulation**]: [1-1/2 inches (38 mm)] [2 inches (50 mm)] [3 inches (75 mm)] thick.
c. Phenolic: [1-1/2 inches (38 mm)] [2 inches (50 mm)] [3 inches (75 mm)] thick.

L. Heat-Recovery Piping:

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

a. Cellular Glass: 1-1/2 inches (38 mm) thick.
b. Flexible Elastomeric: 1 inch (25 mm) thick.
c. Mineral-Fiber, [**Preformed Pipe Insulation, Type I**] [**or**] [**Pipe and Tank Insulation**]: 1 inch (25 mm) thick.
d. Phenolic: 1 inch (25 mm) thick.
e. Polyisocyanurate: 1 inch (25 mm) thick.
f. Polyolefin: 1 inch (25 mm) thick.

3.19 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water and Brine:

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

a. Cellular Glass: 3 inches (75 mm) thick.
b. Flexible Elastomeric: 3 inches (75 mm) thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 3 inches (75 mm) thick.
d. Phenolic: 2 inches (50 mm) thick.
e. Polyisocyanurate: 2 inches (50 mm) thick.
f. Polyolefin: 3 inches (75 mm) thick.
g. Polystyrene: 2 inches (50 mm) thick.

B. Condenser-Water Supply and Return:

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

a. Cellular Glass: 2 inches (50 mm) thick.
b. Flexible Elastomeric: 2 inches (50 mm) thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
d. Phenolic: 2 inches (50 mm) thick.
e. Polyisocyanurate: 2 inches (50 mm) thick.

f. Polyolefin: **2 inches (50 mm)** thick.
g. Polystyrene: **2 inches (50 mm)** thick.

C. Heating-Hot-Water Supply and Return, 200 Deg F (93 Deg C) and Below:

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

a. Cellular Glass: **3 inches (75 mm)** thick.
b. Mineral-Fiber, Preformed Pipe Insulation, Type I: **2 inches (50 mm)** thick.
c. Phenolic: **2 inches (50 mm)** thick.
d. Polyisocyanurate: **2 inches (50 mm)** thick.

D. Heating-Hot-Water Supply and Return, above 200 Deg F (93 Deg C):

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

a. Calcium Silicate: **3 inches (75 mm)** thick.
b. Cellular Glass: **3 inches (75 mm)** thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I or II: **2 inches (50 mm)** thick.

E. Steam and Steam Condensate, 350 Deg F (177 Deg C) and Below:

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

a. Calcium Silicate: **4 inches (100 mm)** thick.
b. Cellular Glass: **4 inches (100 mm)** thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I or II: **3 inches (75 mm)** thick.

F. Steam and Steam Condensate, above 350 Deg F (177 Deg C):

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

a. Calcium Silicate: **5 inches (125 mm)** thick.
b. Cellular Glass: **5 inches (125 mm)** thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I or II: **4 inches (100 mm)** thick.

G. Refrigerant Suction and Hot-Gas Piping:

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

a. Cellular Glass: **2 inches (50 mm)** thick.
b. Flexible Elastomeric: **2 inches (50 mm)** thick.
c. Mineral-Fiber, Preformed Pipe Insulation, Type I: **2 inches (50 mm)** thick.
d. Phenolic: **2 inches (50 mm)** thick.
e. Polyisocyanurate: **2 inches (50 mm)** thick.
f. Polyolefin: **2 inches (50 mm)** thick.
g. Polystyrene: **2 inches (50 mm)** thick.

H. Refrigerant Suction and Hot-Gas Flexible Tubing:

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

   a. Flexible Elastomeric: **2 inches (50 mm)** thick.
   b. Polyolefin: **2 inches (50 mm)** thick.

I. Heat-Recovery Piping:

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

   a. Cellular Glass: **2 inches (50 mm)** thick.
   b. Flexible Elastomeric: **2 inches (50 mm)** thick.
   c. Mineral-Fiber, Preformed Pipe Insulation, Type I: **2 inches (50 mm)** thick.
   d. Phenolic: **2 inches (50 mm)** thick.
   e. Polyisocyanurate: **2 inches (50 mm)** thick.
   f. Polyolefin: **2 inches (50 mm)** thick.
   g. Polystyrene: **2 inches (50 mm)** thick.

J. Dual-Service Heating and Cooling:

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

   a. Cellular Glass: **3 inches (75 mm)** thick.
   b. Mineral-Fiber, Preformed Pipe Insulation, Type I: **2 inches (50 mm)** thick.
   c. Phenolic: **2 inches (50 mm)** thick.
   d. Polyisocyanurate: **2 inches (50 mm)** thick.

K. Fuel Oil Piping, Heated:

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

   a. Cellular Glass: **2 inches (50 mm)** thick.
   b. Mineral-Fiber, Preformed Pipe Insulation, Type I: **2 inches (50 mm)** thick.

3.20 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

A. Loose-fill insulation, for belowground piping, is specified in Section 232113.13 "Underground Hydronic Piping" and Section 336313 "Underground Steam and Condensate Distribution Piping."

B. Chilled Water, All Sizes: Cellular glass, **2 inches (50 mm)** thick.

C. Condenser-Water Supply and Return, All Sizes: Cellular glass, **2 inches (50 mm)** thick.

D. Heating-Hot-Water Supply and Return, All Sizes, 200 Deg F (93 Deg C) and Below: Cellular glass, **3 inches (75 mm)** thick.

E. Heating-Hot-Water Supply and Return, All Sizes, above 200 Deg F (93 Deg C):

1. Calcium Silicate: **3 inches (75 mm)** thick.

2. Cellular Glass: **3 inches (75 mm)** thick.

F. Steam and Steam Condensate, All Sizes, 350 Deg F (177 Deg C) and Below:

1. Calcium Silicate: **4 inches (100 mm)** thick.
2. Cellular Glass: **4 inches (100 mm)** thick.

G. Steam and Steam Condensate, All Sizes, above 350 Deg F (177 Deg C):

1. Calcium Silicate: **5 inches (125 mm)** thick.
2. Cellular Glass: **5 inches (125 mm)** thick.

H. Dual-Service Heating and Cooling, All Sizes, 40 to 200 Deg F (4 to 93 Deg C): Cellular glass, **3 inches (75 mm)** thick.

I. Fuel Oil Piping, All Sizes, Heated: Cellular glass, **2 inches (50 mm)** thick.

3.21 INDOOR, FIELD-APPLIED JACKET SCHEDULE

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

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

C. Piping, Concealed:

1. None.
2. [**PVC**] [**PVC, Color-Coded by System**]: [**20 mils (0.5 mm)**] [**30 mils (0.8 mm)**] thick.
3. Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch (0.41 mm)**] [**0.020 inch (0.51 mm)**] [**0.024 inch (0.61 mm)**] [**0.032 inch (0.81 mm)**] [**0.040 inch (1.0 mm)**] thick.
4. Painted Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch (0.41 mm)**] [**0.020 inch (0.51 mm)**] [**0.024 inch (0.61 mm)**] [**0.032 inch (0.81 mm)**] thick.
5. Stainless Steel, [**Type 304**] [**or**] [**Type 316**], [**Smooth 2B Finish**] [**Corrugated**] [**Stucco Embossed**]: [**0.010 inch (0.25 mm)**] [**0.016 inch (0.41 mm)**] [**0.020 inch (0.51 mm)**] [**0.024 inch (0.61 mm)**] thick.

D. Piping, Exposed:

1. None.
2. [**PVC**] [**PVC, Color-Coded by System**]: [**20 mils (0.5 mm)**] [**30 mils (0.8 mm)**] thick.
3. Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch (0.41 mm)**] [**0.020 inch (0.51 mm)**] [**0.024 inch (0.61 mm)**] [**0.032 inch (0.81 mm)**] [**0.040 inch (1.0 mm)**] thick.
4. Painted Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch (0.41 mm)**] [**0.020 inch (0.51 mm)**] [**0.024 inch (0.61 mm)**] [**0.032 inch (0.81 mm)**] thick.
5. Stainless Steel, [**Type 304**] [**or**] [**Type 316**], [**Smooth 2B Finish**] [**Corrugated**] [**Stucco Embossed**]: [**0.010 inch (0.25 mm)**] [**0.016 inch (0.41 mm)**] [**0.020 inch (0.51 mm)**] [**0.024 inch (0.61 mm)**] thick.

3.22 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

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

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

C. Piping, Concealed:

1. None.
2. [**PVC**] [**PVC, Color-Coded by System**]: [**20 mils (0.5 mm)**] [**30 mils (0.8 mm)**] thick.
3. Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch (0.41 mm)**] [**0.020 inch (0.51 mm)**] [**0.024 inch (0.61 mm)**] [**0.032 inch (0.81 mm)**] [**0.040 inch (1.0 mm)**] thick.
4. Painted Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**]: [**0.016 inch (0.41 mm)**] [**0.020 inch (0.51 mm)**] [**0.024 inch (0.61 mm)**] [**0.032 inch (0.81 mm)**] thick.
5. Stainless Steel, Type [**304**] [**316**] [**304 or 316**], [**Smooth 2B Finish**] [**Corrugated**] [**Stucco Embossed**]: [**0.010 inch (0.25 mm)**] [**0.016 inch (0.41 mm)**] [**0.020 inch (0.51 mm)**] [**0.024 inch (0.61 mm)**] thick.

D. Piping, Exposed:

1. PVC: [**20 mils (0.5 mm)**] [**30 mils (0.8 mm)**] [**40 mils (1.0 mm)**] thick.
2. [**Painted**]Aluminum, [**Smooth**] [**Corrugated**] [**Stucco Embossed**] [**with Z-Shaped Locking Seam**]: [**0.016 inch (0.41 mm)**] [**0.020 inch (0.51 mm)**] [**0.024 inch (0.61 mm)**] [**0.032 inch (0.81 mm)**] [**0.040 inch (1.0 mm)**] thick.
3. Stainless Steel, Type [**304**] [**316**] [**304 or 316**], [**Smooth 2B Finish**] [**Corrugated**] [**Stucco Embossed**] [**with Z-Shaped Locking Seam**]: [**0.010 inch (0.25 mm)**] [**0.016 inch (0.41 mm)**] [**0.020 inch (0.51 mm)**] [**0.024 inch (0.61 mm)**] thick.

3.23 UNDERGROUND, FIELD-INSTALLED INSULATION JACKET

A. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

END OF SECTION 230719

SECTION 230900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

B. Related Sections include the following:

1. Section 230519 "Meters and Gages for HVAC Piping" for measuring equipment that relates to this Section.

1.3 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Master slave/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

1.4 SYSTEM PERFORMANCE

A. Comply with the following performance requirements:

1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.

4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:

   a. Water Temperature: Plus or minus 1 deg F (0.5 deg C).
   b. Water Flow: Plus or minus 5 percent of full scale.
   c. Water Pressure: Plus or minus 2 percent of full scale.
   d. Space Temperature: Plus or minus 1 deg F (0.5 deg C).
   e. Ducted Air Temperature: Plus or minus 1 deg F (0.5 deg C).
   f. Outside Air Temperature: Plus or minus 2 deg F (1.0 deg C).
   g. Dew Point Temperature: Plus or minus 3 deg F (1.5 deg C).
   h. Temperature Differential: Plus or minus 0.25 deg F (0.15 deg C).
   i. Relative Humidity: Plus or minus 5 percent.
   j. Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
   k. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
   l. Airflow (Terminal): Plus or minus 10 percent of full scale.
   m. Air Pressure (Space): Plus or minus 0.01-inch wg (2.5 Pa).
   n. Air Pressure (Ducts): Plus or minus 0.1-inch wg (25 Pa).
   o. Carbon Monoxide: Plus or minus 5 percent of reading.
   p. Carbon Dioxide: Plus or minus 50 ppm.
   q. Electrical: Plus or minus 5 percent of reading.

1.5 ACTION SUBMITTALS

A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.

1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Bill of materials of equipment indicating quantity, manufacturer, and model number.

2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
3. Wiring Diagrams: Power, signal, and control wiring.
4. Details of control panel faces, including controls, instruments, and labeling.
5. Written description of sequence of operation.
6. Schedule of dampers including size, leakage, and flow characteristics.
7. Schedule of valves including flow characteristics.
8. DDC System Hardware:

   a. Wiring diagrams for control units with termination numbers.
   b. Schematic diagrams and floor plans for field sensors and control hardware.
   c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
10. Controlled Systems:

    a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    c. Written description of sequence of operation including schematic diagram.
    d. Points list.

C. Samples for Verification: For each color required, of each type of thermostat[**or sensor**] cover.

1.6 INFORMATIONAL SUBMITTALS

A. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.

B. Qualification Data: For [**Installer**] [**and**] [**manufacturer**].

C. Software Upgrade Kit: For Cleveland Clinic to use in modifying software to suit future systems revisions or monitoring and control revisions.

D. Field quality-control test reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.

2. Interconnection wiring diagrams with identified and numbered system components and devices.
3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
5. Calibration records and list of set points.

B. Software and Firmware Operational Documentation: Include the following:

1. Software operating and upgrade manuals.
2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.
5. Software license required by and installed for DDC workstations and control systems.

1.8 MAINTENANCE MATERIAL SUBMITTALS

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

1. Replacement Materials: One replacement diaphragm or relay mechanism for each unique [**pneumatic damper motor**] [**valve motor**] [**controller**] [**thermostat**] [**positioning relay**].
2. Maintenance Materials: One thermostat adjusting key(s).
3. Maintenance Materials: One pneumatic thermostat test kit.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with ASHRAE 135 for DDC system components.

1.10 DELIVERY, STORAGE, AND HANDLING

[Retain first paragraph below if factory installation of controls is required.]

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.11 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Section 281600 "Intrusion Detection" to achieve compatibility with equipment that interfaces with that system and with building master clock.

C. Coordinate equipment with Section 281300 "Access Control" to achieve compatibility with equipment that interfaces with that system.

D. Coordinate equipment with Section 275313 "Clock Systems" to achieve compatibility with equipment that interfaces with that system.

E. Coordinate equipment with Section 284619 "PLC Electronic Detention Monitoring and Control Systems" to achieve compatibility with equipment that interfaces with that system.

F. Coordinate equipment with Section 260943 "Network Lighting Controls" to achieve compatibility with equipment that interfaces with that system.

G. Coordinate equipment with Section 283111 "Digital, Addressable Fire-Alarm System" and Section 283112 "Zoned (DC Loop) Fire-Alarm System" to achieve compatibility with equipment that interfaces with that system.

H. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

I. Coordinate equipment with Section 260913 "Electrical Power Monitoring and Control" to achieve compatibility of communication interfaces.

J. Coordinate equipment with Section 262416 "Panelboards" to achieve compatibility with starter coils and annunciation devices.

K. Coordinate equipment with Section 262419 "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

L. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Section 033000 "Cast-in-Place Concrete."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

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

2.2 CONTROL SYSTEM

A. Manufacturers:

1. Honeywell International Inc.; Home & Building Control – Controlco (Integration only)
2. Johnson Controls, Inc.; Controls Group.
3. Siemens Building Technologies, Inc.
4. TAC Americas, INC.

B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

C. Control system shall include the following:

1. Building intrusion detection system specified in Section 281600 "Intrusion Detection."
2. Building clock control system specified in Section 275313 "Clock Systems."
3. Building lighting control system specified in Section 260943 "Network Lighting Controls."
4. Fire alarm system specified in Section 283111 "Digital, Addressable Fire-Alarm System" and Section 283112 "Zoned (DC Loop) Fire-Alarm System."

2.3 DDC EQUIPMENT

A. Operator Workstation: Bring operating system up to current revision.

B. Diagnostic Terminal Unit: Portable notebook-style, PC-based microcomputer terminal capable of accessing system data by connecting to system network with minimum configuration as follows:
1. Verify requirements per project.

C. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.
b. Discrete/digital, analog, and pulse I/O.
c. Monitoring, controlling, or addressing data points.
d. Software applications, scheduling, and alarm processing.
e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Standard Application Programs:

a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.
b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
c. Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.
d. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
e. Remote communications.
f. Maintenance management.
g. Units of Measure: Inch-pound and SI (metric).

4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
5. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

D. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.
b. Discrete/digital, analog, and pulse I/O.
c. Monitoring, controlling, or addressing data points.

3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
4. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.

E. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.

3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation[**with three-position (on-off-auto) override switches and status lights**].
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA)[**with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer**].
6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
7. Universal I/Os: Provide software selectable binary or analog outputs.

F. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

G. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
2. Maximum response time of 10 nanoseconds.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.4 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.

1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.
2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. [**Perform scheduling with real-time clock.**]Perform automatic system diagnostics; monitor system and report failures.
3. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.
4. Enclosure: Dustproof rated for operation at 32 to 120 deg F (0 to 50 deg C).
[Retain subparagraph above for mounting in conditioned space; retain subparagraph below if outdoors or in wet ambient conditions.]

5. Enclosure: Waterproof rated for operation at 40 to 150 deg F (5 to 65 deg C).

2.5 ALARM PANELS

A. Unitized cabinet with suitable brackets for wall or floor mounting. Fabricate of 0.06-inch- (1.5-mm-) thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish.[**Provide common keying for all panels.**]

B. Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted on hinged cover.

1. Alarm Condition: Indicating light flashes and horn sounds.
2. Acknowledge Switch: Horn is silent and indicating light is steady.
3. Second Alarm: Horn sounds and indicating light is steady.
4. Alarm Condition Cleared: System is reset and indicating light is extinguished.
5. Contacts in alarm panel allow remote monitoring by independent alarm company.

2.6 ANALOG CONTROLLERS

A. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.

B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70 deg F (minus 23 to plus 21 deg C), and single- or double-pole contacts.

C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

1. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.

D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.

E. Receiver Controllers: Single- or multiple-input models with control-point adjustment, direct or reverse acting with mechanical set-point adjustment with locking device, proportional band adjustment, authority adjustment, and proportional control mode.

1. Remote-control-point adjustment shall be plus or minus 20 percent of sensor span, input signal of 3 to 13 psig (21 to 90 kPa).
2. Proportional band shall extend from 2 to 20 percent for 5 psig (35 kPa).
3. Authority shall be 20 to 200 percent.
4. Air-supply pressure of 18 psig (124 kPa), input signal of 3 to 15 psig (21 to 103 kPa), and output signal of zero to supply pressure.

5. Gages: [**1-1/2 inches (38 mm)**] [**2-1/2 inches (64 mm)**] [**3-1/2 inches (89 mm)**] in diameter, 2.5 percent wide-scale accuracy, and range to match transmitter input or output pressure.

2.7 TIME CLOCKS

A. Manufacturers:

1. ATC-Diversified Electronics.
2. Grasslin Controls Corporation.
3. Paragon Electric Co., Inc.
4. Precision Multiple Controls, Inc.
5. SSAC Inc.; ABB USA.
6. TCS/Basys Controls.
7. Theben AG - Lumilite Control Technology, Inc.
8. Time Mark Corporation.

B. Seven-day, programming-switch timer with synchronous-timing motor and seven-day dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.

C. Solid-state, programmable time control with [**4**] [**8**] separate programs each with up to 100 on-off operations; 1-second resolution; lithium battery backup; keyboard interface and manual override; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; system fault alarm; and communications package allowing networking of time controls and programming from PC.

2.8 ELECTRONIC SENSORS

A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

B. Thermistor Temperature Sensors and Transmitters:

1. Manufacturers:

   a. BEC Controls Corporation.
   b. Ebtron, Inc.
   c. Heat-Timer Corporation.
   d. I.T.M. Instruments Inc.
   e. MAMAC Systems, Inc.
   f. RDF Corporation.

2. Accuracy: Plus or minus [**0.5 deg F (0.3 deg C)**] [**0.36 deg F (0.2 deg C)**] at calibration point.
3. Wire: Twisted, shielded-pair cable.

4. Insertion Elements in Ducts: Single point, [**8 inches (200 mm)**] [**18 inches (460 mm)**] long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (0.84 sq. m).
5. Averaging Elements in Ducts: [**36 inches (915 mm) long, flexible**] [**72 inches (1830 mm) long, flexible**] [**18 inches (460 mm) long, rigid**]; use where prone to temperature stratification or where ducts are larger than 10 sq. ft. (1 sq. m).
6. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches (64 mm).
7. Room Sensor Cover Construction: Manufacturer's standard locking covers.

   a. Set-Point Adjustment: [**Concealed**] [**Exposed**].
   b. Set-Point Indication: [**Concealed**] [**Keyed**] [**Exposed**].
   c. Thermometer: [**Concealed**] [**Exposed**] [**Red-reading glass**] [**Spiral bimetal**].
   d. Color: <**Insert color from manufacturer's full range.**>
   e. Orientation: [**Vertical**] [**Horizontal**].

8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
9. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

C. RTDs and Transmitters:

1. Manufacturers:

   a. BEC Controls Corporation.
   b. MAMAC Systems, Inc.
   c. RDF Corporation.

2. Accuracy: Plus or minus 0.2 percent at calibration point.
3. Wire: Twisted, shielded-pair cable.
4. Insertion Elements in Ducts: Single point, [**8 inches (200 mm)**] [**18 inches (460 mm)**] long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (0.84 sq. m).
5. Averaging Elements in Ducts: [**18 inches (460 mm) long, rigid**] [**24 inches (610 mm) long, rigid**] [**48 inches (1200 mm) long, rigid**] [**24 feet (7.3 m) long, flexible**]; use where prone to temperature stratification or where ducts are larger than 9 sq. ft. (0.84 sq. m); length as required.
6. Insertion Elements for Liquids: Brass socket with minimum insertion length of 2-1/2 inches (64 mm).
7. Room Sensor Cover Construction: Manufacturer's standard locking covers.

   a. Set-Point Adjustment: [**Concealed**] [**Exposed**].
   b. Set-Point Indication: [**Concealed**] [**Keyed**] [**Exposed**].
   c. Thermometer: [**Concealed**] [**Exposed**] [**Red-reading glass**] [**Spiral bimetal**].
   d. Color: <**Insert color from manufacturer's full range.**>
   e. Orientation: [**Vertical**] [**Horizontal**].

8. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
9. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.

D. Humidity Sensors: Bulk polymer sensor element.

1. Manufacturers:

    a. BEC Controls Corporation.
    b. General Eastern Instruments.
    c. MAMAC Systems, Inc.
    d. ROTRONIC Instrument Corp.
    e. TCS/Basys Controls.
    f. Vaisala.

2. Accuracy: [**5**] [**2**] percent full range with linear output.
3. Room Sensor Range: 20 to 80 percent relative humidity.
4. Room Sensor Cover Construction: Manufacturer's standard locking covers.

    a. Set-Point Adjustment: [**Concealed**] [**Exposed**].
    b. Set-Point Indication: [**Concealed**] [**Keyed**] [**Exposed**].
    c. Thermometer: [**Concealed**] [**Exposed**] [**Red-reading glass**] [**Spiral bimetal**].
    d. Color: <**Insert color from manufacturer's full range.**>
    e. Orientation: [**Vertical**] [**Horizontal**].

5. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
6. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of [**32 to 120 deg F (0 to 50 deg C)**] [**minus 22 to plus 185 deg F (minus 30 to plus 85 deg C)**] [**minus 40 to plus 170 deg F (minus 40 to plus 76 deg C)**].
7. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.

E. Pressure Transmitters/Transducers:

1. Manufacturers:

    a. BEC Controls Corporation.
    b. General Eastern Instruments.
    c. MAMAC Systems, Inc.
    d. ROTRONIC Instrument Corp.
    e. TCS/Basys Controls.
    f. Vaisala.

2. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.

    a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
    b. Output: 4 to 20 mA.
    c. Building Static-Pressure Range: 0- to 0.25-inch wg (0 to 62 Pa).
    d. Duct Static-Pressure Range: 0- to 5-inch wg (0 to 1240 Pa).

3. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure; linear output 4 to 20 mA.

4. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure and tested to 300-psig (2070-kPa); linear output 4 to 20 mA.
5. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
6. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

F. Room Sensor Cover Construction: Manufacturer's standard locking covers.

1. Set-Point Adjustment: [**Concealed**] [**Exposed**].
2. Set-Point Indication: [**Concealed**] [**Keyed**] [**Exposed**].
3. Thermometer: [**Concealed**] [**Exposed**] [**Red-reading glass**] [**Spiral bimetal**].
4. Color: <**Insert color from manufacturer's full range.**>
5. Orientation: [**Vertical**] [**Horizontal**].

G. Room sensor accessories include the following:

1. Insulating Bases: For sensors located on exterior walls.
2. Guards: [**Locking; heavy-duty, transparent plastic; mounted on separate base**] [**Metal wire, tamperproof**] [**Locking, solid metal, ventilated**].
3. Adjusting Key: As required for calibration and cover screws.

2.9 PNEUMATIC SENSORS

A. Pneumatic Transmitters: Vibration and corrosion resistant.

1. Space-Temperature Sensors: Linear-output type, 50 to 100 deg F (10 to 38 deg C) range, with blank locking covers matching room thermostats.
2. Room Return-Air Temperature Sensors: Linear-output type with bimetal sensing element and corrosion-proof construction, 50 to 100 deg F (10 to 38 deg C) range, designed to be mounted in light troffers.
3. Duct-Mounted or Immersion-Type Temperature Sensors: Range as required for 3- to 15-psig (21- to 103-kPa) output signal.
4. Temperature Transmitters: Rigid-stem type with bimetal sensing elements unless averaging is required, 3- to 15-psig (21- to 103-kPa) output signal.

   a. Averaging-Element Sensors: Single- or multiple-unit capillary elements.
   b. Tamperproof Sensors: Corrosion-resistant construction, suitable for mounting on vibrating surface with exposed capillary protected with temperature-compensated armor or protective tubing.
   c. Pipe-Mounted Temperature-Sensing Elements: Rod-and-tube type; with separable wells filled with heat-conductive compound.
   d. Outdoors: Provide bulb shield with mounting bracket.

5. Space and Duct Humidity Transmitters: One pipe, directly proportional, with minimum sensing span of 20 to 80 percent relative humidity for 3- to 15-psig (21- to 103-kPa) output signal, corrosion resistant and temperature compensated, and with factory-calibrated adjustment.

a. Space Mounting: With covers to match thermostats.

6. Differential-Pressure Transmitters: One pipe, direct acting for gas, liquid, or steam service; pressure sensor and transmitter of linear-output type; with range of 0 to 50 psig (0 to 344 kPa), and 3- to 15-psig (21- to 103-kPa) output signal.
7. Differential-Air-Pressure Transmitters: One pipe, direct acting, double bell; unidirectional with suitable range for expected input; and temperature compensated.

a. Accuracy: 5 percent of full range and 2 percent of full scale at midrange.
b. Output Signal: 3 to 15 psig (21 to 103 kPa).

B. Digital-to-Pneumatic Transducers: Convert plus or minus 12-V dc pulse-width-modulation outputs, or continuous proportional current or voltage to 0 to 20 psig (0 to 140 kPa).

1. Manufacturers:

a. BEC Controls Corporation.
b. MAMAC Systems, Inc.

C. Pneumatic Valve/Damper Position Indicator: Potentiometer mounted in enclosure with adjustable crank-arm assembly connected to damper to transmit 0 to 100 percent valve/damper travel.

2.10 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg (0 to 1240 Pa).

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig (55 to 414 kPa), piped across pump.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.

E. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

H. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

1. Manufacturers:

a. BEC Controls Corporation.
b. I.T.M. Instruments Inc.

2.11 GAS DETECTION EQUIPMENT

A. Manufacturers:

1. B. W. Technologies.
2. CEA Instruments, Inc.
3. Ebtron, Inc.
4. Gems Sensors Inc.
5. Greystone Energy Systems Inc.
6. Honeywell International Inc.; Home & Building Control.
7. INTEC Controls, Inc.
8. I.T.M. Instruments Inc.
9. MSA Canada Inc.
10. QEL/Quatrosense Environmental Limited.
11. Sauter Controls Corporation.
12. Sensidyne, Inc.
13. TSI Incorporated.
14. Vaisala.
15. Vulcain Inc.

B. Carbon Monoxide Detectors: Single or multichannel, dual-level detectors using solid-state plug-in sensors with a 3-year minimum life; suitable over a temperature range of 32 to 104 deg F (0 to 40 deg C); with 2 factory-calibrated alarm levels at [**50 and 100**] [**35 and 200**] ppm.

C. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 deg F (minus 5 to plus 55 deg C) and calibrated for 0 to 2 percent, with continuous or averaged reading, 4- to 20-mA output;, for wall mounting.

D. Oxygen Sensor and Transmitter: Single detectors using solid-state zircon cell sensing; suitable over a temperature range of minus 32 to plus 1100 deg F (0 to 593 deg C) and calibrated for 0 to 5 percent, with continuous or averaged reading, 4- to 20-mA output; for wall mounting.

E. Occupancy Sensor: Passive infrared, with time delay, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment; for flush mounting.

2.12 FLOW MEASURING STATIONS

A. Duct Airflow Station: Combination of air straightener and multiport, self-averaging pitot tube station.

1. Manufacturers:

    a. Air Monitor Corporation.
    b. Wetmaster Co., Ltd.

2. Casing: Galvanized-steel frame.
3. Flow Straightener: Aluminum honeycomb, 3/4-inch (20-mm) parallel cell, 3 inches (75 mm) deep.
4. Sensing Manifold: Copper manifold with bullet-nosed static pressure sensors positioned on equal area basis.

2.13 THERMOSTATS

A. Manufacturers:

    1. Erie Controls.
    2. Danfoss Inc.; Air-Conditioning and Refrigeration Div.
    3. Heat-Timer Corporation.
    4. Sauter Controls Corporation.
    5. tekmar Control Systems, Inc.
    6. Theben AG - Lumilite Control Technology, Inc.

B. Combination Thermostat and Fan Switches: Line-voltage thermostat with push-button or lever-operated fan switch.

    1. Label switches [**"FAN ON-OFF"**] [**"FAN HIGH-LOW-OFF"**] [**"FAN HIGH-MED-LOW-OFF"**].
    2. Mount on single electric switch box.

C. Electric, solid-state, microcomputer-based room thermostat with remote sensor.

    1. Automatic switching from heating to cooling.
    2. Preferential rate control to minimize overshoot and deviation from set point.
    3. Set up for four separate temperatures per day.
    4. Instant override of set point for continuous or timed period from 1 hour to 31 days.
    5. Short-cycle protection.
    6. Programming based on [**weekday, Saturday, and Sunday**] [**every day of week**].
    7. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable, remote sensor, and fan on-auto.
    8. Battery replacement without program loss.
    9. Thermostat display features include the following:

        a. Time of day.
        b. Actual room temperature.
        c. Programmed temperature.
        d. Programmed time.
        e. Duration of timed override.
        f. Day of week.
        g. System mode indications include "heating," "off," "fan auto," and "fan on."

D. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, 55 to 85 deg F (13 to 30 deg C) set-point range, and 2 deg F (1 deg C) maximum differential.

E. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, 55 to 85 deg F (13 to 30 deg C) set-point range, and 2 deg F (1 deg C) maximum differential.

1. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
2. Selector Switch: Integral, manual on-off-auto.

F. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.

1. Bulbs in water lines with separate wells of same material as bulb.
2. Bulbs in air ducts with flanges and shields.
3. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
4. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
5. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
6. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.

G. Fire-Protection Thermostats: Listed and labeled by an NRTL acceptable to authorities having jurisdiction; with fixed or adjustable settings to operate at not less than 75 deg F (24 deg C) above normal maximum operating temperature, and the following:

1. Reset: Manual.

H. Pneumatic Room Thermostats: [**One**] [**Two**] [**Three**] pipe(s), fully proportional with adjustable throttling range and tamperproof locking settings, direct or reverse acting as required. Factory calibrated at 2.5 psig/deg F (17.2 kPa/deg C).

1. Factory Calibration: 2.5 psig/deg F (17.2 kPa/deg C).
2. Range: 45 to 85 deg F (7 to 30 deg C).
3. Sensitivity Adjustment Range: 1 to 4 psig/deg F (7 to 27.6 kPa/deg C).
4. Dual-Temperature Thermostats: Automatic changeover from normal setting to lower setting for unoccupied cycles, with manual-reset lever to permit return to normal temperatures during unoccupied cycles, with automatic reset to normal during next cycle of operation.
5. Limits: Field adjustable, to limit setting cooling set point below 75 deg F (24 deg C), and heating set point above 75 deg F (24 deg C).
6. Room Thermostat Cover Construction: Manufacturer's standard locking covers.

a. Set-Point Adjustment: [**Concealed**] [**Exposed**].
b. Set-Point Indication: [**Concealed**] [**Keyed**] [**Exposed**].
c. Thermometer: [**Concealed**] [**Exposed**] [**Red-reading glass**] [**Spiral bimetal**].

d. Color: <**Insert color from manufacturer's full range.**>
e. Orientation: [**Vertical**] [**Horizontal**].

7. Room thermostat accessories include the following:

a. Insulating Bases: For thermostats located on exterior walls.
b. Thermostat Guards: [**Locking; heavy-duty, transparent plastic; mounted on separate base**] [**Metal wire, tamperproof**] [**Locking, solid metal, ventilated**].
c. Adjusting Key: As required for calibration and cover screws.
d. Aspirating Boxes: For flush-mounted aspirating thermostats.
e. Set-Point Adjustment: 1/2-inch- (13-mm-) diameter, adjustment knob.

I. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.

J. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type; with adjustable set point in middle of range, adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.

K. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- [**or automatic-**]reset switch that trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or below set point.

1. Bulb Length: Minimum 20 feet (6 m).
2. Quantity: One thermostat for every 20 sq. ft. (2 sq. m) of coil surface.

L. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- [**or automatic-**]reset switch that trips if temperature sensed across any 12 inches (300 mm) of bulb length is equal to or above set point.

1. Bulb Length: Minimum 20 feet (6 m).
2. Quantity: One thermostat for every 20 sq. ft. (2 sq. m) of coil surface.

M. Heating/Cooling Valve-Top Thermostats: Proportional acting for proportional flow, with molded-rubber diaphragm, remote-bulb liquid-filled element, direct and reverse acting at minimum shutoff pressure of 25 psig (172 kPa), and cast housing with position indicator and adjusting knob.

2.14 HUMIDISTATS

A. Manufacturers:

1. MAMAC Systems, Inc.
2. ROTRONIC Instrument Corp.

B. Pneumatic Room Humidistats: Wall-mounting, proportioning type with adjustable throttling range, [**20 to 90**] [**55 to 95**] [**25 to 65**] percent operating range, and cover matching room thermostat cover.

C. Duct-Mounting Humidistats: Electric insertion, 2-position type with adjustable, 2 percent throttling range, 20 to 80 percent operating range, and single- or double-pole contacts.

D. Pneumatic Duct-Mounting Humidistats: Proportioning type with adjustable throttling range, [**20 to 90**] [**55 to 95**] [**25 to 65**] percent operating range, in galvanized-steel duct box.

2.15 ACTUATORS

A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.

1. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
3. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
4. Spring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
5. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
6. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).

B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.

1. Manufacturers:

   a. Belimo Aircontrols (USA), Inc.

2. Valves: Size for torque required for valve close off at maximum pump differential pressure.
3. Dampers: Size for running torque calculated as follows:

   a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
   b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
   c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
   d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
   e. Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
   f. Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.

4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Power Requirements (Two-Position Spring Return): [**24**] [**120**] [**230**]-V ac.
8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
10. Temperature Rating: [**Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C)**] [**40 to 104 deg F (5 to 40 deg C)**].
11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F (Minus 30 to plus 121 deg C).
12. Run Time: [**12 seconds open, 5 seconds closed**] [**30 seconds**] [**60 seconds**] [**120 seconds**].

C. Pneumatic Valve Operators: Rolling-diaphragm, spring-loaded, piston type with spring range as required and start-point adjustment[**and positioning relay**]. Operator shall maintain full shutoff at maximum pump differential pressure.

D. Pneumatic Damper Operators: Rolling-diaphragm, piston type with adjustable stops and spring return, sized to operate with sufficient reserve power to provide smooth modulating action or two-position action. Where actuators operate in sequence, provide pilot positioners.

1. Pilot Positioners: With the following characteristics:

   a. Start Point: Adjustable from 2 to 12 psig (14 to 83 kPa).
   b. Operating Span: Adjustable from 5 to 13 psig (35 to 90 kPa).
   c. Linearity: Plus or minus 10 percent of output signal span.
   d. Hysteresis: 3 percent of span.
   e. Response: 0.25-psig (1723-Pa) input change.
   f. Maximum Pilot Signal Pressure: 20 psig (140 kPa).
   g. Maximum Control Air-Supply Pressure: 60 psig (410 kPa).

2. Actuator Housing: Molded or die-cast zinc or aluminum.[**Terminal unit actuators may be high-impact plastic with ambient temperature rating of 50 to 140 deg F (10 to 60 deg C) unless located in return-air plenums.**]
3. Inlet-Vane Operators: High pressure, with pilot positioners.

2.16 CONTROL VALVES

A. Manufacturers:

1. Danfoss Inc.; Air Conditioning & Refrigeration Div.
2. Erie Controls.
3. Hayward Industrial Products, Inc.
4. Magnatrol Valve Corporation.
5. Neles-Jamesbury.
6. Parker Hannifin Corporation; Skinner Valve Division.
7. Pneuline Controls.
8. Sauter Controls Corporation.

B. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.

C. Hydronic system globe valves shall have the following characteristics:

1. NPS 2 (DN 50) and Smaller: Class [**125**] [**250**] bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 2-1/2 (DN 65) and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.

a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.

4. Sizing: [**3-psig (21-kPa)**] [**5-psig (35-kPa)**] maximum pressure drop at design flow rate or the following:

a. Two Position: Line size.
b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.

5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

D. Steam system globe valves shall have the following characteristics:

1. NPS 2 (DN 50) and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 2-1/2 (DN 65) and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel seats.

a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.

4. Sizing: For pressure drop based on the following services:

a. Two Position: 20 percent of inlet pressure.
b. Modulating **15-psig (103-kPa)** Steam: 80 percent of inlet steam pressure.

c. Modulating **16- to 50-psig (110- to 350-kPa)** Steam: 50 percent of inlet steam pressure.

d. Modulating More Than **50-psig (350-kPa)** Steam: As indicated.

5. Flow Characteristics: Modified linear characteristics.
6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of operating (inlet) pressure.

E. Butterfly Valves: 200-psig (1380-kPa), 150-psig (1034-kPa) maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.

1. Body Style: [**Wafer**] [**Lug**] [**Grooved**].
2. Disc Type: [**Nickel-plated ductile iron**] [**Aluminum bronze**] [**Elastomer-coated ductile iron**] [**Epoxy-coated ductile iron**].
3. Sizing: 1-psig (7-kPa) maximum pressure drop at design flow rate.

F. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig (860 kPa) and 250 deg F (121 deg C) operating conditions.
2. Sizing: 3-psig (21-kPa) maximum pressure drop at design flow rate, to close against pump shutoff head.
3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

G. Self-Contained Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig (860 kPa) and 250 deg F (121 deg C) operating conditions.
2. Thermostatic Operator: [**Wax**] [**Liquid**]-filled [**integral**] [**remote**] sensor with [**integral**] [**remote**] adjustable dial.

2.17 DAMPERS

A. Manufacturers:

1. Air Balance Inc.
2. Don Park Inc.; Autodamp Div.
3. TAMCO (T. A. Morrison & Co. Inc.).
4. United Enertech Corp.
5. Vent Products Company, Inc.

B. Dampers: AMCA-rated, [**parallel**] [**opposed**]-blade design; 0.108-inch- (2.8-mm-) minimum thick, galvanized-steel or 0.125-inch- (3.2-mm-) minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- (1.6-mm-) thick galvanized steel with maximum blade width of 8 inches (200 mm) and length of 48 inches (1220 mm).

1. Secure blades to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with [**oil-impregnated sintered bronze**] [**nylon**] blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
2. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
3. Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. (50 L/s per sq. m) of damper area, at differential pressure of 4-inch wg (1000 Pa) when damper is held by torque of 50 in. x lbf (5.6 N x m); when tested according to AMCA 500D.

2.18 AIR SUPPLY

A. Manufacturers:

1. Drainview Products.
2. Pneuline Controls.

B. Control and Instrumentation Tubing: Copper tubing complying with ASTM B 88, Type K (ASTM B 88M, Type A) or ASTM B 280 Type ACR.

1. Fittings: Cast-bronze solder fittings complying with ASME B16.18; or wrought-copper solder fittings complying with ASME B16.22, except forged-brass compression-type fittings at connections to equipment.
2. Joining Method: Soldered or brazed.

C. Tank: ASME storage tank with drain test cock, automatic moisture removal trap, tank relief valve, and rubber-cork vibration isolation mounting pads.

D. Duplex Air Compressor: Capacity to supply compressed air to temperature-control system.

1. Pressure control with adjustable electric contacts, set to start and stop both compressors at different pressures.
2. Electrical alternation set with motor starters and disconnect to operate compressors alternately or on time schedule.

E. Compressor Type: [**Reciprocating**] [**Scroll**].

F. Size compressor and tank to operate compressor not more than [**20**] [**30**] minutes during a 60-minute period.

G. Compressor Accessories: Low-resistance intake-air filter, and belt guards.

H. System Accessories: Air filter rated for 97 percent efficiency at rated airflow, and combination filter/pressure-reducing station or separate filter and pressure-reducing station.

I. Refrigerated Air Dryer: Self-contained, refrigerated air dryer complete with heat exchangers, moisture separator, internal wiring and piping, and with manual bypass valve.

1. Heat Exchangers: Air-to-refrigerant coils with centrifugal-type moisture separator and automatic trap assembly.
2. Refrigeration Unit: Hermetically sealed, operating to maintain dew point of 13 deg F (minus 11 deg C) at 20 psig (140 kPa), housed in steel cabinet with access door and panel.
3. Accessories: Air-inlet temperature gage, air-inlet pressure gage, on-off switch, high-temperature light, power-on light, refrigerant gage on back, air-outlet temperature gage, air-outlet pressure gage, and with contacts for remote indication of power status and high-temperature alarm.

J. Desiccant Dryer: Obtains dew point in pneumatic air piping between compressor and tank at least 15 deg F (minus 9 deg C) below inlet-air dew point at design conditions.

K. Pressure Gages: Black letters on white background, 2-1/2 inches (64 mm) in diameter, flush or surface mounting, with front calibration screw to match sensor, and having a graduated scale in psig (kPa).

L. Instrument Pressure Gages: Black letters on white background, 1-1/2 inches (38 mm) in diameter, stem mounted, with suitable dial range.

M. Diaphragm Control and Instrument Valves: 1/4-inch (6-mm) forged-brass body with reinforced polytetrafluoroethylene diaphragm, stainless-steel spring, and color-coded phenolic handle.

N. Gage Cocks: Tee or level handle, bronze, rated for 125 psig (860 kPa).

O. Relays: For summing, reversing, and amplifying highest or lowest pressure selection; with adjustable I/O ratio.

P. Switches: With indicating plates and accessible adjustment; calibrated and marked.

Q. Pressure Regulators: Zinc or aluminum castings with elastomeric diaphragm, balanced construction to automatically prevent pressure buildup, and producing flat reduced-pressure curve.

R. Particle Filters: Zinc or aluminum castings with 97 percent filtration efficiency at rated airflow, quick-disconnect service devices, and aluminum or plastic bowl with metal guard and manual drain cock.

S. Combination Filter/Regulators: Zinc or aluminum castings with elastomeric diaphragm, balanced construction to automatically prevent pressure buildup, and producing flat reduced-pressure curve; with threaded pipe connections, quick-disconnect service devices, and aluminum or plastic bowl with metal guard and manual drain cock.

T. Airborne Oil Filter: Filtration efficiency of 99.9 percent for airborne lubricating oil particles of 0.025 micron or larger.

U. Pressure Relief Valves: ASME rated and labeled.

1. High Pressure: Size for installed capacity.
2. Low Pressure: Size for installed capacity of pressure regulators and set at 20 percent above low pressure.

V. Pressure-Reducing Stations: Two parallel pressure regulators.

2.19 CONTROL CABLE

A. Electronic and fiber-optic cables for control wiring are specified in Section 271500 "Communications Horizontal Cabling."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that [**conditioned**]power supply is available to control units and operator workstation.

B. Verify that pneumatic piping and duct-, pipe-, and equipment-mounted devices are installed before proceeding with installation.

3.2 INSTALLATION

A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.

B. Connect and configure equipment and software to achieve sequence of operation specified.

C. Mount compressor and tank unit on [**elastomeric mounts**] [**spring isolators with 1-inch (25 mm) static deflection**] [**restrained spring isolators with 1-inch (25-mm) static deflection**]. Vibration isolators are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment." Isolate air supply with wire-braid-reinforced rubber hose. Secure and anchor according to manufacturer's written instructions and seismic-control requirements.

1. Pipe manual and automatic drains to nearest floor drain.
2. Supply instrument air from compressor units through filter, pressure-reducing valve, and pressure relief valve, with pressure gages and shutoff and bypass valves.

D. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices [**48 inches (1220 mm)**] [**60 inches (1530 mm)**] above the floor.

1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

E. Install guards on thermostats in the following locations:

1. Entrances.
2. Public areas.
3. Where indicated.

F. Install automatic dampers according to Section 233300 "Air Duct Accessories."

G. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

H. Install labels and nameplates to identify control components according to Section 230553 "Identification for HVAC Piping and Equipment."

I. Install hydronic instrument wells, valves, and other accessories according to Section 232113 "Hydronic Piping."

J. Install steam and condensate instrument wells, valves, and other accessories according to Section 232213 "Steam and Condensate Heating Piping."

K. Install refrigerant instrument wells, valves, and other accessories according to Section 232300 "Refrigerant Piping."

L. Install duct volume-control dampers according to Section 233113 "Metal Ducts" and Section 233116 "Nonmetal Ducts."

M. Install electronic and fiber-optic cables according to Section 271500 "Communications Horizontal Cabling."

3.3 PNEUMATIC PIPING INSTALLATION

A. Install piping in mechanical equipment rooms inside mechanical equipment enclosures, in pipe chases, or suspended ceilings with easy access.

1. Install copper tubing with maximum unsupported length of 36 inches (915 mm), for tubing exposed to view.
2. Install polyethylene tubing in metallic raceways or electrical metallic tubing. Electrical metallic tubing materials and installation requirements are specified in Section 260533 "Raceways and Boxes for Electrical Systems."

B. Install terminal single-line connections, less than 18 inches (460 mm) in length, with copper or polyethylene tubing run inside flexible steel protection.

C. In concealed locations such as pipe chases and suspended ceilings with easy access, install [**copper**] [**polyethylene bundled and sheathed**] [**polyethylene tubing in electrical metallic**] tubing. Electrical metallic tubing materials and installation requirements are specified in Section 260533 "Raceways and Boxes for Electrical Systems."

D. In concrete slabs, furred walls, or ceilings with no access, install copper or polyethylene tubing in electrical metallic tubing or vinyl-jacketed polyethylene tubing.

1. Protect embedded-copper and vinyl-jacketed polyethylene tubing with electrical metallic tubing extending 6 inches (150 mm) above finished slab and 6 inches (150 mm) into slab. Pressure test tubing before and after pour for leak and pinch.
2. Install polyethylene tubing in electrical metallic tubing extending 6 inches (150 mm) above floor line; pull tubing into electrical metallic tubing after pour.

E. Install tubing with sufficient slack and flexible connections to allow for vibration of piping and equipment.

F. Purge tubing with dry, oil-free compressed air before connecting control instruments.

1. Bridge cabinets and doors with flexible connections fastened along hinge side; protect against abrasion. Tie and support tubing.

G. Number-code or color-code control air piping for future identification and service of control system, except local individual room control tubing.

H. Pressure Gages or Test Plugs: Install on branch lines at each receiver controller and on signal lines at each transmitter, except individual room controllers.

3.4 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. Install raceways, boxes, and cabinets according to Section 260533 "Raceways and Boxes for Electrical Systems."

B. Install building wire and cable according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

C. Install signal and communication cable according to Section 271500 "Communications Horizontal Cabling."

1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
2. Install exposed cable in raceway.
3. Install concealed cable in raceway.
4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.

D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect[**, test, and adjust**] field-assembled components and equipment installation, including connections[**, and to assist in field testing**]. Report results in writing.

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

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
4. Pressure test control air piping at 30 psig (207 kPa) or 1.5 times the operating pressure for 24 hours, with maximum 5-psig (35-kPa) loss.
5. Test calibration of [**pneumatic**] [**electronic**] controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
6. Test each point through its full operating range to verify that safety and operating control set points are as required.
7. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
8. Test each system for compliance with sequence of operation.
9. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check installation of air supply for each instrument.
6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
8. Check temperature instruments and material and length of sensing elements.
9. Check control valves. Verify that they are in correct direction.
10. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
11. Check DDC system as follows:

    a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.6 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.

2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:

    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Flow:

    a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
    b. Manually operate flow switches to verify that they make or break contact.

6. Pressure:

    a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:

    a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
    b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 230900

SECTION 231113 - FACILITY FUEL-OIL PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes diesel-fuel-oil distribution systems and the following:

1. Underground Fuel Oil Piping
2. Underground Fuel Oil Vent Piping
3. Underground Fuel Oil Transfer Sumps
4. Fiberglass Underground Storage Tanks (Double Wall)
5. Fuel Tank and Piping Monitoring System
6. Fuel Filtration System
7. Fuel Transfer Pump Package
8. Day Tank and Transfer Tank with Containment Basin and Transfer Pumps
9. Submersible Turbine Pump
10. Tank Selection and Main Tank Pump Controller
11. Underground Warning Tape

1.3 DEFINITIONS

A. AST: Aboveground storage tank.

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

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

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

E. FPM: Vinylidene fluoride-hexafluoropropylene copolymer rubber.

F. FRP: Glass-fiber-reinforced plastic.

G. UST: Underground storage tank.

1.4 PERFORMANCE REQUIREMENTS

A. Maximum Operating-Pressure Ratings: Manufacturer recommended fuel-oil supply pressure at oil-fired appliances.

B. Delegated Design: Design restraint and anchors for fuel-oil piping, ASTs, and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

C. Seismic Performance: Factory-installed support attachments for AST shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, and dimensions of individual components and profiles. Also include, where applicable, rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1. Piping specialties.
2. Valves: Include pressure rating, capacity, settings, and electrical connection data of selected models.
3. Each type and size of fuel-oil storage tank. Indicate dimensions, weights, loads, components, and location and size of each field connection.
4. Fuel-oil storage tank accessories.
5. Fuel-oil storage tank piping specialties.
6. Fuel-oil storage tank pumps.
7. Fuel-oil transfer pumps.
8. Fuel maintenance system.
9. Liquid-level gage system.
10. Leak-detection and monitoring system.

B. Shop Drawings: For facility fuel-oil piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1. Shop Drawing Scale: **1/4 inch per foot (1:50)**.
2. For fuel-oil storage tanks and pumps, include details of supports and anchors.

C. Delegated-Design Submittal: For fuel-oil piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of anchors and seismic restraints.
2. Design Calculations: Calculate requirements for selecting seismic restraints.

3. Detail fabrication and assembly of pipe anchors, hangers, supports for multiple pipes, and attachments of the same to building structure.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans and details, drawn to scale, on which fuel-oil piping is shown and coordinated with other installations, using input from installers of the items involved.

B. Site Survey: Plans, drawn to scale, on which fuel-oil piping and tanks are shown and coordinated with other services and utilities.

C. Qualification Data: For qualified professional engineer.

D. Seismic Qualification Certificates: For ASTs, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Brazing certificates.

F. Welding certificates.

G. Field quality-control reports.

H. Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuel-oil equipment and accessories to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

A. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

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

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

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.

E. Comply with ASME B31.9, "Building Services Piping," for fuel-oil piping materials, installation, testing, and inspecting.

F. Comply with requirements of the EPA and of state and local authorities having jurisdiction. Include recording of fuel-oil storage tanks and monitoring of tanks and piping.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Lift and support fuel-oil storage tanks only at designated lifting or supporting points, as shown on Shop Drawings. Do not move or lift tanks unless empty.

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

C. Store pipes and tubes with protective PE coating to avoid damaging the coating and to protect from direct sunlight.

D. Store PE pipes and valves protected from direct sunlight.

1.10 PROJECT CONDITIONS

A. Interruption of Existing Fuel-Oil Service: Do not interrupt fuel-oil service to facilities occupied by Cleveland Clinic or others unless permitted under the following conditions and then only after arranging to provide temporary fuel-oil supply according to requirements indicated:

1. Notify the Cleveland Clinic no fewer than seven days in advance of proposed interruption of fuel-oil service.
2. Do not proceed with interruption of fuel-oil service without the Cleveland Clinic’s written permission.

1.11 COORDINATION

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

1.12 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-oil storage tanks and flexible, double-containment piping and related equipment that fail in materials or workmanship within specified warranty period.

1. Storage Tanks:

a. Failures include, but are not limited to, the following when used for storage of fuel oil at temperatures not exceeding **150 deg F** **(66 deg C)**:

1) Structural failures including cracking, breakup, and collapse.

2) Corrosion failure including external and internal corrosion of steel tanks.

b. Warranty Period: 30 years from date of Substantial Completion.

2. Flexible, Double-Containment Piping and Related Equipment:

a. Failures due to defective materials or workmanship for materials installed together, including piping, dispenser sumps, entry boots, and sump mounting adapters.
b. Warranty Period: 30 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL

A. The products in this section shall all be supplied by one company. There will be no substitutions from manufactures listed.

B. Approved Manufacturer:

1. Service Station Equipment.

C. Shutoff valves in fuel oil system: cast steel, Milwaukee Ball Valve,(or equal) F91CS, carbon steel, stainless steel ball, 300 PSI.

D. Back Pressure Valve: Cash

2.2 PIPING, VALVES, STRAINERS, AND PIPING ACCESSORIES

A. Fusible emergency shutoff valve shall be as manufactured by Morrison Brothers company or approved equivalent sizes 1 "and smaller shall be Model 939, sizes larger than 1" shall be Model 346D1.

2.3 UNDERGROUND FUEL OIL PIPING

A. The piping system shall meet all of the applicable performance specifications and regulatory agency requirements set forth by the following organizations: Underwriters Laboratories (UL), Institute of Petroleum (IP), National Fire Protection Agency (NFPA), Environmental Protection Agency (EPA), International Standards Organization (ISO), Plastic Pipe Institute (PPI).

B. The piping shall be of a double wall construction, with the primary pipe loosely fitting into the secondary pipe. Standoff legs on the inside of the secondary pipe will allow rapid communications of leaks to a containment chamber. Both the primary and secondary pipes shall be fluorinated on the inside and outside of the pipe offering the maximum fuel resistance. This fluorination layer will be integrated into the matrix of the pipe thus preventing any possibility of delaminating. The pipe used shall carry the UL971 listing marks from Underwriters Laboratories. The piping shall have a 30 year manufacturing warranty. Piping shall have a bend radius of 25 times the OD of the pipe, with an operating temperature range of -40°F (-40°C) and +140°F (+60°C). The primary pipe shall be capable of being pressure tested to 150psi, while the secondary pipe shall be capable of being tested to 50psi. The primary and secondary piping shall also be rated for vacuums of up to -14.5psi.

C. Fittings will be fluorinated electro fusion type, and of an HDPE material. The manufacturer of these fittings shall be Frialen. Fittings which include couplers, elbows, tees and HDPE to steel terminations will be electro fused to the pipe. Only fittings supplied by the manufacturer shall be used and will all carry an Underwriters Laboratories listing to UL971. Fittings which are electro fused shall only be fused using equipment specifically designed to do so and supplied by the manufacturer. The electro fusion machine must have a double check system with error and memory facility, a printing facility, while having the ability to sense ambient temperature in order auto correct the welding times. The memory, error reporting and printing facilities shall be used for all installations. All electro fusion fittings shall be individually bar coded as a method of being singularly identified by the electro fusion welder, and preventing the operator with tampering with temperatures and welding times. This bar code shall be entered either with a scanner or manually. The fittings shall also have a traceability barcode in order to trace the fitting manufacture to the raw materials.

D. Penetrations into sumps shall be made either with high Nitrile entry boots or with fluorinated LDPE electro fusion entry boots. All parts of the penetration boots in contact with the environment shall be manufactured of non-metallic components, while inside the sump any metallic screws shall be manufactured from brass. Test boots shall be used inside the sumps. Test boots shall also be manufactured of high Nitrile rubber and will have a Schroeder valve to allow testing of the interstitial space between the primary and secondary pipe.

E. Manufacturer: basis of design is IPP using Marley Petroplas Fluorinated double wall pipe and Frialen Electro Fusion fittings. Equals will be considered as long as they are proven equal in design and/or performance.

2.4 UNDERGROUND FUEL OIL VENT PIPING

A. Primary and Secondary pipe shall have continuous glass fibers filament in a matrix of epoxy resin. Pipe shall be in compliance with ASTM D2310. Pipe shall be factory tested per manufacturer recommendations.

B. Fittings- Compression molded fittings shall be manufactured using an epoxy on primary and vinyl ester for secondary molding compound. The molding compound shall be reinforced with chopped glass fiber.

C. Adhesives- adhesive and curing agents shall be either UL Listed 8000 or 7000 series adhesive.

D. Pipe and fittings shall be joined with 8000 or 7000 series adhesives using matching tapered bell/coupling and spigot. Pipe shall be installed per manufacturer's recommendations.

E. Primary pipe systems should be tested prior to use to assure soundness of all joints and connections per manufacturer's recommendations.

F. Manufacturer: IPP fluorinated double wall pipe. Acceptable manufacturer: UPP

2.5 UNDERGROUND FUEL OIL TRANSFER SUMPS OR FRP.

A. Transfer Sumps shall be designed and constructed of materials strong enough for their intended use; transfer sumps shall not collapse, crack or break due to ground movement, tank movement, settling or backfill or static pressure associated with high ground water conditions. Transfer sumps shall be provided with a watertight cover that does not require mechanical means to provide compression of the cover seal.

B. All containment chambers for underground storage tanks shall be made of materials which are compatible with all EPA approved fuels and additives. Evidence shall be provided to support the chemical resistance of the materials for the temporary storage of petroleum and alcohol-based fuels as well as long term exposure to ground environments.

C. Transfer Sumps constructed of fiberglass as manufactured by Western Fiberglass.

D. Sumps constructed of Poly ethylene are preferred if the correct size is available for the application.

E. Transfer Sumps shall be fitted with pipe and conduit entries which are semi-absorbent to ground movement and sufficiently flexible to permit angled entries up to 15 degrees off of the fusion bonded centerline in vertical or horizontal direction. Seals shall be compatible with the fluids contained within the chamber as well as the surrounding ground environment and capable of withstanding a static head pressure of 6 feet fusion bonded. Seals shall not utilize rubber.

F. Manhole covers shall be used for access to the Transfer Sumps.

1. The manhole covers, rings and skirts shall be non-metallic to prevent failure due to corrosion. The covers and rings shall be made of nylon/fiberglass composite material that will not crack, break or delaminate. The skirt shall be made of high-density polyethylene.

2. Covers shall be spark proof. The surface resistively of the manhole cover shall be less than 1 x 108Ohms.

3. All manholes shall be made of materials which are compatible with all EPA approved fuels and additives. Evidence shall be provided to support the chemical resistance of the materials.

4. Covers shall be fire resistant and self-extinguishing.

5. Covers shall be designed to exceed H-20 (or EN124 D) load requirements.

6. Covers shall have a textured surface finish to prevent pedestrian slip hazards in wet conditions.

7. Provide Fibrelite model FL7A lifting tool for removal of cover.

8. Basis of design is by Fibrelite FL90 HD. Equal by Franklin (Safe-Lite series with slide action cover and lift tool) and OPW (Conquistador series with Key lift provision and stick handle) will be considered .

2.6 FIBERGLASS UNDERGROUND STORAGE TANKS (DOUBLE WALL):

A. General

1. Fiberglass UL-labeled double wall underground storage tanks in sizes and with fittings indicated.

2. Concrete shall conform to Division 3.

3. Loading Conditions - Tank shall meet the following design criteria:

a. External hydrostatic pressure: Buried in ground with 7 feet of overburden over the top of the tank. The hole fully flooded and a safety factor of 2:1 against general buckling.

b. Surface loads: Withstand surface H-20 axle loads.

c. Internal load: Inner tank shall withstand 3-5 psi air pressure test with 5 to 1 safety factor. Outer tank shall withstand a 5 PSIG test with inner tank test pressure maintained. Test prior to installation since this design condition is to test for leakage.

d. Tank shall be designed to support accessory equipment such as heating coils, ladders, drop tubes, etc.(refer to drawing for these details if needed).

4. Product Storage Requirements

a. Tanks shall be vented, as tanks are designed for operation at atmospheric pressure only.

b. Tanks shall be capable of storing liquids with specific gravity up to 1.1.

c. Tanks shall be capable of storing liquids up to a maintained temperature of 150 degrees F at the tank interior surface.

d. Tanks shall be chemically inert to petroleum products.

e. Tank shall have a factory brine filled interstice between the primary and secondary walls of the tank.

5. Dimensional Requirements

    a. Nominal capacity of each tank shall be ____ gallons.

    b. Nominal outside diameter of the inner tank shall be __ feet

    c. Approximate overall length of the tanks shall be __ feet __ inches

6. Anchor Straps - Provide fiberglass - reinforced plastic anchor straps for each tank shown. Number and location of straps shall be as specified by Manufacturer. Each strap shall be capable of withstanding the buoyancy load for tank diameter:

    a. Straps shall be standard as supplied by the tank Manufacturer.

7. Certification Plate - Underwriter's Laboratory label shall be permanently affixed to each tank.

8. Tanks must comply with National Fire Protection Association 30, "Flammable and Combustible Liquids Code," and NFPA 31, "Standard(s) for the Installation of Oil Burning Equipment."

9. Man Ways, Collars and Covers

    a. 30” Manways shall be furnished complete with UL approved gaskets, bolts and covers. Cover shall be suitable for five (5) 4 inch NPT connections.

    b. Provide two (2) 48 inch diameter water tight attached collar riser from the top of tank to underside of manhole cover, flat sided.

    c. Provide Fibrelite model EBW 781 -486-12 slide action cover manhole for each manway riser with slide action handle model 781-341-01. OPW and Fibrelite are also acceptable.

    d. Provide a tank bottom sump, approx. 8 inches in diameter and 4 inches in depth for water collection. This should be installed in the tank at the low end of the tank and under a shell or manway fitting for access by the filtration system (if specified) or from grade through a sealable spill container.

10. Submersible Pumps

    a. Refer to submersible turbine pump elsewhere in this specification section.

11. Fill Tubes and Accessories

    a. Tubes shall be aluminum and have a OPW Model 71 SO overfill prevention valve.

    b. Provide OPW Model 633T top seal adapter, OPW model 634TT top seal cap, and OPW Model 6511A 5 gallon capacity spill container with sealable cover, replaceable container, and plugged drain valve. Products listed are for basis of design.

12. Fittings -Threaded - N.P.T.

    a. All threaded fittings on UL-labeled tanks shall be of a material of construction consistent with the requirements of the UL label. All fittings to be supplied with cast iron plugs.

    b. All standard threaded fittings are 4 inch in diameter and shall be half couplings. Reducers are to be used for smaller sized where specified and provided by Contractor.

    c. Thread Standards - All threaded fittings shall have machine tolerances in accordance with the ANSI standard for each fitting size.

    d. Strength - N.P.T. fittings shall withstand a minimum of 150 ft-lb of torque and 1,000 ft-lb of bending, both with 2:1 factor of safety.

13. Lifting Lugs - Provide lifting lug(s) on all tanks. Lugs shall be capable of withstanding weight of tank with a safety factor of 3:1.

14. Accessories

    a. Provide _____ inch foot valve for generator suction line and the filtration unit suction line.

    b. Provide OPW model 233E extraction fitting for removal of foot valve.

    c. Provide OPW model 104AOW 18” monitoring/observation well manhole for access to brine reservoir and to the tank gauge level probe.

    d. Provide ____"open vent for vapor vent termination.

B. Tank supplier shall provide all required control panels, sensors and accessories for hydrostatic tank monitoring system and distribution piping containment system.

C. Tanks shall be constructed in compliance with:

   1. UL 1316, Underwriters Laboratories, Inc., "Standard for Glass Fiber Reinforced Plastic Underground Storage Tanks for petroleum products, alcohols, and alcohol-gasoline mixtures".

D. Concrete Deadman: Provide concrete deadman with tank as designed by Tank Manufacturer to resist buoyancy forces of underground water.

E. Tank manufacturer shall include a minimum 30-year warranty.

F. Manufacturer: Xerxes Model DWT-11.

2.7 FUEL TANK AND PIPING MONITORING SYSTEM

A. Controller: The controller shall be microprocessor-based, and shall be designed and constructed with modular architecture permitting field upgrades and. Configuration and set-up data - memory. Replacement or substitution of any controller plug-in card shall not require system re-configuration. Real-Time clock and non-critical log data, such as inventory, delivery, alarm, theft, error, and leak reports shall be maintained in a battery backed non-volatile memory.

1. System shall include digital display for viewing tank information and LED indicators for the alarm conditions. System shall have the capability to continuously monitor up to twelve (12) TMS 3000 dual-float magneto-strictive in-tank level probes and up to twenty-four TMS 3000 discrete external leak sensor. System shall operate on 120 volt, single phase power.

B. Main Console: The console shall be housed in a lockable wall mounted NEMA 4X enclosure. The console shall include microprocessor board, probe/sensor card, power supply, control IJO and communications interfaces. Front panel display shall include audible and visual alarms, user friendly pushbutton controls, and optional impact printer. The display shall be nine digit, seven segment, quasi-alphanumeric LED type, with LED alarm annunciators for five (5) alarm conditions; leak,[three (3) tank product set points, and one (1) bottom water set point per tank. Displays shall include product gross or net, percent of capacity, product and water level, product temperature, and product type. As a minimum, eight (8) relay outputs and eight (8) contact closure inputs shall be provided. All relays and inputs shall be user-programmable for activation by following event types; Power fail Recovery, System Error Tank Leak, Product Set points, Water Set points, External Leak sensors, External Contact closure inputs and Line leak. The system shall be supplied with three industrial quality front panel sealed pushbuttons labeled MODE, TANK SELECT, and TEST.

1. Pushbuttons are utilized in conjunction with the display screen to select tank quantities, view, set, acknowledge alarm conditions; set configuration data, initiate system tests, view inventory and other logged data. The system shall provide hardcopy environmental compliance reports via front panel 24 column printer with auto rewind. The RS-232 serial port shall be provided as standard for two-way communications with a PC computer. Microsoft Windows compatible software shall be provided to retrieve and display current tank statuses, remotely read, write and initialize system setup, clock, and configuration data. An RS-485 port shall be provided as standard for connection to remote display and annunciator panels. The system shall be independently third party certified and have the capability to automatically or manually conduct a static volumetric tank tightness test to an accuracy of 0.2 gph for monthly monitoring and 0.1 gph for annual precision testing, with minimum test times of two hours and eight hours respectively. System shall be capable of performing both tests with as little as 20% of tank capacity.

2. IMPACT PRINTER will be provided. The auto rewind printer for NEMA 4X consoles shall provide print-outs available on a take-up spool. Fuel management, environmental compliance and system status reports shall be available. These reports shall be available manually upon demand, via a front panel PRINT button, or programmed to be automatically available. It shall utilize standard 2.23” wide x 1.5” diameter calculator type paper and print 24-columns. The printer ink shall be delivered via a replaceable ink cartridge capable of 22million characters.

3. RELAY CARDS shall be provided. An eight (8)-Form A (NO) relay outputs with eight (8) dry contact inputs shall be installed in the 1st IO slot. The relays and inputs shall be fully programmable and provide standard and "latching" control to external devices. The inputs shall be able to operate in standard or "generator" modes. The outputs and inputs shall be able to differentiate tanks for use with the "in-tank" leak detection function.

4. ANALOG CARDS will be provided. These cards include either six (6) or twelve (12) analog outputs. Choice of the card depends upon the number of outputs required by other devices. The analog selections shall include: 4-20mA. The analog channels shall be fully programmable and output shall include gross gallons, net gallons, product level inches, and temperature and water level inches.

5. COMMUNICATION CARDS will be provided. A MODBUS RTU connection card shall be included.

6. Main Console shall be Pneumercator Series TMS3000.

C. Remote annunciator: Remote Console shall consist of two items; a solid state electronic wall mounted NEMA 4X weatherproof enclosure housing Strobe/Siren combination and separate A/C power module and wiring junction box. The audible annunciator shall have a minimum rating of 101db at ten (10) feet. The visual annunciator shall be strobe type with a minimum rating of fifteen (15) candela. Multiple annunciators shall have the capacity of being connected in a daisy chain or parallel configuration. The remote annunciator shall monitor status of main console alarms. The Remote Annunciator shall be Pneumercator RA 200 K.

1. Test/Reset switch assembly in a separate NEMA 4X enclosure shall be provided. Acknowledging alarms shall only silence the horn, leaving alarm light lit until condition is corrected. The Test button shall be provided to verify operation of both the audible and visual alarms. System shall operate on 120 volt, single phase power. The Remote Test/Reset Switch shall be Pneumercator RS 2.

D. Tank Monitor Probe: Probe shall be designed for underground storage tank applications and shall have performance characteristics permitting 0.1 gph or better in-tank leak test with continuous gauging accuracy of +/-0.0005 inches for product, +/- 0.001 for water and +/-0.001 degrees F. for temperature. Probe shall contain an array of at least five (5) temperature sensors along its length for accurate volumetric temperature compensation.

1. Probe to console communication shall employ digital transmission techniques carried over standard, readily available two-conductor, shielded cable, with a maximum cable length restriction of 4000 feet. Probe operating temperature and pressure shall be -40 to +175°F. and 150 PSIG respectively. Probes shall be supplied with product float, water float, six (6) foot leader cable with watertight connector, and centering rings for riser mounted applications.

2. Probe shall be UL approved for use in Class I, Division I, Group C&D hazardous locations.

3. Probe shall be Pneumercator Model: MP450S-xxx-25 for rigid lengths from 2 to 18 feet.

E. Leak Sensors:

1. Mechanical/Electrical room diked area: Dry contact switch leak sensor shall be available for liquid detection in the diked containment area. Leak sensor shall be equal to Pneumercator Model LS 600 LDBN.

2. Brine Reservoir: Sensors shall be 3-wire type consisting of a single magnetic float capable of detecting breached inner or outer walls of a double-wall fiberglass tank. The reservoir sensor and its components shall be provided with a non-corroding PVC outer housing, float and guide stem assembly, and sixteen (16) feet of 4 conductor #18 A WG gage wire.(only if you have underground fiberglass tanks).

   a. Sensor shall mount in a specified man way on top of each tank and rest on the reservoir floor. The Hydrostatic sensor shall detect changes in the reservoir brine solution when level drops below 2 inches or rises above 11 inches of liquid. Leak sensor shall be equal to Pneumercator Model RSU800.

3. Piping/Sumps:(tank sumps, transition sumps) Discriminating type shall employ both electro-optical and conductivity technologies for detecting and differentiating between hydrocarbon and water. Sensor assemblies shall be provided with a twenty-five (25) foot, 3-conductor, #22 A WG gage wire cable. Sensor shall include supervised wiring technology to automatically detect sensor or find wiring faults. Leak sensor shall be equal to Pneumercator Model ES 825-200F.

F. Remote Displays:

1. Remote Displays: Remote Displays shall provide digital access to the tank management information available from the TMS console. This includes information such as tank level and/or alarm status for individual or all tanks. The Remote Displays shall be wall mountable and housed in NEMA 12 enclosures with the option to up-grade to NEMA 4, 4X or Explosion proof enclosures. Remote Displays shall communicate with the TMS console through an analog card, transceiver board or RS 485 port.

   a. Electronic Tank Display: The Display shall be designed to provide remote access to all digital and audible TMS information. It shall not include the ability to program the main console. Up to sixteen (16) Display units shall be connected up to 5000 feet from the TMS console.

2. The Display shall be housed in a NEMA 4x enclosure and shall include a digital display for viewing tank information, LED indicators for alarm conditions, audible annunciator and user-friendly push-button controls. The display shall be nine digits, seven-segment quasi-alphanumeric “ultra-bright”, sunlight readable, LED type. The display shall include product gross and net gallons, percent of capacity, 90% Ullage, product and water level, product temperature, and product type. There shall be five (5) LED alarm annunciators for five (5) alarm conditions; one (1) leak, three (3) tank product set points, and one (1) bottom water set point per tank. The LED alarm lights shall be visible from at least seventy five (75) feet and the seven-segment display data shall be readable from no less than twenty (25) feet.

3. The system shall be supplied with three industrial quality front panel sealed push buttons labeled MODE, TANK SELECT, and TEST. These push buttons are utilized in conjunction with the display screen to select and view tank quantities, acknowledge alarm conditions, view inventory and other logged data. The Smart Display shall be an

independently addressable, micro-processor device that communicates with the TMS console over the RS 485 Peripheral Expansion Bus.

4. Standard Remote Display shall be equal to Pneumercator ETD 1000.

2.8 FUEL FILTRATION SYSTEM –

A. A UL 508 listed fuel purification system shall be furnished to automatically circulate and clean fuel in above and/or below ground storage tanks on a preprogrammed basis without the use of replaceable filter elements. The system shall be centrifugal based and capable of removing a minimum of 99.5 percent of all water, including emulsified water and 98 percent of the solid or particulate contaminants found in fuel to approximately 10 microns. The system shall be PLC based with an Operator Interface Touch Screen Panel mounted on the front door that allows for programming and alarm monitoring. An audible alarm with light, alarm acknowledge button and a system HOA switch with key lock shall be mounted on the front door for easy operator use. Internal relays shall be available for providing system alarm status. The system shall include a continuous duty motor and fuel pump capable of pumping fuel at not less than __gallons per minute with a ___hp motor. All system components shall be housed in a NEMA 4 rated weather proof, key locked cabinet. In addition, all electrical components shall be housed in individual NEMA 4X enclosures to protect the internal electrical components and wiring connections when the enclosure doors are open. A 2 hour full system operations test with fuel shall be conducted at the factory before shipment to verify the system is working within parameters and has no leaks in the plumbing. The system shall pass a 75 psi end-of-test pressure test.

1. The factory packaged purification system shall consist of the following:

a. NEMA 4 Weatherproof enclosure:

1) 14-gauge steel construction with welded seams and flanged door opening.
2) Suitable for pad or wall mounting.
3) Hinged front doors.
4) Gasketed Operator Interface Touch Screen in front door.
5) Containment basin in bottom with Manual drain plug and leak sensor.
6) Key Lockable Handle (Level 1 Security)
7) (Left and Right side 1-inch NPT inlet Nipples.
8) Manual ½” or 1” inch shutoff ball valves, bronze with stainless steel ball and Teflon seal shall be factory installed on the inlet and outlet piping connections.
9) Finished in white powder coating.

b. Pump:

1) Positive displacement gear pump.
a) Aluminum housing
b) Steel gears
c) Hardened steel shaft
d) Mechanical shaft seal
e) Pressure relief valve
f) Priming Tee

2) 5, 11 or 25 GPM at 100 psi capacity at 1800 rpm

c. Motor:
1) 1/3, 1 or 2 HP
a) 120 VAC, Single phase, 60 Hz (other power capabilities available)
b) Open drip proof construction
c) Integral overload protection
2) Flexible, self-aligning shaft coupler

d. Controls:
1) PLC Based with Full System Heater
2) Touch Screen interface with Full System Heater
3) Security Code Activated (Level 2 Security)

e. Fuel Purifier:
1) RCI FP 800 or 1000
2) Flow Rate 15 or 40 GPM
3) High Water Sensor; Full System Heater
4) Water Drain Valve - Manual 1" Brass. Automatic Drain Kit
5) Water Removal - 99.5%
6) Particulate Removal - 98% to 10 Microns.

f. System Alarms:
1) Fuel Leak in Basin
2) High Water
3) High Pressure > 75 PSI
4) Pump Fail
5) Preventative Maintenance Due

g. Interface to other devices:
1) 5 - Dry Contact relays, rated at 5 AMPS
a) All 4 system alarms
b) Alarm Summary
2) Options
a) MODBUS
b) Ethernet
c) Shall be coordinated with BAS contractor.

h. Audible and Visual Alarms - installed on outside of front door

i. Alarm Acknowledge Switch - installed on outside of front door

j. HOA Switch with Key (Level 1 Security) - installed on outside of front door

k. Pump and purifier installed with unions

l. Control Devices:
1) Pump Motor Starter
a) 20A single pole circuit breaker
b) 30A DP contactor

c) Pump control switch
   i. Auto, Off, Manual
   ii. Weatherproof, key operated
   iii. Control power fuses
   iv. Connection terminal blocks

m. Full System Test
   1) 2 Hour Test with Fuel
   2) End of Test Pressure increased to 75 PSI

n. Automatic 1" Valves controlled by PLC with MTU multi tank option:

2. The system shall not require the replacement or periodic cleaning of any type filter element or screens. The system shall include a magnetic fuel decontamination unit designed to help prevent the buildup of microbiological contamination.

3. Basis of design is "RCI Technologies" model FRS-660----------X-UL -3

4. Automatic Recirculating System (x represents the number of tanks from 2 to 4) (216) 431-6100.

2.9 FUEL TRANSFER PUMP PACKAGE:

A. Provide and install a factory assembled "Packaged" Duplex Fuel Oil Pump Set to deliver fuel oil to the steam boilers. The set shall have all components mounted on a steel base support fabricated of 3/16" steel plate with 3" steel side rails sealed to form a containment basin with 1/2" NPT plugged drain connection.

1. Containment basin shall encompass the entire perimeter of the duplex pump set and no components or factory piping shall overhang.

2. Piping shall be schedule 40, ASTM Grade A-53 black steel pipe with A-105 forged steel socket welded fittings and A-105 150# forged steel flanges. Systems assembled with threaded fittings and unions will not be acceptable.

3. Provide a leak sensor in the pump set containment basin to shut off the pumps and energize an audible and visual alarm should a leak be detected. The level sensor shall be a normally closed float switch with covering shroud to protect switch from damage or accidental tripping. System shall be as manufactured by Lonergan Pump Systems or similar with options listed.

B. Pumps shall have capacity as scheduled. Provide a duplex pump set to serve the boiler fuel oil supply. The second pump in the duplex set shall provide standby service.

C. Provide one UL listed (1) duplex oil strainer, sized to produced less than 1/2 PSI pressure drop, through a clean brass strainer basket with the maximum anticipated flow. Strainer shall be of one-piece cast iron and come complete with level wrench handle. A differential pressure gauge shall be shall be provided to monitor strainer basket cleanliness shall include visual indication of clean, change required and dirty strainer. Interconnecting piping from the suction strainer to single discharge connection including gate, relief, and check valves per pump.

D. Provide two (2) Lonergan GP series direct coupled Viking fuel oil pumps with ductile iron housing and self adjusting mechanical viton seals, each with a capacity of ----- GPH @ ----- PSIG discharge pressure when operating with No. 2 fuel oil. Each pump shall be close coupled to not less than a ------HP, 1725 RPM totally enclosed fan cooled motor, capable of operating on ----- volts, ----phase. Provide a non fused disconnect switch for each pump.

E. Provide two (2) UL listed external bronze body fuel oil pump relief valves in each pump discharge line sized to relieve full flow of the pump without causing the pump motor to overload or any component's pressure rating to be exceeded if the discharge is inadvertently shut off. Valves shall be piped from the system to the return line in the field according to NFPA 30. Pumps with internal relief valves are not recommended. Manufacturer: SSECO or equivalent.

F. Provide two (2) class 800 forged steel flanged check valves on the discharge side of each pump.

G. Carbon steel ball valves, class 150 flanged, shall be provided on both the suction and discharge of each pump to provide pump isolation for service. Valve shall include lockable handle so a padlock can be applied to prevent accidental closing or opening if pump is removed from service.

H. One (2) 4" compound gauge shall be provided on each side of the duplex strainer. Gauge shall be liquid filled to dampen pulsation, with bright finish stainless steel case, brass movement, and bronze bourbon tube. Gauge shall read 30" vacuum - 30 psig and shall be mounted with isolation ball valve.

I. Two (2) 4" dial pressure gauges to be placed on discharge side of each pump. The gauges shall be liquid filled to dampen pulsation, have bright finished stainless steel case, brass movement and bronze bourbon tube. Gauge range shall be based on the fuel oil system operating pressure and shall be mounted with isolation ball valves.

J. Provide a-Lonergan FL series time delayed flow sensing switch on the discharge of the pump set to bring on the lag pump should the lead pump fail to maintain flow. Flow switch shall be vane operated to actuate a single double throw snap switch. Switch will be wired back to the main control cabinet for alarm and annunciation for lead pump failure.

K. Install in the oil return line a Lonergan RVI series back pressure regulating valve, 1 1/2" NPT, stainless body with viton diaphragm and disc, to maintain a 5 to150 PSI pressure range

L. Provide where shown in the fuel oil supply line Lonergan FLV-PSL series quick closing, spring loaded / solenoid actuated, flanged lever gate fire valves with fusible link arranged so that the valve will automatically close if the link melts or if the valve shall receives a normally open switch closure from a thermally actuated fire indicating safety switch. Valve shall be equipped with an end switch to interface with the fuel oil management system.

M. Provide for underground storage tanks a continuous tank level transmitter, with 4-20 mA output, Buna N float, mounting junction box. Lonergan FPB series or approved equal.

N. Provide pump set mounted system control cabinet with fused main disconnect switch to monitor and control the fuel oil delivery system in response to system demand. Cabinet must be labeled as conforming to UL508A and shall be completely pre-wired, tested and shipped as an integrated system to insure jobsite reliability. Control strategy shall be microprocessor based and utilize a PLC (Programmable Logic Controller). Relay logic is not acceptable. Cabinet enclosure shall be constructed of a minimum of 14-gauge steel, continuously welded and constructed to NEMA 3R standards. Cabinet interior and exterior shall be primed and finished in durable chemical resistant enamel suitable for industrial environments. PLC shall have sufficient I/O to accomplish all necessary control functions. The control strategy shall be burned into an EPROM at the factory, and shall be safeguarded against re-configuration by un-authorized / un-qualified personnel. Each pump shall be capable of manual operation in the event of a controller failure. Cabinet shall consist of but not be limited to the following:

1. Microprocessor based PLC with automatic pump alternation
2. Self-protected U-line magnetic motor starters with adjustable overload protection
3. Manual-Off-Auto illuminated mode selector switch for each pump
4. Alarm silence / System reset push-button
5. Alarm buzzer
6. Discrete output for each major alarm to interface with the BMS
7. Control logic to engage pump set from a dry contact input for remote Start-Stop from any day tank
8. Control logic to start lag pump if lead pump fails to establish or maintain flow in loop
9. Back-lit 4 line LCD display factory programmed for tank level indication in percent volume, system status and alarm display
10. Direct modbus protocol communication ports.

O. The control panel as per the NEC 110.1 shall be labeled with the panels Short Circuit Current Rating. The entire Power Circuit shall be rated at not less than 42KIA.

P. The control system shall automatically energize the lead pump once every 24 • hours to verify suction piping integrity, pump prime and verify pump operation. Each pump shall be engaged and if either lead or lag pump fails any of these tests, the control system shall generate an audible and visual alarm to indicate a flow lost condition.

Q. The control system shall annunciate the following alarms: Pump Thermal Overload Status change, Pump System Prime Failure (each), Pump elapsed run time (each), Pump set leak, Pump flow failure (each), Containment piping leak, Fuse valve closed. The operator will establish each pump mode of operation:

1. Pump Auto - With both pumps in auto, the controller will engage each pump in an alternating fashion when the control panel receives a PUMP SET ENGAGE dry contact switch closure from the day tank(s) being fueled. (Pump 1 is engaged until demand is satisfied and the switch opens, the next time a device signals demand to the system, pump 2 will engage).

2. Off - If a pump is turned off, the system will not select that pump. However, if the opposite pump is in the auto mode, the system will automatically select the pump that is in auto.

3. Manual - If a pump is selected as manual, that pump will operate continuously as long as that pump is in manual mode regardless of any alarm or pump set on signals.

R. Alarms: The system controller shall include a LCD display for pump set statue, alarm listing, and trouble shooting functions. The LCD display will include a separate page for viewing the most recent alarms/events with scrolling capability to view the past alarm/event memory. Each event and alarm condition is time and date stamped.

S. This system shall record and annunciate the following alarms: Pump Motor Thermal Overload Trip, Pump Loss Of Flow and Pump Set Leak. The control system shall also record the following events: Pump Engaged Elapsed Time (auto mode only), Pump control Switch in Not in Auto position.

T. Note: All alarms shall be provided in the system controller even if not required in the system design. They shall be available for future use.

U. Underground Storage Tank Leak - The system will monitor the tank's leak condition via a float switch contact. If the tank is a leak condition as indicated by the closing of a dry contact, the MAIN UNDERGROUND STORAGE TANK LEAK alarm will be displayed, the pump will shut down and the panel buzzer will sound. The system will not be able to be restarted until the alarm is cleared and the system is reset.

V. Day Tanks and Transfer Tank Low Level - The system will monitor a low level normally open dry contact from the transfer tank or day tank controller. If the transfer tank's or day tank's low level switch should make, the system will display the TRANSFER TANK LOW LEVEL alarm or DAY TANK #1 alarm or DAY TANK #2 alarm and sound the panel mounted alarm buzzer.

W. Flow Failure - A flow sensor located in the discharge line of the pump set shall monitor the pumps. If the sensor does not see flow, with a pump engaged within 30 seconds, the system will disengage the lead pump, engage the lag pump, sound the alarm panel buzzer and display a flow failure alarm. The system will pump with the lag pump from until the alarm is cleared and the system is reset. If flow is still not established within 30 seconds with the lag pump, the system will shut down.

X. Pump Set Leak • The containment basin of the duplex oil pumping system may contain an optional a float switch which will make on rise if a leak occurs. If a leak occurs, the system will display the PUMP SET LEAK alarm and sound the panel mounted alarm buzzer. The system will not be able to be restarted until the float sensor is cleared, there is no liquid in the containment basin and the system is reset.

Y. Containment Piping Leak - The system will monitor any normally open dry contact leak detection sensor in the double wall piping. If any sensor contact makes, the system will display the PIPING LEAK DETECTED alarm and sound the panel mounted alarm buzzer. The system will also be locked out from pumping until the alarm is clear and the system is reset.

Z. Pump Set Primed Test - The control system shall automatically energize the lead pump once every 24 hours time to verify suction piping integrity, pump prime and to verify pump operation. Once the lead pump has satisfactory flow and operation, the system shall engage the lag pump and the same test shall be performed. These tests shall be recorded in the controller memory with a Time/Date stamp for later verification. If either lead or lag pump fails any of these tests, the control system shall sound the alarm panel buzzer and display a flow failure alarm.

AA. Pump Overload Trip - The system will monitor each pump's motor starter overload. If the controller receives an overload trip alarm condition the system will sound the alarm panel buzzer and display pump overload trip condition alarm. The system will engage the opposite pump upon each demand call until the alarm is cleared and the system is reset.

BB. Pump Set Strainer Dirty - The strainer includes a differential pressure switch/indicator wired to provide indication to the control panel display that the strainer baskets need to be shifted and clean. Also the switch has a tri-colored scale plate, green (0-4 PSI), yellow for change (5-8 PSI), red for dirty (9-12 PSI). The differential pressure switch/indicator also include a magnetic actuated reed switch to provide signal to the controller displaying a "Pump Set Strainer Dirty" warning.

CC. Fire Valve Closed - The system will monitor any fire valves in the fuel oil line with position end switches. If a valve is indicated closed by the closing of a dry contact, the FIRE VALVE CLOSED alarm will be displayed, the pump set will shut down and the panel buzzer will sound. The system will not be able to be restarted until the alarm is cleared and the system is reset.

DD. Pump Not In Auto - The system will monitor each pump's mode selector switch. If the pump selector switch is changed from the auto position, the system will sound the alarm panel buzzer and display the appropriate PUMP NOT IN AUTO alarm.

EE. Emergency Shut Off - The system has the ability to monitor any normally open emergency shut off switch. If emergency shutdown is indicated by the closing of a dry contact, the EMERGENCY SHUT DOWN alarm will be displayed, the pump set will shut down and the panel buzzer will sound. The system will not be able to restart until the alarm is cleared and the system is reset.

FF. Pressing the reset button can silence the alarm buzzer.

GG. Normally dry contact alarm outputs, which close upon each individual alarm, will be provided to interface with the building management system

HH. Not In Auto - If the Mod Selector switch is not in the Auto position the alarm will sound and display" NOT IN AUTO".

2.10 DAY TANKS AND TRANSFER TANK AND RETURN PUMPS

A. Furnish and install _____-gallon day tanks, and ______gallon transfer tank. Tanks shall be UL-2085 Fireguard Thermally Insulated, FG Double-Wall Steel Aboveground Storage tanks as indicated on plans.

B. The tanks shall be designed for aboveground storage of flammable and combustible liquids at atmospheric pressure. Tanks shall include integral steel secondary containment and thermal insulation that provides a minimum two-hour fire rating.

C. Each tank shall be delivered as a complete UL-2085 assembly with two factory supplied, welded-on saddles.

D. Inner and Outer Tank shall be manufactured in accordance with UL-142 Standard for Steel Aboveground Tanks for Flammable and Combustible Liquids. Entire tank shall be labeled for Underwriters Laboratories UL 2085 Standard for Insulated Secondary Containment Aboveground Tank for Flammable Liquids. The tank design shall comply with UL 2085 "Protected" Tank standard.

E. Tank shall be manufactured and labeled in strict accordance with Steel Tank Institute (STI) Fireguard® Thermally Insulated, Double Wall Steel Aboveground Storage Tank standards as applied by a licensee of the STI. Tank shall be subject to the STI's Quality Assurance program and shall be backed by the STI 30 year limited warranty.

F. Tank shall be of double wall construction and provide complete secondary containment of the primary storage tank's contents by an impervious steel outer wall.

G. Threaded fittings with thread protectors shall be supplied as follows (all fittings must be located on tank top per UL):

1. One (1) 2" - Interstitial Monitoring.
2. One (1) 2"- Normal Vent, Primary Tank.
3. One (1) 4"- Emergency Vent, Primary Tank.
4. One (1) 4" - Emergency Vent, Secondary Tank.
5. One (1) 4"-Product Fill.
6. One (1) 2"- Product Pump or Supply.
7. One (1) 4" - Product Return.
8. One (1) 2" - Liquid Level Gauge.
9. Additional fittings as indicated on drawings.

H. Accessories

1. Duplex Overflow return pumps, ___V, ___ phase.

2. Door mounted disconnect.

3. Loss of flow pump alarm.

4. Vacuum gauge.

5. Day Tank Controller and Accessories

a. Provide continuous day tank level control probe arranged to monitor and display the fuel oil level in percentage of volume. Probe shall be designed for installation in the top of the tank to control high-level / return pump on, high-high level / system shut down, low-level level, and remote supply pump on/off conditions.

b. Provide in basin a rupture basin float switch with alarm and pump shut down which functions upon detection of oil in the rupture basin.

c. Provide a time delayed flow sensing switch on the discharge of the return pump. Flow switch shall be vane operated to actuate a single double throw snap switch. Switch will be wired back to the day tank control cabinet for alarm and annunciation. Alarm shall also close solenoid valves in the tanks flow control manifold.

d. Provide _____ day tank supply flow control manifold. Manifold shall include (2) normally closed solenoid valves that shall open when the tank demands fuel, isolation ball valves for solenoids and by-pass tee with ball valve, and basket type strainer. All ball valves shall have lockable handles, which can padlocked closed in case of a solenoid removed for service. Piping shall be schedule 40, ASTM Grade A-53 black steel pipe with A-105 forged steel socket welded fittings and A-105 150# forged steel flanges. Manifolds that have threaded fittings will not be acceptable.

e. Provide generator fuel cooler sized for generator with the following items:
   1) Isolation and bypass ball valve manifold with temperature gauges for fuel in and fuel out.
   2) ___ volt, ___-phase fan controlled and powered by day tank control panel.
   3) Thermocouple and well long enough to sense temperature at bottom of day tank.
   4) All disconnects, starters and transformers.
   5) Not required for Transfer tank.

f. Cabinet shall be completely pre-wired, tested and shipped as an integrated system to insure jobsite reliability and shall be capable of operating on 480V/3 phase. Control strategy shall be microprocessor-based and shall have sufficient I/O to accomplish all necessary control functions. Enclosure shall be constructed of a minimum of 14-gauge steel, constructed to NEMA 3R standards. Cabinet interior and exterior shall be primed and finished in durable chemical-resistant enamel suitable for industrial environments. The control strategy shall be burned into an EPROM at the factory, safeguarded against re-configuration by unauthorized or unqualified personnel with all manual switching wired direct in order to run the system if a processor lost should occur. Black phenolic labels with engraved white lettering shall identify all cabinet front devices and control cabinet shall consist of but not be limited to the following:

g. Microprocessor based PLC control system with alternation, lead/lag supply pump control.

h. Supply Signal to Duplex pump set

i. Motor circuit breakers

j. Fused control circuit transformer

k. Manual-Off-Auto illuminated mode selector switch for return pump and remote supply signal

l. Back-lit 4 line LCD display factory programmed for tank level indication in percent volume, system status and alarm

m. Alarm silence / System reset and system test push-buttons

n. Alarm buzzer

o. Direct MODBUS protocol communication ports.

p. The system controller shall include a LCD display for pump set status, alarm listings, and trouble shooting functions. The display page shall be provided for viewing the most recent alarms/events with each event and alarm condition time and date stamped. Other items that can be viewed: day tank volume in percentage, elapsed run time of each pump and cooler fan motor.

6. Alarms - Discrete Output

a. Low Level Alarm (45%)

b. High Level Alarm (90%)

c. High - High Level Alarm (95%)

d. Rupture Basin Leak Detected

e. Oil In Vent

f. Flow Failure

g. Return Pump Overload Trip

h. Normally dry contact alarm outputs, which close upon each individual alarm, will be provided to interface with the building management system.

i. Remote Emergency Stop and Panel Emergency Stop

j. Pumps and/or Cooler Not in Auto

k. Day Tank and Transfer Tank High Temperature

I. Approved Manufacturers: Tank design is based on SSECO or Lonergan. Similar designs will be considered also and must be approved by Cleveland Clinic Engineer.

2.11 SUBMERSIBLE TURBINE PUMP

A. The pump shall be manufactured to the proper length as determined by the tank diameter, type of tank, and bury depth. Pumps shall be provided in the Day Tank, Transfer Tank, and Underground Storage Tanks. Refer to drawings.

1. The day tanks and transfer tank shall be provided with a single pump, 3/4 horsepower, 480 V/3 phase.

2. The underground storage tanks shall be provided with a duplex pump set, 2 horsepower for each pump, 480 V/3 phase.

B. A variable length telescopic feature shall be provided such that the length of the pump is field adjusted at the job site to fit the specific pump length required.

C. The pumping unit shall not incorporate any flexible diaphragms and all sealing shall be accomplished with O-rings or UL recognized gaskets. The pump shall be rated to operate between -409F (-40BC) and 104BF (409C) with non-gelled product.

D. FE Petro Inc. shall manufacture the pump.

2.12 TANK SELECTION AND MAIN UNDERGROUND STORAGE TANK PUMP CONTROLLER

A. Functions of the controller shall be as follows:

1. Control flow of fuel from Underground Storage Tanksand future underground storage tanks to Day Tanks and Transfer Tank .

2. Day Tanks and Transfer Tank level control and day tanks and transfer tank return control.

3. Underground Storage Tank selection and return fuel valve control.

B. The following accessories shall be field installed and wired by the contractor:

1. Provide a Lonergan Pump type FT-420-XX to monitor the fuel level in the day tanks and transfer tank. 2 inch NPT required on the top of the tank.

2. Provide a Lonergan Pump FT-1 -XX to sense a leak in the day tanks and transfer tank rupture basin. 2 inch NPT required on the top of the rupture basin of transfer tank.

3. Provide a Lonergan Pump SMSL-1 leak sensor in the 2 inch vent to monitor fuel in the vent of the day tanks and transfer tank.

4. Provide a Lonergan Pump FLV-PSL series quick closing spring loaded/solenoid actuated flanged lever gate fire valve with fusible fink arranged so the valve will automatically close if the link melts or if the valve receives a normally open switch closure from a thermally actuated fire indicating safety switch. Valve shall be equipped with end switch to interface with the Main Fuel Distribution Control Panel.

5. Provide a Lonergan pump _____ inch flow control manifold model number 80811 in each of the return lines for the underground storage tanks (2).

6. Provide Lonergan Pump FL style flow sensor in each main underground storage tank supply line (2) and in the transfer tank return line (1).

C. Provide Pump Control cabinet per UL 508 to monitor and control the supply and return of fuel from the designated main underground storage tanks in response to system Day Tanks and Transfer Tank demand. Cabinet shall be completely pre-wired, tested and shipped as an integral system to insure jobsite reliability. Control strategy shall be microprocessor based and utilize a PLC (Programmable Logic Controller). Relay logic is not acceptable. Cabinet enclosure shall be constructed of a minimum of 14-gauge steel, continuously welded and constructed to NEMA 3R standards. Cabinet interior and exterior shall be primed and finished in durable chemical resistant enamel suitable for industrial environments. PLC shall have sufficient I/O to accomplish all necessary control functions. The control strategy shall be burned into an EPROM at the factory, and shall be safeguarded against reconfiguration by unauthorized/unqualified personnel. Black phenolic labels with engraved white lettering shall identify all cabinet devices. System shall be manufactured by Lonergan Pumps Inc or equivalent. Cabinet shall consist of but not limited to the following:

1. Microprocessor based PLC with alternation for Day Tanks and Transfer Tank return pumps

2. Power feed disconnect switch with door interlock

3. Fused primary and secondary control transformer

4. System mode selector switch for lead tank 1/lag tank 2, lead tank 2/lag tank 1, lead tank 1/tank 2 off, lead tank 2/tank 1 off and all tanks off Self-protected U-Line combination motor starters with over load protection

5. ______starters shall be provided. Starters shall be ____ volt ___ phase with 42KIA interrupting capacity, (including two starters for the future underground storage tank.)

6. Manual-Off-Auto illuminated pump mode selector switch for each pump

7. Alarm silence / System reset push button

8. Alarm buzzer

9. Discrete output for a common alarm interface with the BAS

10. Back-lit 4 line LCD display

11. MODBOS Communications

12. Discrete output for common alarm to interface with the BAS

13. Underground Storage Tank Selector Switch, Lead/Lag all tanks

14. Emergency Stop twist lock button

15. Pilot Lights for Underground Storage Tank in Service

16. (3) Three LED pilot lights for tank in service (including future UST)

17. Inputs and control logic to interface with tank gauging system for each main underground storage tank high and low level indication.

18. Backlit 4 line LCD display factory programmed for the following. The LCD shall display pump status, alarm listing and troubleshooting functions. A display page shall be provided for viewing the most recent alarm/events with each event and alarm condition time and date stamped.

    a. Day Tanks and Transfer Tank level display in percentage

    b. Pump elapsed run time for each pump

    c. Thermal over load alarm for each pump motor

    d. No flow alarm for each main underground storage tank pump and Day Tanks and Transfer Tank return pumps

    e. Sump leak alarm, input from Gauging System

    f. Underground Storage Tank low-level high-level and alarm, each tank.

    g. Input from Gauging System.

    h. Underground Storage Tank leak alarm, each tank. Input from Gauging System.

    i. Day Tanks and Transfer Tank low level alarm

    j. Day Tanks and Transfer Tank high level alarm

    k. Day Tanks and Transfer Tank high-high level alarm

    l. Fuel in Day Tanks and Transfer Tank vent alarm

    m. Day Tanks and Transfer Tank Rapture Basin alarm

n. Remote Emergency Stop Alarm

o. Panel mounted Emergency Stop Alarm

p. Emergency Gate Valve Closure

q. Pumps not it auto (4) alarms

r. Check Day Tanks and Transfer Tank Level sensor Alarm

2.13 Sequence of Operation

A. Lead Tank Selection - Each underground storage tank including the future underground tank will have four position selector switches: lead, lag, stand by and off. If more than two underground tanks are in the lead, lag or stand by position an error message will be displayed. Each tank will also have a lead / lag turbine pump and a flow control manifold in the tanks return line. The lead tank return line solenoid valve will remain open for the duration that particular tank is in the lead position. In the event the lead tank fuel fall to a low level (input from the Gauging System) the controller will close the lead tank return valve switch the lag tank to the lead position and open its return line valve. The system will now alternate this tank lead / lag pumps during demand for fuel. If a tank is taken out of service or all tanks are low on fuel, the system will go into alarm mode and energize any pump regardless of any demand for fuel.

B. Pumps Off - if the supply or return pump is turned off the system will not select that pump.

C. Pumps Manual - If a pump is selected as manual the system will engage the pump for continuously operations regardless of any alarm or pump on or pump off signal. Underground Storage tank pumps will function in manual mode only if the corresponding main Underground Storage tank is designated as the lead tank.

D. Pumps Auto - Day Tanks and Transfer Tank Return pumps with pumps on auto mode the controller will engage each pump in a alternating fashion when the fuel level in Day Tanks and Transfer Tank level reaches 90%, alarm will sound and the return pump will remain engaged until the fuel level is reduced to 85%, during which time the supply pump will be locked out. Once the fuel level is reduced the system will reset itself and the supply pump will operate normally, however the alarm will remain until the alarm is cleared and the system is reset. In the event that selected return pump fails and the flow sensor detects a no flow situation the system will go into alarm state and the lag return pump will be engaged.

E. Underground Storage Tank Pumps - Underground Storage tank pump will engage in the lead underground tank when the level in the day tanks or transfer tank reaches 50% and remain on until the level reaches 85%. In the event the flow sensor for this pump senses a no flow condition, the pump will be shut down go into alarm state and if the lag tank is in service the flow control manifold will switch tanks engage that's tank's pump till the Day Tanks and Transfer Tank reaches 85%

F. Alarms

1. Pump Motor Overload Trip - The system will monitor each pump's motor starter overload. If the controller receives a trip alarm from one of the Day Tanks or Transfer Tank return pumps, an alarm is sounded and the lag return pump will engage. In the event that an overload occurs in both return pumps, the supply pumps will be locked out until the alarm is cleared. If the controller receives a trip alarm from the supply pump motor starter, alarm will sound and if the lag tank is in service the flow control manifold will switch tanks and engage that pump until Day Tanks and Transfer Tank demand for fuel is meant.

2. Flow Failure: Underground Storage Tanks - The flow sensor in each of the underground storage tank discharge lines will monitor the flow during demand from the Day Tanks and Transfer Tank. If the sensor does not detect flow within 30 seconds (field adjustable) that pump will disengage alarm will sound and display a flow failure for that tank. If the lag tank is in service the flow control manifold will switch tanks and engage that pump until the Day Tanks and Transfer Tank Demand is meant. If flow is not established within 30 seconds (field adjustable) in the lag tank, the system will shut down.

    a. Day Tanks and Transfer Tank Return Pumps - The flow sensor in each of the return pump lines detects no flow within 5 seconds of engagement of the pump, that pump will disengage alarm will sound and displayed and the lag pump if in auto will engage. In the event that no flow is detected within 5 seconds or the lag pump is not in service the system will lock out the supply pumps.

3. Sump Leak - The system will monitor sump leak input from the Gauging System. When a sump leak signal is received the system will sound the alarm and display "SUMP LEAK" the system will be locked out from pumping until the alarm is cleared and the system is reset.

4. Underground Storage Tank Low Level - The system will monitor Underground Storage tank low-level inputs for each tank from the Gauging System. When a low tank level signal is received, alarm will be sounded and display "TANK # LOW LEVEL". That underground tank pump is disengaged and the flow control manifold switches to the lag tank if that tank is in service

5. Underground Storage Tank # Leak - The system will monitor the underground storage tank leak inputs for each tank from the Gauging System. When main tank # leak alarm is received alarm will be sounded and display "UNDERGROUND STORAGE TANK # LEAK. System will remain in service.

6. Day Tanks and Transfer Tank Low Level - If the fuel level in the Day Tanks or Transfer Tank continues to drop to a level of 45%, the alarm will sound and the system will display "Day Tank Low level", "Day Tank Low level" or 'Transfer Tank Low level"

7. Day Tanks and Transfer Tank High Level - If the fuel level in the Day Tanks or Transfer Tank continue to rise to 90%, the system will engage the respective tank return pump, sound the alarm and display "Day Tank High level", "Day Tank High level" or "Transfer Tank High level". The respective return pump will remain engaged until the fuel level is

reduced to 85%. The system will function normally once the fuel level has reached 85%, however the high level alarm will remain until the system is reset.

8. Day Tanks and Transfer Tank High-High Level - If the fuel continues to rise and the fuel level reaches 95%, the system will sound the alarm and display "Day Tank High-High level", "Day Tank High-High level" or 'Transfer Tank High-High level". The return pump will remain engaged until the fuel level reaches 85%, however the supply pumps will be locked out until the alarm condition is cleared and the system is reset.

9. Fuel in Day Tanks and Transfer Tank Vent - If either day tank, or transfer tank oil in vent sensor makes, the system will display "Oil in day tank Vent", "Oil in day tank Vent" or "Oil in transfer tank Vent". The system will be locked out from supplying additional fuel to the respective day tank or transfer tank until the alarm is cleared and the system is reset.

10. Remote Emergency Stop - When a remote Emergency signal is received the system will sound the alarm and display "Remote Emergency Alarm". The system will shut down and a signal will be sent to the emergency supply line gate valve to close. The system will remain locked out until the alarm is cleared and the system is reset.

11. Local Emergency Stop - When the panel mounted Emergency Stop Button is pushed the system will sound the alarm and display "Local Emergency Alarm". The system will shut down and a signal will be sent to the emergency supply line gate valve to close. The system will remain locked out until the alarm is cleared and the system is reset.

12. Pump Not In Auto - If a pump selector switch is positioned in manual or the off position, the alarm sounds and displays "PUMP # Not In Auto" the system does not shut down. Alarm condition is cleared by putting the system in Auto Mode and resetting the system.

13. Emergency Gate Valve Closure - In the event that the fusible link of the emergency gate valves melts, closing the valve a signal will be sent to the Main Fuel Distribution Control Panel. The system will shut down and the alarm will sound and display "Emergency Gate Valve Closure". The system will remain locked out until the alarm is cleared and the system is reset.

14. Fuel in Day Tanks and Transfer Tank Level Sensor Failure - In the event that the 4-20 ma level input falls to less than 4ma the system shuts down to prevent a over flow, the alarm sounds and displays "Day tank Level Probe Failure, Day tank Level Probe Failure or Transfer tank Level Probe Failure". System shall lock out of auto mode until the alarm is cleared and the system is reset.

15. Note: All alarms are to be transmitter to BMS via MODBUS.

16. Note: Pressing the reset button will silence the alarm buzzer.

G. The Main controller will contain all control components for the future underground storage tank. The System PLC will be programmed for two main underground storage tanks. When the third underground storage tank is installed the System PLC will be upgraded. If at any time the future underground storage tank is taken out of "off mode" the PLC will ignore this command and display an error message.

2.14 DAY TANK AND TRANSFER TANK CONTROL PANEL:

A. Provide Day Tank Control cabinets per UL 508 to monitor and control the supply and return of fuel from the designated Underground Storage Tank to Daytanks and Transfer tank, demand. Cabinet shall be completely pre-wired, tested and shipped as an integrated system to insure jobsite reliability. Control strategy shall be microprocessor based and utilize a PLC (Programmable Logic Controller). Relay logic or hybrid logic is not acceptable. Cabinet enclosure shall be constructed of a minimum of 14-gauge steel, continuously welded and constructed to NEMA 3R standards. Cabinet interior and exterior shall be primed and finished in durable chemical resistant enamel suitable for industrial environments. PLC shall have sufficient I/O to accomplish all necessary control functions. The control strategy shall be burned into an EPROM at the factory, and shall be safeguarded against reconfiguration by unauthorized / unqualified personnel. Black phenolic labels with engraved white lettering shall identify all cabinet devices. System shall be manufactured by Lonergan or approved equal. Cabinet shall consist of but not limited to the following:

1. Microprocessor based PLC

2. Power feed fused disconnect switch with door interlock

3. Control transformer, fused primary and secondary

4. Self-protected U-Line combination motor starters with over load and short circuit protection. For return pump and fuel cooler fan. Starter shall be 480 volt, 3 phase with 42KIA interrupting capacity.

5. Manual-Off-Auto LED illuminated pump mode selector switch for return pump, fuel cooler fan and supply signal to Main tank controller.

6. Alarm silence / System reset push-button

7. Alarm Buzzer

8. Discrete output for a common alarm interface with the BMS

9. MODBUS communications

10. Panel mounted Emergency Stop twist lock button

11. Provision for remote Emergency Stop Station

12. Power On LED pilot light

13. CAL 9300 temperature controller

14. Backlit 4 line LCD display factory programmed for the following. The LCD shall display status, alarm listing and troubleshooting functions. A display page shall be provided for viewing the most recent alarm /events with each event and alarm condition time and date stamped.

    a. Day Tank level display in percentage

b. Elapsed run time for return pump and cooler fan motor

c. Thermal over load alarm for return pump motor and cooler fan motor

d. No flow alarm in flow control manifold

e. No flow alarm for day tank and transfer tank return pumps

f. Day tanks and transfer tank low-level alarm.

g. Day tanks and transfer tank high-level alarm

h. Day tanks and transfer tank high high-level alarm

i. Fuel in Day tanks and transfer tank vent alarm

j. Day tanks and transfer tank rupture basin alarm

k. Remote Emergency Stop Alarm

l. Panel mounted Emergency Stop Alarm

m. Pumps and cooler fan motor not in auto (3) alarms

n. Check Day tanks and transfer tank level sensor alarm

o. Day tanks and transfer tank fuel high temperature alarm

B. Sequence of Operation

1. Day tanks and Transfer tank Supply Signal

a. OFF - If any of the day tanks' or transfer tank's supply signal is turned off the system will not request fuel from the remote pump set nor engage the flow control manifold solenoid valves regardless of any demand for fuel from the level controller.

b. MANUAL - if the day tanks' or transfer tank's supply signal is selected as manual, the system will engage the remote underground storage tank supply pump continuously and the day tanks or transfer tank flow control manifold solenoid valves will be held open as long as the day tanks or transfer tank supply signal is in manual, regardless of any alarms and pump off signals.

c. AUTO - With the supply signal in Auto, a signal will be sent to the Main Tank Controller to engage main underground storage tank supply pump and open the day tanks' and transfer tank's flow control manifold solenoid valve when the day tank level is at 50%. The system will continue to engage the supply signal until the fuel level has reached 85%.

2. Day Tank Return Pumps

   a. OFF - If a pump is turned off the system will not select that pump. However if the other return pump is in auto mode, the system will automatically select the pump that is in auto.

   b. MANUAL - If a pump is selected to manual, that pump will operate continuously as long as that pump is in manual mode regardless of any alarm or level control signals.

   c. AUTO - With the return pumps in auto, the controller will engage each pump in an alternating fashion. If the fuel rises to a level of 90%, the system will engage the return pump and remain engaged until the fuel level is reduced to 85%.

3. Fuel Cooler Fan

   a. OFF - The fuel cooler fan will not engage regardless of any generator on input signal.

   b. MANUAL - If the cooler fan is selected to manual the controller will engage the fan continuously as long as the fan is in manual mode regardless of the absence of the generator on signal.

   c. AUTO - With the fan cooler in automatic mode, the fan will engage when a signal is received from the generator controller that the generator is running and remain engaged as long as the generator signal is present.

   d. Fuel Cooler Fan will not be provided on the Transfer Tank,_____.

4. Alarms

   a. Return Pump Overload Trip - The system will monitor each return pump starter overload. If the controller receives a trip alarm from any of these motor starters an alarm is sounded and display "PUMP # OVERLOAD" and the lag return pump will engage. In the event that an overload occurs in the three return pumps, the supply signal will be locked out until the alarm is cleared and the system is reset.

   b. Cooler Fan Overload Trip - In the event of an overload of the cooler fan motor an alarm is sounded and displayed "COOLER FAN OVERLOAD". Alarm will remain until the system is reset.

5. Flow Failures

   a. Supply flow failure - The flow sensor in the supply flow control manifold will monitor the flow during demand to the day tanks and transfer tanks. If the sensor does not detect flow within 30 seconds (field adjustable) the request for fuel supply signal will disengage, alarm will sound and display "SUPPLY FLOW FAILURE". System will be locked out until the alarm is cleared and the system is reset.

b. Day Tanks and Transfer Tank Return Pump - The flow sensor in the return line detects no flow within 5 seconds of engagement of the return pump, that pump will disengage, alarm will sound and display "RETURN PUMP # FLOW FAILURE". In the event that no flow is detected within 5 seconds the system will lock out the supply signal.

c. Day Tanks and Transfer Tank Low Level - If the fuel level in the Day Tanks or Transfer Tank continues to drop to a level of 45%, the alarm will sound and the system will display "Day Tank Low level", "Day Tank Low level" or 'Transfer Tank Low level"

d. Day Tanks and Transfer Tank High Level - tf the fuel level in the Day Tanks or Transfer Tank continue to rise to 90%, the system will engage the respective tank return pump, sound the alarm and display "Day Tank High level", "Day Tank High level" or 'Transfer Tank High level". The respective return pump will remain engaged until the fuel level is reduced to 85%. The system will function normally once the fuel level has reached 85%, however the high level alarm will remain until the system is reset.

e. Day Tanks and Transfer Tank High-High Level - If the fuel continues to rise and the fuel level reaches 95%, the system will sound the alarm and display "Day Tank High-High level", "Day Tank High-High level" or 'Transfer Tank High-High level". The return pump will remain engaged until the fuel level reaches 85%, however the supply pumps will be locked out until the alarm condition is cleared and the system is reset.

f. Fuel in Day Tanks and Transfer Tank Vent - If either day tank or transfer tank oil invent sensor makes, the system will display "Oil in day tank Vent", "Oil in day tank Vent" or "Oil in transfer tank Vent". The system will be locked out from supplying additional fuel to the respective day tank or transfer tank until the alarm is cleared and the system is reset.

g. Emergency Stop - When the panel mounted Emergency Stop Button is pushed the system will sound the alarm and display "Emergency Alarm". The system will remain locked out until the alarm is cleared and the system is reset.

h. Not In Auto - If a pump or cooler fan selector switch is positioned in manual or the off position, the alarm sounds and displays "PUMP # Not In Auto" the system does not shut down. Alarm condition is cleared by putting the system in Auto Mode and resetting the system.

i. Fuel in Day Tanks and Transfer Tank Level Sensor Failure - In the event that the 4-20 ma level input falls to less than 4ma the system shuts down to prevent a over flow, the alarm sounds and displays "Day tank Level Probe Failure, Day tank Level Probe Failure or TT-1 Level Probe Failure". System shall lock out of auto mode until the alarm is cleared and the system is reset.

j. High Fuel Temperature - In the event the returning fuel from the generator is not cooled sufficiently the alarm will sound and display "FUEL HIGH TEMPERATURE WARNING" The return pump will engage to circulate the high temperature back to the Underground Storage Tank and replenish the fuel when the level reached the 50% level. A second alarm will be activated if the temperature reaches a critical level as specifies by the Generator Manufacturer, a dry contact signal sent to the generator controller. Alarms will remain in effect until cleared and the system reset.

k. Note: All alarms are to be transmitter to BAS via MODBUS.

l. Note: Pressing the reset button will silence the alarm buzzer.

2.15 UNDERGROUND WARNING TAPE

A. Non-adhesive 4 mil polyethelene tape, 3 inches wide. Yellow tape with black letters reading "Caution Fuel Oil Lines Below", or "Caution Fuel Oil Tank Below".

B. Acceptable manufacturers: Marking Services Incorporated or Seton.

PART 3 - EXECUTION

3.1 GENERAL

A. Submit to the Architect, Construction Manager and Owner at least three days prior to performing any of the following items a schedule when the following installation procedures can be observed:

1. Lifting and placing of tank in hole.

2. Field pressure testing of tank.

3. Verification that the UL label is located on the tank.

4. Anchoring of tank as per manufacturer's recommendation.

5. Compacting of backfill (minimum of every 12 inches). Ensure filter fabric (polyethylene unacceptable) is used in areas which have one or more of the following:

   a. Ground water levels that rise and fall frequently.

   b. Unstable soils (muck and landfills).

   c. Water conditions with silty soils.

6. Pressure testing of piping.

B. Installation of underground system shall comply with API Publication 1615, "Installation of Underground Petroleum Storage Systems."

C. Installers certified by the State Fire Marshall shall supervise the installation, removal or repair of underground storage tanks and piping.

3.2 FUEL OIL PIPING

A. Run all fuel oil supply, return and vent piping in general as indicated.

B. Provide flexible piping connections to tank.

C. Install piping in a manner to avoid damage during installation, testing, or operation.

D. Install piping according to NFPA 30A and NFPA 31.

E. Provide excavation, trenching, and backfilling. A 4 inch layer of sand or fine gravel shall be placed and tamped in the trench to provide uniform bedding for the containment pipe.

F. The entire trench shall be evenly backfilled with a similar material as the bedding in 6 inch compacted layers to a minimum height of 6 inches above the top of the piping system. The remaining trench shall be evenly and continuously backfilled in uniform layers with suitable excavated soil. Bedding and backfill materials shall be as recommended by the manufacturer. Comply with the latest edition of OSHA 2226.

G. Install piping a minimum of 18 inches below grade and sloped at a minimum 1/8 inch per foot down to the tank.

H. Test piping (except for fill piping) at 150 percent of maximum operating pressure, or 50 PSIG air pressure, whichever is greater for a period of one hour while all joints are soaped. If lines have held product or after backfilling, test all lines hydrostatically at 110 percent of maximum operating pressure, but not less than 50 PSIG.

I. Isolate piping from tanks prior to testing.

J. Install continuous underground warning tape above piping at one half depth of bury.

3.3 FUEL OIL STORAGE TANKS

A. Install underground fiberglass tank according to manufacturer's current installation instruction.

B. Install tank according to NFPA 30A, NFPA 31.

C. Test with 5 PSIG on inner tank (minimum 30 minutes) after verifying integrity of inner tank. Maintain the inner tank and test outer tank with minimum 5 PSIG pressure while soaping the skin of the tank. Do not approach end caps or man ways while tanks are being tested. Use an air gauge with quarter pound increments.

D. Install continuous underground warning tape along perimeter of tank at one half depth of bury.

3.4 FUEL OIL FILTRATION SYSTEM

A. Follow manufacturer's recommendation for installation and pipe connections.

B. Connect Fuel Oil piping to unit. Unit is equipped with:

1. _____ NPT connection, ball valve on inlet.

2. _____NPT connection, ball valve on outlet.

C. Connect Water Discharge 1/2" NPT Unit Connection to nearest drain.

3.5 STARTUP SERVICE

A. Provide by service technicians employed or authorized by the manufacturer to provide start-up service. Include copies of the startup report in the operating and maintenance manual.

3.6 TRAINING

A. A. Provide a minimum of four hours of onsite training by employees of the manufacturer in addition to the start-up services. Training shall include system concepts and basic troubleshooting.

END OF SECTION 231113

SECTION 232113 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:

1. Hot-water heating piping.
2. Chilled-water piping.
3. Condenser-water piping.
4. Glycol cooling-water piping.
5. Makeup-water piping.
6. Condensate-drain piping.
7. Blowdown-drain piping.
8. Air-vent piping.
9. Safety-valve-inlet and -outlet piping.

B. Related Sections include the following:

1. Section 232123 "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.

1.3 DEFINITIONS

A. PTFE: Polytetrafluoroethylene.

B. RTRF: Reinforced thermosetting resin (fiberglass) fittings.

C. RTRP: Reinforced thermosetting resin (fiberglass) pipe.

1.4 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:

1. Hot-Water Heating Piping: <**Insert** **psig** **(kPa)**> at **200 deg F** **(93 deg C)**.
2. Chilled-Water Piping: <**Insert** **psig** **(kPa)**> at **200 deg F** **(93 deg C)**.

3. Dual-Temperature Heating and Cooling Water Piping: <**Insert psig (kPa)**> at **200 deg F (93 deg C)**.
4. Condenser-Water Piping: <**Insert psig (kPa)**> at **150 deg F (66 deg C)**.
5. Glycol Cooling-Water Piping: <**Insert psig (kPa)**> at **150 deg F (66 deg C)**.
6. Makeup-Water Piping: **80 psig (552 kPa)** at **150 deg F (66 deg C)**.
7. Condensate-Drain Piping: **150 deg F (66 deg C)**.
8. Blowdown-Drain Piping: **200 deg F (93 deg C)**.
9. Air-Vent Piping: **200 deg F (93 deg C)**.
10. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. Plastic pipe and fittings with solvent cement.
2. RTRP and RTRF with adhesive.
3. Pressure-seal fittings.
4. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
5. Air control devices.
6. Chemical treatment.
7. Hydronic specialties.

B. LEED Submittals:

1. Product Data for Credit IEQ 4.1: For solvent cements and adhesive primers, documentation including printed statement of VOC content.

C. Shop Drawings: Detail, at **1/4 (1:50)** scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Welding certificates.

C. Field quality-control test reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.9 QUALITY ASSURANCE

A. Installer Qualifications:

1. Installers of Pressure-Sealed Joints: Installers shall be certified by the pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.
2. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by the manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

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

C. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: [**ASTM B 88, Type K (ASTM B 88M, Type A)**] [**and**] [**ASTM B 88, Type L (ASTM B 88M, Type B)**].

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A).

C. Wrought-Copper Fittings: ASME B16.22.

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

a. Anvil International, Inc.
b. S. P. Fittings; a division of Star Pipe Products.
c. Victaulic Company.

d. Mueller.

2. Grooved-End Copper Fittings: ASTM B 75 (ASTM B 75M), copper tube or ASTM B 584, bronze casting.
3. Grooved-End-Tube Couplings: Rigid pattern, unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves,[**prelubricated**] EPDM gasket rated for minimum 230 deg F (110 deg C) for use with housing, and steel bolts and nuts.

D. Copper or Bronze Pressure-Seal Fittings:

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

a. Stadler-Viega.
b. Rigid

2. Housing: Copper.
3. O-Rings and Pipe Stops: EPDM.
4. Tools: Manufacturer's special tools.
5. Minimum 200-psig (1379-kPa) working-pressure rating at 250 deg F (121 deg C).

E. Wrought-Copper Unions: ASME B16.22.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Grooved Mechanical-Joint Fittings and Couplings:

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

   a. Anvil International, Inc.
   b. Central Sprinkler Company; a division of Tyco Fire & Building Products.
   c. National Fittings, Inc.
   d. S. P. Fittings; a division of Star Pipe Products.
   e. Victaulic Company.

2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
3. Couplings: Ductile- or malleable-iron housing and synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

I. Steel Pressure-Seal Fittings:

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

   a. Victaulic Company.

2. Housing: Steel.
3. O-Rings and Pipe Stop: EPDM.
4. Tools: Manufacturer's special tool.
5. Minimum 300-psig (2070-kPa) working-pressure rating at 230 deg F (110 deg C).

J. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.3 PLASTIC PIPE AND FITTINGS

A. CPVC Plastic Pipe: ASTM F 441/F 441M, Schedules 40 and 80, plain ends as indicated in Part 3 "Piping Applications" Article.

B. CPVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM F 438 for Schedule 40 pipe; ASTM F 439 for Schedule 80 pipe.

C. PVC Plastic Pipe: ASTM D 1785, Schedules 40 and 80 solid, plain ends as indicated in Part 3 "Piping Applications" Article.

D. PVC Plastic Pipe Fittings: Socket-type pipe fittings, ASTM D 2466 for Schedule 40 pipe; ASTM D 2467 for Schedule 80 solid pipe.

2.4 FIBERGLASS PIPE AND FITTINGS

A. RTRP: ASTM D 2996, filament-wound pipe with tapered bell and spigot ends for adhesive joints.

B. RTRF: Compression or spray-up/contact molded of same material, pressure class, and joining method as pipe.

C. Flanges: ASTM D 4024. Full-face gaskets suitable for the service, minimum 1/8-inch (3.2-mm) thick, 60-70 durometer. ASTM A 307, Grade B, hex head bolts with washers.

2.5 JOINING MATERIALS

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

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

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

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

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

E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

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

G. Solvent Cements for Joining Plastic Piping:

1. CPVC Piping: ASTM F 493.

a. CPVC solvent cement shall have a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
b. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

a. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

b. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

H. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

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

I. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.6 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings:

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

a. Charlotte Pipe and Foundry Company.
b. IPEX Inc.
c. KBi.
d. Mission.
e. Fernco.

2. [**CPVC**] [**PVC**] [**CPVC and PVC**] one-piece fitting with one threaded brass or copper insert and one Schedule 80 solvent-cement-joint end.

B. Plastic-to-Metal Transition Unions:

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

a. Charlotte Pipe and Foundry Company.
b. IPEX Inc.
c. KBi.
d. NIBCO INC.
e. Mission.
f. Fernco.

2. MSS SP-107, [**CPVC**] [**PVC**] [**CPVC and PVC**] union. Include brass or copper end, Schedule 80 solvent-cement-joint end, rubber gasket, and threaded union.

2.7 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

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

    a. Capitol Manufacturing Company.
    b. Central Plastics Company.
    c. Hart Industries International, Inc.
    d. Jomar International Ltd.
    e. Matco-Norca, Inc.
    f. McDonald, A. Y. Mfg. Co.
    g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    h. Wilkins; a Zurn company.
    i. Mueller.

2. Description:

    a. Standard: ASSE 1079.
    b. Pressure Rating: [**125 psig (860 kPa) minimum at 180 deg F (82 deg C)**] [**150 psig (1035 kPa)**] [**250 psig (1725 kPa)**].
    c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

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

    a. Capitol Manufacturing Company.
    b. Central Plastics Company.
    c. Matco-Norca, Inc.
    d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
    e. Wilkins; a Zurn company.

2. Description:

    a. Standard: ASSE 1079.
    b. Factory-fabricated, bolted, companion-flange assembly.
    c. Pressure Rating: [**125 psig (860 kPa) minimum at 180 deg F (82 deg C)**] [**150 psig (1035 kPa)**] [**175 psig (1200 kPa)**] [**300 psig (2070 kPa)**].
    d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

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

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

2. Description:

a. Nonconducting materials for field assembly of companion flanges.
b. Pressure Rating: **150 psig (1035 kPa)**.
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

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

a. Elster Perfection.
b. Grinnell Mechanical Products.
c. Matco-Norca, Inc.
d. Precision Plumbing Products, Inc.
e. Victaulic Company.
f. Mueller.

2. Description:

a. Standard: IAPMO PS 66
b. Electroplated steel nipple. complying with ASTM F 1545.
c. Pressure Rating: **300 psig (2070 kPa)** at **225 deg F (107 deg C)**.
d. End Connections: Male threaded or grooved.
e. Lining: Inert and noncorrosive, propylene.

2.8 AIR CONTROL DEVICES

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

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

1. Amtrol, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett Domestic Pump; a division of ITT Industries.
4. Taco.

C. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2 (DN 15).
5. Discharge Connection: <**Insert size**>.
6. CWP Rating: 150 psig (1035 kPa).
7. Maximum Operating Temperature: 225 deg F (107 deg C).

D. Automatic Air Vents:

1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2 (DN 15).
5. Discharge Connection: NPS 1/4 (DN 8).
6. CWP Rating: 150 psig (1035 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).

E. Bladder-Type Expansion Tanks:

1. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

F. Tangential-Type Air Separators:

1. Tank: Welded steel; ASME constructed and labeled for 125-psig (860-kPa) minimum working pressure and 375 deg F (191 deg C) maximum operating temperature.
2. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
3. Tangential Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; flanged connections for NPS 2-1/2 (DN 65) and larger.
4. Blowdown Connection: Threaded.
5. Size: Match system flow capacity.

2.9 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (860 kPa).

B. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig (860 kPa).

C. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig (5170 kPa).

D. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch (20-mm) misalignment.
4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

E. Spherical, Rubber, Flexible Connectors:

1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.
4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

F. Expansion fittings are specified in Section 230516 "Expansion Fittings and Loops for HVAC Piping."

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, **NPS 2-1/2 (DN 65)** and smaller**,** shall be the following:

1. Type **L (B)**, drawn-temper copper tubing, wrought-copper fittings, and **soldered** joints.

B. Hot-water heating piping, aboveground, **NPS 3 (DN 80)** and larger**,** shall be any of the following:

1. Type [**L (B)**, drawn-temper copper tubing, wrought-copper fittings, and **soldered** joints.
2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

C. Hot-water heating piping installed belowground and within slabs shall be the following:

1. Type **K (A)**, annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

D. Chilled-water piping, aboveground, **NPS 2-1/2 (DN 65)** and smaller**,** shall be the following:

1. Type **L (B)**, drawn-temper copper tubing, wrought-copper fittings, and **soldered**] joints.

E. Chilled-water piping, aboveground, **NPS 3 (DN 80)** and larger**,** shall be any of the following:

1. Type **L (B)**, drawn-temper copper tubing, wrought-copper fittings, and **soldered** joints.
2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

F. Chilled-water piping installed belowground and within slabs shall be the following:

1. Type K (A), annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

G. Condenser-water piping, aboveground, shall bethe following:

1. Schedule **40** steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

H. Condenser-water piping installed belowground and within slabs shall be the following:

1. Type K (A), annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

I. Glycol cooling-water piping, aboveground, shall be[**any of**] the following:

1. Type **L (B)**, drawn-temper copper tubing, wrought-copper fittings, and brazed joints.
2. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.

J. Glycol cooling-water piping installed belowground and within slabs shall be the following:

1. Type K (A), annealed-temper copper tubing, wrought-copper fittings, and brazed joints. Use the fewest possible joints.

K. Makeup-water piping installed aboveground shall be[**either of**] the following:

1. Type **L (B)**, drawn-temper copper tubing, wrought-copper fittings, and **soldered** joints.

L. Makeup-Water Piping Installed Belowground and within Slabs: Type K (A), annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

M. Condensate-Drain Piping: Type **L (B)**, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

N. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

O. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
2. Outlet: Type K (A), annealed-temper copper tubing with soldered or flared joints.

P. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.

3.2 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.

B. Install balancing valves in the return pipe of each heating or cooling terminal.

C. Install check valves at each pump discharge and elsewhere as required to control flow direction.

D. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; and pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

E. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.3 PIPING INSTALLATIONS

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

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

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

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

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

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

I. Install piping to allow application of insulation.

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

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, **NPS 3/4 (DN 20)** minimum ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install valves according to Section 230523 "General-Duty Valves for HVAC Piping."

P. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

Q. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.

R. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).

S. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Section 230516 "Expansion Fittings and Loops for HVAC Piping."

T. Identify piping as specified in Section 230553 "Identification for HVAC Piping and Equipment."

U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.4 HANGERS AND SUPPORTS

A. Hanger, support, and anchor devices are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.

B. Seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet (6 m) or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4 (DN 20): Maximum span, 7 feet (2.1 m); minimum rod size, 1/4 inch (6.4 mm).
2. NPS 1 (DN 25): Maximum span, 7 feet (2.1 m); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1-1/2 (DN 40): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
4. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).
5. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod size, 3/8 inch (10 mm).
6. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod size, 3/8 inch (10 mm).
7. NPS 4 (DN 100): Maximum span, 14 feet (4.3 m); minimum rod size, 1/2 inch (13 mm).
8. NPS 6 (DN 150): Maximum span, 17 feet (5.2 m); minimum rod size, 1/2 inch (13 mm).
9. NPS 8 (DN 200): Maximum span, 19 feet (5.8 m); minimum rod size, 5/8 inch (16 mm).
10. NPS 10 (DN 250): Maximum span, 20 feet (6.1 m); minimum rod size, 3/4 inch (19 mm).
11. NPS 12 (DN 300): Maximum span, 23 feet (7 m); minimum rod size, 7/8 inch (22 mm).
12. NPS 14 (DN 350): Maximum span, 25 feet (7.6 m); minimum rod size, 1 inch (25 mm).
13. NPS 16 (DN 400): Maximum span, 27 feet (8.2 m); minimum rod size, 1 inch (25 mm).
14. NPS 18 (DN 450): Maximum span, 28 feet (8.5 m); minimum rod size, 1-1/4 inches (32 mm).
15. NPS 20 (DN 500): Maximum span, 30 feet (9.1 m); minimum rod size, 1-1/4 inches (32 mm).

E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
2. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
4. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
5. NPS 2-1/2 (DN 65): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
6. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).

F. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

G. Fiberglass Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

H. Support vertical runs at roof, at each floor, and at 10-foot (3-m) intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

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

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

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

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

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

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

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

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

H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
3. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.
4. PVC Nonpressure Piping: Join according to ASTM D 2855.

I. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

J. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

K. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

L. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.6 HYDRONIC SPECIALTIES INSTALLATION

A. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Manual vents at heat-transfer coils and elsewhere as required for air venting.

B. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

C. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

[Retain one of two paragraphs and associated subparagraphs below.]

D. Install expansion tanks above the air separator. Install tank fitting in tank bottom and charge tank. Use manual vent for initial fill to establish proper water level in tank.

1. Install tank fittings that are shipped loose.
2. Support tank from floor or structure above with sufficient strength to carry weight of tank, piping connections, fittings, plus tank full of water. Do not overload building components and structural members.

E. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system Project requirements.

3.7 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Section 230519 "Meters and Gages for HVAC Piping."

3.8 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Close-coupled, in-line centrifugal pumps.
2. Close-coupled, end-suction centrifugal pumps.
3. Separately coupled, horizontally mounted, in-line centrifugal pumps.
4. Separately coupled, vertically mounted, in-line centrifugal pumps.
5. Separately coupled, base-mounted, end-suction centrifugal pumps.
6. Separately coupled, base-mounted, double-suction centrifugal pumps.
7. Separately coupled, vertically mounted, double-suction centrifugal pumps.
8. Separately coupled, vertically mounted, turbine centrifugal pumps.
9. Wet-rotor pumps.
10. Automatic condensate pump units.

1.3 DEFINITIONS

A. Buna-N: Nitrile rubber.

B. EPT: Ethylene propylene terpolymer.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

1.5 CLOSEOUT SUBMITTALS

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

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Mechanical Seals: One mechanical seal(s) for each pump.

PART 2 - PRODUCTS

2.1 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

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

1. Armstrong Pumps Inc.
2. Aurora Pump; Division of Pentair Pump Group.
3. Grundfos Pumps Corporation.
4. ITT Corporation; Bell & Gossett.
5. Peerless Pump Company.
6. TACO Incorporated.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.

C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet**,** replaceable bronze wear rings**,** and threaded [**companion-flange**] [**union-end**] connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft: [**Steel, with copper-alloy shaft sleeve**] [**Stainless steel**].

[Retain one of two "Seal" subparagraphs below. Retain first subparagraph for service temperatures above 200 deg F (93 deg C); retain second subparagraph for service temperatures 200 deg F (93 deg C) or lower. In first subparagraph, retain "Buna-N" option for temperature rating of 225 deg F (107 deg C); retain "EPT" option for 250 deg F (120 deg C) and for glycol solutions.]

4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and [**Buna-N**] [**EPT**] bellows and gasket. Include water slinger on shaft between motor and seal.
5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: [**Permanently lubricated ball bearings**] [**Oil lubricated; bronze-journal or thrust type**].

D. Motor: Single speed and rigidly mounted to pump casing.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Enclosure: [**Open, dripproof**] [**Totally enclosed, fan cooled**] [**Totally enclosed, air over**] [**Open, externally ventilated**] [**Totally enclosed, nonventilated**] [**Severe duty**] [**Explosion proof**] [**Dust-ignition-proof machine**].
b. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
c. Motor Bearings: [**Permanently lubricated**] [**Grease-lubricated**] ball bearings.
d. Unusual Service Conditions:

1) Ambient Temperature: <**Insert deg C**>.
2) Altitude: <**Insert feet (meters)**> above sea level.
3) High humidity.

e. Efficiency: Premium efficient.
f. NEMA Design: <**Insert designation**>.
g. Service Factor: <**Insert value**>.

E. Capacities and Characteristics:
a. See schedule on drawings

2.2 CLOSE-COUPLED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Armstrong Pumps Inc.
2. Aurora Pump; Division of Pentair Pump Group.
3. ITT Corporation; Bell & Gossett.
4. Peerless Pump Company.
5. TACO Incorporated.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.

C. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, drain plug at bottom and air vent at top of volute, threaded gage tappings at inlet and outlet, and [**threaded companion-flange**] [**flanged**] connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
3. Pump Shaft: [**Steel, with copper-alloy shaft sleeve**] [**Stainless steel**].
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and [**Buna-N**] [**EPT**] bellows and gasket. Include water slinger on shaft between motor and seal.
5. Pump Bearings: [**Permanently lubricated ball bearings**] [**Oil lubricated; bronze-journal or thrust type**].

D. Motor: Single speed and rigidly mounted to pump casing with integral pump support.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

   a. Enclosure: [**Open, dripproof**] [**Totally enclosed, fan cooled**] [**Totally enclosed, air over**] [**Open, externally ventilated**] [**Totally enclosed, nonventilated**] [**Severe duty**] [**Explosion proof**] [**Dust-ignition-proof machine**].
   b. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
   c. Motor Bearings: [**Permanently lubricated**] [**Grease-lubricated**] ball bearings.
   d. Unusual Service Conditions:

      1) Ambient Temperature: <**Insert deg C**>.
      2) Altitude: <**Insert feet (meters)**> above sea level.
      3) High humidity.

   e. Efficiency: Premium efficient.
   f. NEMA Design: <**Insert designation**>.
   g. Service Factor: <**Insert value**>.

E. Capacities and Characteristics:
   a. See schedule on drawings

2.3 SEPARATELY COUPLED, HORIZONTALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

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

1. Armstrong Pumps Inc.
2. Aurora Pump; Division of Pentair Pump Group.

3. Grundfos Pumps Corporation.
4. ITT Corporation; Bell & Gossett.
5. TACO Incorporated.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally.

C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, and threaded [**companion-flange**] [**union-end**] connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. For pumps not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: [**Steel, with copper-alloy shaft sleeve**] [**Stainless steel**].
4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and [**Buna-N**] [**EPT**] bellows and gasket. Include water slinger on shaft between motor and seal.
5. Pump Bearings: [**Permanently lubricated ball bearings**] [**Oil lubricated; bronze-journal or thrust type**].

D. Shaft Coupling: [**Molded-rubber insert with interlocking spider**] [**Interlocking frame with interconnecting springs**] capable of absorbing vibration.

E. Motor: Single speed and [**resiliently**] [**rigidly**] mounted to pump casing.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Enclosure: [**Open, dripproof**] [**Totally enclosed, fan cooled**] [**Totally enclosed, air over**] [**Open, externally ventilated**] [**Totally enclosed, nonventilated**] [**Severe duty**] [**Explosion proof**] [**Dust-ignition-proof machine**].
b. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
c. Motor Bearings: [**Permanently lubricated**] [**Grease-lubricated**] ball bearings.
d. Unusual Service Conditions:

1) Ambient Temperature: <**Insert deg C**>.
2) Altitude: <**Insert feet (meters)**> above sea level.
3) High humidity.

e. Efficiency: Premium efficient.
f. NEMA Design: <**Insert designation**>.
g. Service Factor: <**Insert value**>.

F. Capacities and Characteristics:
a. See schedule on drawings

2.4 SEPARATELY COUPLED, VERTICALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

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

1. Armstrong Pumps Inc.
2. Aurora Pump; Division of Pentair Pump Group.
3. ITT Corporation; Bell & Gossett.
4. Peerless Pump Company.
5. TACO Incorporated.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted vertically.

C. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, replaceable bronze wear rings, and threaded [**companion-flange**] [**union-end**] connections.
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: [**Steel, with copper-alloy shaft sleeve**] [**Stainless steel**].

[Retain one of two "Seal" subparagraphs below. Retain first subparagraph for service temperatures above 200 deg F (93 deg C); retain second subparagraph for service temperatures 200 deg F (93 deg C) or lower. In first subparagraph, retain "Buna-N" option for temperature rating of 225 deg F (107 deg C); retain "EPT" option for 250 deg F (120 deg C) and for glycol solutions.]

4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and [**Buna-N**] [**EPT**] bellows and gasket. Include water slinger on shaft between motor and seal.
5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: [**Permanently lubricated ball bearings**] [**Oil lubricated; bronze-journal or thrust type**].

D. Shaft Coupling: Axially split spacer coupling.

E. Motor: Single speed and rigidly mounted to pump casing with lifting eyebolt and supporting lugs in motor enclosure.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Enclosure: [**Open, dripproof**] [**Totally enclosed, fan cooled**] [**Totally enclosed, air over**] [**Open, externally ventilated**] [**Totally enclosed, nonventilated**] [**Severe duty**] [**Explosion proof**] [**Dust-ignition-proof machine**].
b. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
c. Motor Bearings: [**Permanently lubricated**] [**Grease-lubricated**] ball bearings.
d. Unusual Service Conditions:

1) Ambient Temperature: <**Insert deg C**>.
2) Altitude: <**Insert feet (meters)**> above sea level.
3) High humidity.

e. Efficiency: Premium efficient.
f. NEMA Design: <**Insert designation**>.
g. Service Factor: <**Insert value**>.

F. Capacities and Characteristics:
a. See schedule on drawings

2.5 SEPARATELY COUPLED, BASE-MOUNTED, END-SUCTION CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Armstrong Pumps Inc.
2. Aurora Pump; Division of Pentair Pump Group.
3. ITT Corporation; Bell & Gossett.
4. Peerless Pump Company.
5. TACO Incorporated.

B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, end-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

C. Pump Construction:

1. Casing: Radially split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and [**threaded companion-flange**] [**flanged**] connections.[**Provide integral mount on volute to support the casing, and provide attached piping to allow removal and replacement of impeller without disconnecting piping or requiring the realignment of pump and motor shaft.**]
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For pumps not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: [**Steel, with copper-alloy shaft sleeve**] [**Stainless steel**].
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and [**Buna-N**] [**EPT**] bellows and gasket.
5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.

D. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. [**Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor.**] [**EPDM coupling sleeve for variable-speed applications.**]

E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

F. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

G. Motor: Single speed, secured to mounting frame, with adjustable alignment.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Enclosure: [**Open, dripproof**] [**Totally enclosed, fan cooled**] [**Totally enclosed, air over**] [**Open, externally ventilated**] [**Totally enclosed, nonventilated**] [**Severe duty**] [**Explosion proof**] [**Dust-ignition-proof machine**].
b. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
c. Motor Bearings: [**Permanently lubricated**] [**Grease-lubricated**] ball bearings.
d. Unusual Service Conditions:

1) Ambient Temperature: <**Insert deg C**>.
2) Altitude: <**Insert feet (meters)**> above sea level.
3) High humidity.

e. Efficiency: Premium efficient.
f. NEMA Design: <**Insert designation**>.
g. Service Factor: <**Insert value**>.

H. Capacities and Characteristics:

a. See schedule on drawings

2.6 SEPARATELY COUPLED, BASE-MOUNTED, DOUBLE-SUCTION CENTRIFUGAL PUMPS

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

1. Armstrong Pumps Inc.
2. Aurora Pump; Division of Pentair Pump Group.
3. ITT Corporation; Bell & Gossett.
4. Peerless Pump Company.
5. TACO Incorporated.

B. Description: Factory-assembled and -tested, centrifugal, impeller-between-bearings, separately coupled, double-suction pump as defined in HI 1.1-1.2 and HI 1.3; designed for base mounting, with pump and motor shafts horizontal.

C. Pump Construction:

1. Casing: [**Radially**] [**Horizontally**] split, cast iron, with replaceable bronze wear rings, threaded gage tappings at inlet and outlet, drain plug at bottom and air vent at top of volute, and ASME B16.1, [**Class 125**] [**Class 250**] flanges.[**Casing supports shall allow removal and replacement of impeller without disconnecting piping.**]
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. For pumps not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: Stainless steel.
4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and [**Buna-N**] [**EPT**] bellows and gasket.
5. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.
6. Pump Bearings: Grease-lubricated ball bearings in cast-iron housing with grease fittings.

D. Shaft Coupling: Molded-rubber insert and interlocking spider capable of absorbing vibration. [**Couplings shall be drop-out type to allow disassembly and removal without removing pump shaft or motor.**] [**EPDM coupling sleeve for variable-speed applications.**]

E. Coupling Guard: Dual rated; ANSI B15.1, Section 8; OSHA 1910.219 approved; steel; removable; attached to mounting frame.

F. Mounting Frame: Welded-steel frame and cross members, factory fabricated from ASTM A 36/A 36M channels and angles. Fabricate to mount pump casing, coupling guard, and motor.

G. Motor: Single speed, secured to mounting frame, with adjustable alignment.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Enclosure: [**Open, dripproof**] [**Totally enclosed, fan cooled**] [**Totally enclosed, air over**] [**Open, externally ventilated**] [**Totally enclosed, nonventilated**] [**Severe duty**] [**Explosion proof**] [**Dust-ignition-proof machine**].
b. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
c. Motor Bearings: Grease lubricated.
d. Unusual Service Conditions:

1) Ambient Temperature: <**Insert deg C**>.
2) Altitude: <**Insert feet (meters)**> above sea level.
3) High humidity.

e. Efficiency: Premium efficient.
f. NEMA Design: <**Insert designation**>.
g. Service Factor: <**Insert value**>.

H. Capacities and Characteristics:
a. See schedule on drawings

2.7 SEPARATELY COUPLED, VERTICALLY MOUNTED, TURBINE CENTRIFUGAL PUMPS

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

1. Aurora Pump; Division of Pentair Pump Group.
2. Peerless Pump Company.

B. Description: Factory-assembled and -tested, [**single-stage**] [**multistage**], centrifugal, impeller-between-bearings, end-suction pump as defined in HI 2.1-2.2 and HI 2.3; designed for installation with pump and motor shafts mounted vertically and projecting into a sump.

C. Pump Construction:

1. Pump Bowl: Cast iron, with [**cone**] [**basket**] strainer, replaceable bronze wear ring, and suction bell.[**Water passages of intermediate bowls shall be coated with porcelain enamel.**]
2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced and keyed to shaft. For pumps not frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft: [**Carbon**] [**Stainless**] steel sized according to manufacturer's requirements.
4. Pump Bearings: Water-lubricated bronze and rubber sleeve bearings in cast-iron housing.
5. Pump Column: ASTM A 53/A 53M, Grade B steel pipe.
6. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and [**Buna-N**] [**EPT**] bellows and gasket. Include water slinger on shaft between motor and seal.
7. Seal: Packing seal consisting of stuffing box with a minimum of four rings of graphite-impregnated braided yarn with bronze lantern ring between center two graphite rings, and bronze packing gland.

D. Shaft Coupling: Keyed with locking collets.

E. Discharge Head: ASME B16.1, [**Class 125**] [**Class 250**] discharge flange with threaded gage tapping. Top of discharge head shall have a registered fit to accurately locate the driver.

F. Drive Ratchet: Nonreversing ratchet.

G. Hollow Shaft Motor: Single speed and secured to discharge head.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

   a. Enclosure: [**Open, dripproof**] [**Totally enclosed, fan cooled**] [**Totally enclosed, air over**] [**Open, externally ventilated**] [**Totally enclosed, nonventilated**] [**Severe duty**] [**Explosion proof**] [**Dust-ignition-proof machine**].
   b. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
   c. Motor Bearings: Grease lubricated.
   d. Unusual Service Conditions:

      1) Ambient Temperature: <**Insert deg C**>.
      2) Altitude: <**Insert feet (meters)**> above sea level.
      3) High humidity.

   e. Efficiency: Premium efficient.
   f. NEMA Design: <**Insert designation**>.
   g. Service Factor: <**Insert value**>.

H. Capacities and Characteristics:
   a. See schedule on drawings

2.8 WET-ROTOR PUMPS

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

1. Armstrong Pumps Inc.
2. Grundfos Pumps Corporation.
3. ITT Corporation; Bell & Gossett.
4. TACO Incorporated.

B. Description: Factory-assembled and -tested, wet-rotor pump.

C. Pump Construction:

1. Body: [**100 percent lead-free bronze**] [**Stainless steel**] [**Cast iron**].
2. Impeller: [**Polypropylene**] [**Noryl**].
3. Pump Shaft: Ceramic.
4. Bearings. Double-sintered carbon.

D. Motor: [**Single**] [**Three**] speed.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

   a. Efficiency: Premium efficient.
   b. NEMA Design: <**Insert designation**>.
   c. Service Factor: <**Insert value**>.

E. Capacities and Characteristics:
   a. See schedule on drawings

2.9 AUTOMATIC CONDENSATE PUMP UNITS

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

   1. Beckett Corporation.
   2. Hartell Pumps Div.; Milton Roy Co.
   3. Little Giant Pump Co.

B. Description: Packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch- (1800-mm-) minimum, electrical power cord with plug.

C. Capacities and Characteristics:
   a. See schedule on drawings

2.10 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

   1. Angle pattern.
   2. [**175-psig (1204-kPa)**] [**300-psig (2060-kPa)**] pressure rating, [**cast**] [**ductile**]-iron body and end cap, pump-inlet fitting.
   3. Bronze startup and bronze or stainless-steel permanent strainers.
   4. Bronze or stainless-steel straightening vanes.
   5. Drain plug.
   6. Factory-fabricated support.

B. Triple-Duty Valve:

   1. Angle or straight pattern.
   2. [**175-psig (1204-kPa)**] [**300-psig (2060-kPa)**] pressure rating, [**cast**] [**ductile**]-iron body, pump-discharge fitting.
   3. Drain plug and bronze-fitted shutoff, balancing, and check valve features.
   4. Brass gage ports with integral check valve and orifice for flow measurement.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

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

3.2 PUMP INSTALLATION

[In first paragraph below, retain "HI 1.4" option for centrifugal pumps and "HI 2.4" option for vertically mounted, turbine centrifugal pumps.]

A. Comply with [**HI 1.4**] [**and**] [**HI 2.4**].

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

E. Equipment Mounting: Install base-mounted pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases specified in

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct bases to withstand, without damage to equipment, seismic force required by code.
3. Construct concrete bases [**4 inches (100 mm)**] [**6 inches (150 mm)**] [**8 inches (200 mm)**] high and extend base not less than 6 inches (150 mm) in all directions beyond the maximum dimensions of base-mounted pumps unless otherwise indicated or unless required for seismic-anchor support.
4. Minimum Compressive Strength: [**5000 psi (34.5 MPa)**] [**4500 psi (31 MPa)**] [**4000 psi (27.6 MPa)**] [**3500 psi (24.1 MPa)**] [**3000 psi (20.7 MPa)**] at 28 days.

F. Equipment Mounting: Install base-mounted pumps on cast-in-place concrete equipment base(s) using [**elastomeric pads**] [**elastomeric mounts**] [**restrained spring isolators**]. Comply with requirements for equipment bases specified in Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1 inch (25 mm)**].
2. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of concrete base.
4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.
7. Install on [**4-inch- (100-mm-)**] [**6-inch- (150-mm-)**] high concrete base[**designed to withstand, without damage to equipment, seismic force required by code**].

G. Equipment Mounting: Install base-mounted pumps using [**elastomeric pads**] [**elastomeric mounts**] [**restrained spring isolators**]. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1 inch (25 mm)**].

H. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and [**elastomeric hangers**] [**spring hangers**] [**spring hangers with vertical-limit stop**] of size required to support weight of in-line pumps.

1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.3 ALIGNMENT

A. Engage a factory-authorized service representative to perform alignment service.

B. Comply with requirements in Hydronics Institute standards for alignment of pump and motor shaft. Add shims to the motor feet and bolt motor to base frame. Do not use grout between motor feet and base frame.

C. Comply with pump and coupling manufacturers' written instructions.

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.4 CONNECTIONS

A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to pump, allow space for service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install [**check, shutoff, and throttling valves**] on discharge side of pumps.

F. Install [**Y-type strainer**] [**suction diffuser**] and shutoff valve on suction side of pumps.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.

I. Install check valve and gate or ball valve on each condensate pump unit discharge.

J. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

K. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Perform the following startup checks for each pump before starting:

    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in the correct direction.

5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain hydronic pumps.

END OF SECTION 232123

SECTION 232213 - STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following for [**LP**] [**LP and HP**] [**HP**] steam and condensate piping:

1. Pipe and fittings.
2. Strainers.
3. Flash tanks.
4. Safety valves.
5. Pressure-reducing valves.
6. Steam traps.
7. Thermostatic air vents and vacuum breakers.
8. Steam and condensate meters.

1.3 DEFINITIONS

A. HP Systems: High-pressure piping operating at more than 15 psig (104 kPa) as required by ASME B31.1.

B. LP Systems: Low-pressure piping operating at 15 psig (104 kPa) or less as required by ASME B31.9.

C. RTRF: Reinforced thermosetting resin (fiberglass) fittings.

D. RTRP: Reinforced thermosetting resin (fiberglass) pipe.

1.4 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures:

1. HP Steam Piping: <**Insert psig (kPa).**>
2. LP Steam Piping: <**Insert psig (kPa).**>
3. Condensate Piping: <**Insert psig (kPa)**> at **250 deg F (121 deg C)**.
4. Makeup-Water Piping: **80 psig (552 kPa)** at **150 deg F (66 deg C)**.
5. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
6. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.

7. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of the following:

1. RTRP and RTRF with adhesive.
2. Pressure-reducing and safety valve.
3. Steam trap.
4. Air vent and vacuum breaker.
5. Flash tank.
6. Meter.

B. Shop Drawings: Detail, **1/4 inch equals 1 foot** **(1:50)** scale, flash tank assemblies and fabrication of pipe anchors, hangers, pipe, multiple pipes, alignment guides, and expansion joints and loops and their attachment to the building structure. Detail locations of anchors, alignment guides, and expansion joints and loops.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Welding certificates.

C. Field quality-control test reports.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

A. Installer Qualifications:

1. Fiberglass Pipe and Fitting Installers: Installers of RTRF and RTRP shall be certified by the manufacturer of pipes and fittings as having been trained and qualified to join fiberglass piping with manufacturer-recommended adhesive.

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

C. Pipe Welding: Qualify processes and operators according to the following:

1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

D. ASME Compliance: Comply with [**ASME B31.1, "Power Piping"**] [**and**] [**ASME B31.9, "Building Services Piping"**] for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp flash tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: [**ASTM B 88, Type L (ASTM B 88M, Type B)**] [**ASTM B 88, Type K (ASTM B 88M, Type A)**].

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K (ASTM B 88M, Type A).

C. Wrought-Copper Fittings and Unions: ASME B16.22.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, plain ends, Type, Grade, and Schedule as indicated in Part 3 piping applications articles.

B. Cast-Iron Threaded Fittings: ASME B16.4; Class 300.

C. Malleable-Iron Threaded Fittings: ASME B16.3; Class 300.

D. Malleable-Iron Unions: ASME B16.39; Class 300.

E. Cast-Iron Threaded Flanges and Flanged Fittings: ASME B16.1, Class 250; raised ground face, and bolt holes spot faced.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

G. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding.
3. Facings: Raised face.

H. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, black steel of same Type, Grade, and Schedule as pipe in which installed.

I. Stainless-Steel Bellows, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforced, protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch (20-mm) misalignment.
4. CWP Rating: 150-psig (1035-kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.3 JOINING MATERIALS

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

1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

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

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

D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.

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

F. Welding Materials: Comply with Section II, Part C, of ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

2.4 DIELECTRIC FITTINGS

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

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

C. Dielectric Unions:

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

a. Capitol Manufacturing Company.
b. Central Plastics Company.
c. Hart Industries, International Inc.
d. Watts Water Technologies, Inc.
e. Zurn Plumbing Products Group.

2. Factory-fabricated union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).

D. Dielectric Flanges:

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

a. Capitol Manufacturing Company.
b. Central Plastics Company.
c. Watts Water Technologies, Inc.

2. Factory-fabricated companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.

E. Dielectric-Flange Kits:

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

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

2. Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
3. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.

2.5 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 230523 "General-Duty Valves for HVAC Piping."

B. Stop-Check Valves:

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

a. Crane Co.
b. Jenkins Valves; a Crane Company.
c. Lunkenheimer Valves.
d. A.Y. McDonald Mfg. Co.
e. Vogt.

2. Body and Bonnet: Malleable iron.
3. End Connections: Flanged or threaded.
4. Disc: Cylindrical with removable liner and machined seat.
5. Stem: Brass alloy.
6. Operator: Outside screw and yoke with cast-iron handwheel.
7. Packing: Polytetrafluoroethylene-impregnated packing with two-piece packing gland assembly.
8. Pressure Class: 250.

2.6 STRAINERS

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 (DN 50) and smaller; flanged ends for strainers NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: Stainless-steel, 20 mesh strainer, and perforated stainless-steel basket with 50 percent free area.
4. Tapped blowoff plug.
5. CWP Rating: 250-psig (1725-kPa) working steam pressure.

B. Basket Strainers:

1. Body: ASTM A 126, Class B cast iron, with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for strainers NPS 2 (DN 50) and smaller; flanged ends for strainers NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: Stainless-steel, 20 mesh strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 250-psig (1725-kPa) working steam pressure.

2.7 FLASH TANKS

A. Shop or factory fabricated of welded steel according to ASME Boiler and Pressure Vessel Code, for 150-psig (1035-kPa) rating; and bearing ASME label. Fabricate with tappings for low-pressure steam and condensate outlets, high-pressure condensate inlet, air vent, safety valve, and legs.

2.8 SAFETY VALVES

A. [**Bronze**] [**or**] [**Brass**] Safety Valves:

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

   a. Consolidated.
   b. Kunkle Valve; a Tyco International Ltd. Company

2. Disc Material: Forged copper alloy.
3. End Connections: Threaded inlet and outlet.
4. Spring: Fully enclosed steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
5. Pressure Class: 250.
6. Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
7. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

B. Cast-Iron Safety Valves:

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

   a. Consolidated.
   b. Kunkle Valve; a Tyco International Ltd. Company

2. Disc Material: Forged copper alloy with bronze nozzle.
3. End Connections: Raised-face flanged inlet and threaded or flanged outlet connections.
4. Spring: Fully enclosed cadmium-plated steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
5. Pressure Class: 250.
6. Drip-Pan Elbow: Cast iron and having threaded inlet, outlet, and drain, with threads complying with ASME B1.20.1.
7. Exhaust Head: Cast iron and having threaded inlet and drain, with threads complying with ASME B1.20.1.
8. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.

2.9 PRESSURE-REDUCING VALVES

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

1. Spence Engineering Company, Inc.

B. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated.

C. Description: Pilot-actuated, diaphragm type, with adjustable pressure range and positive shutoff.

D. Body: Cast iron.

E. End Connections: Threaded connections for valves NPS 2 (DN 50) and smaller and flanged connections for valves NPS 2-1/2 (DN 65) and larger.

F. Trim: Hardened stainless steel.

G. Head and Seat: Replaceable, main head stem guide fitted with flushing and pressure-arresting device cover over pilot diaphragm.

H. Gaskets: Non-asbestos materials.

I. Capacities and Characteristics:

1. Steam Flow Rate: <**Insert lb/h (kg/s).**>
2. Inlet Pressure: <**Insert psig (kPa).**>
3. Outlet Set Pressure: <**Insert psig (kPa).**>
4. Pressure Loss (Wide Open): <**Insert psig (kPa).**>

2.10 STEAM TRAPS

A. Thermostatic Traps:

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

a. Spirax Sarco, Inc.

b. Hoffman

c. Nicholson

2. Body: Bronze angle-pattern body with integral union tailpiece and screw-in cap.
3. Trap Type: Balanced-pressure.
4. Bellows: Stainless steel or monel.
5. Head and Seat: Replaceable, hardened stainless steel.
6. Pressure Class: 125.
7. Model: TD52; bolt-on.

B. Thermodynamic Traps:

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

a. Spirax Sarco, Inc.

b. Hoffman

c. Nicholson

2. Body: Stainless steel with screw-in cap.
3. End Connections: Threaded.
4. Disc and Seat: Stainless steel.
5. Maximum Operating Pressure: 600 psig (4140 kPa).

C. Float and Thermostatic Traps:

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

a. Dunham-Bush, Inc.
b. Hoffman Specialty; Division of ITT Industries.
c. Spirax Sarco, Inc.
d. Nicholson

2. Body and Bolted Cap: ASTM A 126, cast iron.
3. End Connections: Threaded.
4. Float Mechanism: Replaceable, stainless steel.
5. Head and Seat: Hardened stainless steel.
6. Trap Type: Balanced pressure.
7. Thermostatic Bellows: Stainless steel or monel.
8. Thermostatic air vent capable of withstanding 45 deg F (25 deg C) of superheat and resisting water hammer without sustaining damage.
9. Vacuum Breaker: Thermostatic with phosphor bronze bellows, and stainless steel cage, valve, and seat.
10. Maximum Operating Pressure: 125 psig (860 kPa).

D. Inverted Bucket Traps:

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

a. Dunham-Bush, Inc.
b. Hoffman Specialty; Division of ITT Industries.
c. Spirax Sarco, Inc.
d. Nicholson

2. Body and Cap: Cast iron.
3. End Connections: Threaded.
4. Head and Seat: Stainless steel.
5. Valve Retainer, Lever, and Guide Pin Assembly: Stainless steel.
6. Bucket: Brass or stainless steel.
7. Strainer: Integral stainless-steel inlet strainer within the trap body.
8. Air Vent: Stainless-steel thermostatic vent.
9. Pressure Rating: 250 psig (1725 kPa).

2.11 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

A. Thermostatic Air Vents:

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

a. Dunham-Bush, Inc.
b. Hoffman Specialty; Division of ITT Industries.
c. Spirax Sarco, Inc.

2. Body: Cast iron, bronze or stainless steel.
3. End Connections: Threaded.
4. Float, Valve, and Seat: Stainless steel.
5. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
6. Pressure Rating: [**125 psig (861 kPa)**] [**300 psig (2068 kPa)**].
7. Maximum Temperature Rating: **350 deg F (177 deg C)**.

B. Vacuum Breakers:

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

a. Dunham-Bush, Inc.
b. Hoffman Specialty; Division of ITT Industries.
c. Spirax Sarco, Inc.

2. Body: Cast iron, bronze, or stainless steel.
3. End Connections: Threaded.
4. Sealing Ball, Retainer, Spring, and Screen: Stainless steel.
5. O-ring Seal: EPR.
6. Pressure Rating: [**125 psig (861 kPa)**] [**300 psig (2068 kPa)**].
7. Maximum Temperature Rating: **350 deg F (177 deg C)**.

2.12 STEAM METERS

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

1. EMCO Flow Systems; Division of Advanced Energy Company.
2. ISTEC Corp.
3. Preso Meters; a division of Racine Federated Inc.
4. Spirax Sarco, Inc.

B. Meters shall have a microprocessor to display totalizer flow, flow rate, temperature, pressure, time, and date; alarms for high and low flow rate and temperature.

1. Computer shall have 4 to 20-mA or 2 to 10 volt output for temperature, pressure, and contact closure for flow increments.
2. Independent timers to store four peak flow rates and total flow.
3. Interface compatible with central workstation described in Section 230900 "Instrumentation and Control for HVAC."
4. Microprocessor Enclosure: NEMA 250, Type 4.

[Retain one of three paragraphs below.]

C. Sensor: Venturi, of [**stainless-steel**] [**carbon-steel**] construction, for insertion in pipeline between flanges. At least 10:1 turndown with plus or minus 1 percent accuracy over full-flow range.

D. Sensor: Vortex type with stainless-steel wetted parts and [**wafer**] [**flange**] connections; and with a piezoelectric sensor removable and serviceable without shutting down the process. At least 10:1 turndown with plus or minus 1 percent accuracy over full-flow range.

E. Sensor: Spring-loaded, variable-area flowmeter type; density compensated with stainless-steel wetted parts and [**wafer**] [**flange**] connections. At least 10:1 turndown with plus or minus 2 percent accuracy over full-flow range.

2.13 CONDENSATE METERS

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

1. Central Station Steam Co.
2. Lincoln Meter Company.

B. Body: Cast iron, bronze, or brass.

C. Turbine: Copper, brass, or stainless steel.

D. Connections: Threaded for NPS 2 (DN 50) and smaller and flanged for NPS 2-1/2 (DN 65).

E. Totalizer: Meters shall have a microprocessor to display flow, flow rate, time, and date; alarms for high and low flow rate, pressure, and temperature.

1. Computer shall have 4- to 20-mA or 2- to 10-volt output for temperature, pressure, and contact closure for flow increments.
2. Independent timers to store four peak flow rates and total flow.
3. Interface compatible with central workstation specified in Section 230900 "Instrumentation and Control for HVAC."
4. Microprocessor Enclosure: NEMA 250, Type 4.

F. Pressure Rating: Atmospheric.

G. Maximum Temperature Rating: **250 deg F (121 deg C)**.

PART 3 - EXECUTION

3.1 LP STEAM PIPING APPLICATIONS

A. LP Steam Piping, **NPS 2 (DN 50)** and Smaller: Schedule 40, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

B. LP Steam Piping, **NPS 2-1/2 through NPS 12 (DN 65 through DN 300)**: Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. LP Steam Piping, **NPS 14 through NPS 18 (DN 350 through DN 450)**: Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

D. LP Steam Piping, **NPS 20 (DN 500)** and Larger: Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

E. Condensate piping above grade, **NPS 2 (DN 50)** and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

F. Condensate piping above grade, **NPS 2-1/2 (DN 65)** and larger, shall be the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

G. Condensate piping below grade, **NPS 2 (DN 50)** and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

H. Condensate piping below grade, **NPS 2-1/2 (DN 65)** and larger, shall be the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.2 HP STEAM PIPING APPLICATIONS

A. HP Steam Piping, **NPS 2 (DN 50)** and Smaller: Schedule 40, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

B. HP Steam Piping, **NPS 2-1/2 through NPS 12 (DN 65 through DN 300)**: Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

C. HP Steam Piping, **NPS 14 through NPS 18 (DN 350 through DN 450)**: Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

D. HP Steam Piping, **NPS 20 (DN 500)**: Schedule 40, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

E. Condensate piping above grade, **NPS 2 (DN 50)** and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

F. Condensate piping above grade, **NPS 2-1/2 (DN 65)** and larger, shall be the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

G. Condensate piping below grade, **NPS 2 (DN 50)** and smaller, shall be the following:

1. Schedule 80, Type S, Grade B, steel pipe; Class 125 cast-iron fittings; and threaded joints.

H. Condensate piping below grade, **NPS 2-1/2 (DN 65)** and larger, shall be the following:

1. Schedule 80, Type E, Grade B, steel pipe; Class 150 wrought-steel fittings, flanges, and flange fittings; and welded and flanged joints.

3.3 ANCILLARY PIPING APPLICATIONS

A. Makeup-water piping installed above grade shall be the following:

1. Drawn-temper copper tubing, wrought-copper fittings, and [**soldered**] [**brazed**] joints.

B. Makeup-Water Piping Installed below Grade and within Slabs: Annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

C. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

D. Air-Vent Piping:

1. Inlet: Same as service where installed.
2. Outlet: Type K (A) annealed-temper copper tubing with soldered or flared joints.

E. Vacuum-Breaker Piping: Outlet, same as service where installed.

F. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.4 VALVE APPLICATIONS

A. Install shutoff duty valves at branch connections to steam supply mains, at steam supply connections to equipment, and at the outlet of steam traps.

B. Install safety valves on pressure-reducing stations and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.

3.5 PIPING INSTALLATION

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

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

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

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

E. Install piping to permit valve servicing.

F. Install piping free of sags and bends.

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

H. Install piping to allow application of insulation.

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

J. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

K. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) full port-ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

L. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

M. Install condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side down.

O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to top of main pipe.

P. Install valves according to Section 230523 "General-Duty Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 (DN 50) and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 (DN 65) and larger, at final connections of equipment and elsewhere as indicated.

S. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 (DN 20) nipple and full port ball valve in blowdown connection of strainers NPS 2 (DN 50) and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 (DN 50).

T. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Section 230516 "Expansion Fittings and Loops for HVAC Piping."

U. Identify piping as specified in Section 230553 "Identification for HVAC Piping and Equipment."

V. Install drip legs at low points and natural drainage points such as ends of mains, bottoms of risers, and ahead of pressure regulators, and control valves.

1. On straight runs with no natural drainage points, install drip legs at intervals not exceeding **300 feet (90 m)**.
2. Size drip legs same size as main. In steam mains NPS 6 (DN 150) and larger, drip leg size can be reduced, but to no less than NPS 4 (DN 100).

W. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

Y. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.6 STEAM-TRAP INSTALLATION

A. Install steam traps in accessible locations as close as possible to connected equipment.

B. Install gate valve, strainer, and union upstream from trap; install union, check valve, and gate valve downstream from trap unless otherwise indicated.

3.7 PRESSURE-REDUCING VALVE INSTALLATION

A. Install pressure-reducing valves in accessible location for maintenance and inspection.

B. Install bypass piping around pressure-reducing valves, with globe valve equal in size to area of pressure-reducing valve seat ring, unless otherwise indicated.

C. Install gate valves on both sides of pressure-reducing valves.

D. Install unions or flanges on both sides of pressure-reducing valves having threaded- or flanged-end connections respectively.

E. Install pressure gages on low-pressure side of pressure-reducing valves after the bypass connection according to Section 230519 "Meters and Gages for HVAC Piping."

F. Install strainers upstream for pressure-reducing valve.

G. Install safety valve downstream from pressure-reducing valve station.

3.8 STEAM OR CONDENSATE METER INSTALLATION

A. Install meters with lengths of straight pipe upstream and downstream according to steam meter manufacturer's instructions.

B. Provide data acquisition wiring. Refer to Section 230900 "Instrumentation and Control for HVAC."

3.9 SAFETY VALVE INSTALLATION

A. Install safety valves according to ASME B31.1, "Power Piping" and ASME B31.9, "Building Services Piping."

B. Pipe safety-valve discharge without valves to atmosphere outside the building.

C. Install drip-pan elbow fitting adjacent to safety valve and pipe drain connection to nearest floor drain.

D. Install exhaust head with drain to waste, on vents equal to or larger than NPS 2-1/2 (DN 65).

3.10 HANGERS AND SUPPORTS

A. Install hangers and supports according to Section 230529 "Hangers and Supports for HVAC Piping and Equipment." Comply with requirements below for maximum spacing.

B. Seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet (6 m) long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet (6 m) or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.

D. Install hangers with the following maximum spacing and minimum rod sizes:

1. NPS 3/4 (DN 20): Maximum span, 9 feet (2.7 m); minimum rod size, 1/4 inch (6.4 mm).
2. NPS 1 (DN 25): Maximum span, 9 feet (2.7 m); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1-1/2 (DN 40): Maximum span, 12 feet (3.7 m); minimum rod size, 3/8 inch (10 mm).
4. NPS 2 (DN 50): Maximum span, 13 feet (4 m); minimum rod size, 3/8 inch (10 mm).
5. NPS 2-1/2 (DN 65): Maximum span, 14 feet (4.3 m); minimum rod size, 3/8 inch (10 mm).
6. NPS 3 (DN 80): Maximum span, 15 feet (4.6 m); minimum rod size, 3/8 inch (10 mm).
7. NPS 4 (DN 100): Maximum span, 17 feet (5.2 m); minimum rod size, 1/2 inch (13 mm).
8. NPS 6 (DN 150): Maximum span, 21 feet (6.4 m); minimum rod size, 1/2 inch (13 mm).
9. NPS 8 (DN 200): Maximum span, 24 feet (7.3 m); minimum rod size, 5/8 inch (16 mm).
10. NPS 10 (DN 250): Maximum span, 26 feet (8 m); minimum rod size, 3/4 inch (19 mm).
11. NPS 12 (DN 300): Maximum span, 30 feet (9.1 m); minimum rod size, 7/8 inch (22 mm).
12. NPS 14 (DN 350): Maximum span, 32 feet (9.8 m); minimum rod size, 1 inch (25 mm).
13. NPS 16 (DN 400): Maximum span, 35 feet (10.7 m); minimum rod size, 1 inch (25 mm).
14. NPS 18 (DN 450): Maximum span, 37 feet (11.3 m); minimum rod size, 1-1/4 inches (32 mm).
15. NPS 20 (DN 500): Maximum span, 39 feet (11.9 m); minimum rod size, 1-1/4 inches (32 mm).

E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 1/2 (DN 15): Maximum span, 4 feet (1.2 m); minimum rod size, 1/4 inch (6.4 mm).
2. NPS 3/4 (DN 20): Maximum span, 5 feet (1.5 m); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1 (DN 25): Maximum span, 6 feet (1.8 m); minimum rod size, 1/4 inch (6.4 mm).
4. NPS 1-1/2 (DN 40): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
5. NPS 2 (DN 50): Maximum span, 8 feet (2.4 m); minimum rod size, 3/8 inch (10 mm).
6. NPS 2-1/2 (DN 65): Maximum span, 9 feet (2.7 m); minimum rod size, 3/8 inch (10 mm).
7. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (10 mm).

F. Support vertical runs at roof, at each floor, and at 10-foot (3-m) intervals between floors.

G. Fiberglass Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

3.11 PIPE JOINT CONSTRUCTION

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

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

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

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

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

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

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

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

3.12 TERMINAL EQUIPMENT CONNECTIONS

A. Size for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install traps and control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install vacuum breakers downstream from control valve, close to coil inlet connection.

E. Install a drip leg at coil outlet.

3.13 FIELD QUALITY CONTROL

A. Prepare steam and condensate piping according to [**ASME B31.1, "Power Piping"**] [**and**] [**ASME B31.9, "Building Services Piping,"**] and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.

3. Flush system with clean water. Clean strainers.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.

B. Perform the following tests on steam and condensate piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength.
3. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

C. Prepare written report of testing.

END OF SECTION 232213

SECTION 232223 - STEAM CONDENSATE PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes steam condensate pumps.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated. Indicate pump's operating point on curves. Include receiver capacity and material.

B. Shop Drawings: For each pump.

1. Show pump layout and connections.
2. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
3. Include diagrams for power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SINGLE-STAGE, CENTRIFUGAL PUMPS WITH FLOOR-MOUNTED RECEIVER

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

1. Alyan Pump Company; Div. of Hannmann Machinery Systems, Inc.
2. Armstrong Fluid Handling; Div. of Armstrong International, Inc.
3. ITT Corporation; Domestic Pump Division.
4. Nicholson Steam Trap; a division of Spence Engineering Company, Inc.
5. Pentair Pump Group.

6. Roth Pump Company.
7. Skidmore Pump.
8. Spence Engineering Company, Inc.; Division of Circor International, Inc.
9. Spirax-Sarco Inc.
10. Sterling.

B. Description: Factory-fabricated, packaged, electric-driven pumps; with receiver, pumps, controls, and accessories suitable for operation with steam condensate.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASME Compliance: Fabricate and label steam condensate receivers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. Configuration: Duplex floor-mounted pump with receiver and float switches; rated to pump 200 deg F (93 deg C) steam condensate.

D. Receiver:

1. Floor mounted.
2. [**Close-grained cast iron**] [**Welded steel**].
3. Externally adjustable float switches.
4. Flanges for pump mounting.
5. Water-level gage and dial thermometer.
6. Pressure gage at pump discharge.
7. Bronze fitting isolation valve between pump and receiver.
8. Lifting eyebolts.
9. Inlet vent and an overflow.
10. Cast-iron inlet strainer with vertical self-cleaning bronze screen and large dirt pocket.

E. Pumps:

1. Centrifugal, close coupled, vertical design.
2. Permanently aligned.
3. Bronze fitted.
4. Replaceable bronze case ring.
5. Mechanical seals rated at 250 deg F (120 deg C).
6. Mounted on receiver flange.

F. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure: Totally enclosed, fan cooled.
3. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
4. Motor Bearings: Permanently lubricated ball bearings.
5. Unusual Service Conditions:

   a. Ambient Temperature: <**Insert deg C**>.

b. Altitude: <**Insert feet (meters)**> above sea level.
c. High humidity.

6. Efficiency: Premium efficient.
7. NEMA Design: <**Insert designation**>.
8. Service Factor: <**Insert value**>.

G. Control Panel:

1. Factory wired between pumps and float switches, for single external electrical connection.
2. Provide fused, control-power transformer if voltage exceeds 230 V ac.
3. NEMA 250, [**Type 1**] [**Type 3**] [**Type 12**] enclosure with hinged door and grounding lug, mounted on pump.
4. Motor controller for each pump.
5. Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
6. Manual lead-lag control to override electrical pump alternator and manually select the lead pump.
7. Momentary-contact "TEST" push button on cover for each pump.
8. Numbered terminal strip.
9. Disconnect switch.

H. Capacities and Characteristics:

1. Unit Total Capacity: <**Insert sq. ft. EDR (kW)**>.
2. Capacity, Each Pump:

a. Flow: <**Insert gpm (L/s)**>.
b. Discharge Head: <**Insert psig (kPa)**>.
c. Discharge Size: <**Insert NPS (DN)**>.
d. Speed: <**Insert rpm**>.
e. Motor Horsepower: <**Insert value**>.

3. Receiver:

a. Capacity: <**Insert gal. (L)**>.
b. Inlet Size: <**Insert NPS (DN)**>.
c. Height to Inlet: <**Insert inches (mm)**>.

4. Electrical Characteristics:

a. Volts: [**120**] [**230**] [**240**].
b. Phase: Single.
c. Hertz: 60.
d. Full-Load Amperes: <**Insert value**>.
e. Minimum Circuit Ampacity: <**Insert value**>.
f. Maximum Overcurrent Protection: <**Insert amperage**>.

2.2 TWO-STAGE, CENTRIFUGAL PUMPS WITH FLOOR-MOUNTED RECEIVER

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

1. Alyan Pump Company; Div. of Hannmann Machinery Systems, Inc.
2. ITT Corporation; Domestic Pump Division.
3. Nicholson Steam Trap; a division of Spence Engineering Company, Inc.
4. Pentair Pump Group.
5. Roth Pump Company.
6. Skidmore Pump.
7. Spence Engineering Company, Inc.; Division of Circor International, Inc.
8. Spirax-Sarco Inc.
9. Sterling.

B. Description: Factory-fabricated, packaged, electric-driven pumps; with receiver, pumps, controls, and accessories suitable for operation with steam condensate.

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASME Compliance: Fabricate and label steam condensate receivers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. Configuration: Duplex floor-mounted pumps with receiver and float switches; rated to pump minimum 210 deg F (99 deg C) steam condensate with a minimum of 2 feet (6 kPa) of NPSH.

D. Receiver:

1. Floor mounted.
2. [**Close-grained cast iron**] [**Welded steel**].
3. Externally adjustable float switches.
4. Flanges for pump mounting.
5. Water-level gage and dial thermometer.
6. Pressure gage at pump discharge.
7. Bronze gate valves between receiver and pump discharge.
8. Lifting eyebolts.
9. Inlet vent and an overflow.
10. Cast-iron inlet strainer with self-cleaning bronze screen, dirt pocket, and cleanout plug on receiver inlet.

E. Pumps:

1. Centrifugal, two stage, close coupled.
2. Vertical design, permanently aligned, and bronze fitted.
3. Axial-flow first-stage bronze impeller.
4. Enclosed second-stage bronze impeller with replaceable bronze case rings.
5. Stainless-steel shafts.
6. Mechanical seals rated at 250 deg F (120 deg C).
7. Rated to operate with a minimum of 2 feet (6 kPa) of NPSH.
8. Mounted on receiver flanges.

F. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure: Totally enclosed, fan cooled.
3. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
4. Motor Bearings: Permanently lubricated ball bearings.
5. Unusual Service Conditions:

   a. Ambient Temperature: <**Insert deg C**>.
   b. Altitude: <**Insert feet (meters)**> above sea level.
   c. High humidity.

6. Efficiency: Premium efficient.
7. NEMA Design: <**Insert designation**>.
8. Service Factor: <**Insert value**>.

G. Control Panel:

1. Factory wired between pumps and float switches, for single external electrical connection.
2. Provide fused, control-power transformer if voltage exceeds 230 V ac.
3. NEMA 250, [**Type 1**] [**Type 3**] [**Type 12**] enclosure with hinged door and grounding lug, mounted on pump.
4. Motor controller for each pump.
5. Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
6. Manual lead-lag control to override electrical pump alternator and manually select the lead pump.
7. Momentary-contact "TEST" push button on cover for each pump.
8. Numbered terminal strip.
9. Disconnect switch.

H. Capacities and Characteristics:

1. Unit Total Capacity: <**Insert sq. ft. EDR (kW)**>.
2. Capacity, Each Pump:

   a. Flow: <**Insert gpm (L/s)**>.
   b. Discharge Head: <**Insert psig (kPa)**>.
   c. Discharge Size: <**Insert NPS (DN)**>.
   d. Speed: <**Insert rpm**>.
   e. Motor Horsepower: <**Insert value**>.

3. Receiver:

   a. Capacity: <**Insert gal. (L)**>.
   b. Inlet Size: <**Insert NPS (DN)**>.
   c. Height to Inlet: <**Insert inches (mm)**>.

4. Electrical Characteristics:

   a. Volts: [**120**] [**208**] [**230**] [**240**] [**480**].
   b. Phase: [**Single**] [**Three**].
   c. Hertz: 60.
   d. Full-Load Amperes: <**Insert value**>.
   e. Minimum Circuit Ampacity: <**Insert value**>.
   f. Maximum Overcurrent Protection: <**Insert amperage**>.

2.3 SINGLE-STAGE, CENTRIFUGAL PUMPS WITH ELEVATED RECEIVER

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

   1. Alyan Pump Company; Div. of Hannmann Machinery Systems, Inc.
   2. ITT Corporation; Domestic Pump Division.
   3. Nicholson Steam Trap; a division of Spence Engineering Company, Inc.
   4. Pentair Pump Group.
   5. Roth Pump Company.
   6. Skidmore Pump.
   7. Spence Engineering Company, Inc.; Division of Circor International, Inc.
   8. Spirax-Sarco Inc.

B. Description: Factory-fabricated, packaged, electric-driven pumps; with receiver, pumps, controls, and accessories suitable for operation with steam condensate.

   1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
   2. ASME Compliance: Fabricate and label steam condensate receivers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. Configuration: Duplex floor-mounted pump with elevated receiver, float switches, and connecting piping; rated to pump 212 deg F (100 deg C) steam condensate.

D. Receiver:

   1. Mounted on fabricated-steel supports.
   2. [**Close-grained cast iron**] [**Welded steel**].
   3. Externally adjustable float switches.
   4. Water-level gage and dial thermometer.
   5. Pressure gage at pump discharge.
   6. Bronze isolation valves between receiver and pumps.
   7. Lifting eyebolts.
   8. Inlet cascade baffle and convex heads.
   9. Cast-iron inlet strainer with self-cleaning bronze screen, dirt pocket, and cleanout plug on receiver inlet.

E. Pumps:

1. Centrifugal, close coupled.
2. Permanently aligned.
3. Bronze fitted with enclosed bronze impellers.
4. Replaceable bronze case rings.
5. Stainless-steel shafts.
6. Mechanical seals rated at 250 deg F (120 deg C).
7. Mounted on base below receiver.
8. Rated to operate with a minimum of 2 feet (6 kPa) of NPSH.

F. Motor:

1. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
2. Enclosure: Totally enclosed, fan cooled.
3. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
4. Motor Bearings: Permanently lubricated ball bearings.
5. Unusual Service Conditions:

   a. Ambient Temperature: <**Insert deg C**>.
   b. Altitude: <**Insert feet (meters)**> above sea level.
   c. High humidity.

6. Efficiency: Premium efficient.
7. NEMA Design: <**Insert designation**>.
8. Service Factor: <**Insert value**>.

G. Pipe: ASTM A 53/A 53M, Type S, Grade B or ASTM A 106/A 106M; Schedule 80; seamless steel.

H. Fittings NPS 2 (DN 50) and Smaller: ASME B16.1, Class 125 cast iron, threaded.

I. Fittings NPS 2-1/2 (DN 65) and Larger: ASTM A 234/A 234M, steel, for welded connections.

J. Control Panel:

1. Factory wired between pumps and float switches, for single external electrical connection.
2. Provide fused, control-power transformer if voltage exceeds 230 V ac.
3. NEMA 250, [**Type 1**] [**Type 3**] [**Type 12**] enclosure with hinged door and grounding lug, mounted on pump.
4. Motor controller for each pump.
5. Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
6. Manual lead-lag control to override electrical pump alternator and manually select the lead pump.
7. Momentary-contact "TEST" push button on cover for each pump.
8. Numbered terminal strip.
9. Disconnect switch.

K. Capacities and Characteristics:

1. Unit Total Capacity: <**Insert sq. ft. EDR (kW)**>.
2. Capacity, Each Pump:

    a. Flow: <**Insert gpm (L/s).**>
    b. Discharge Head: <**Insert psig (kPa)**>.
    c. Discharge Size: <**Insert NPS (DN)**>.
    d. Speed: <**Insert rpm**>.
    e. Motor Horsepower: <**Insert value**>.

3. Receiver:

    a. Capacity: <**Insert gal. (L)**>.
    b. Inlet Size: <**Insert NPS (DN)**>.
    c. Height to Inlet: <**Insert inches (mm)**>.

4. Electrical Characteristics:

    a. Volts: [**120**] [**208**] [**230**] [**240**] [**480**].
    b. Phase: [**Single**] [**Three**].
    c. Hertz: 60.
    d. Full-Load Amperes: <**Insert value**>.
    e. Minimum Circuit Ampacity: <**Insert value**>.
    f. Maximum Overcurrent Protection: <**Insert amperage**>.

2.4 VERTICAL, WET-PIT-MOUNTED DUPLEX PUMPS

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

    1. Alyan Pump Company; Div. of Hannmann Machinery Systems, Inc.
    2. Armstrong Fluid Handling Div. of Armstrong International, Inc.
    3. ITT Corporation; Domestic Pump Division.
    4. Nicholson Steam Trap; a division of Spence Engineering Company, Inc.
    5. Pentair Pump Group.
    6. Roth Pump Company.
    7. Skidmore Pump.
    8. Spence Engineering Company, Inc.; Division of Circor International, Inc.
    9. Spirax-Sarco Inc.

B. Description: Factory-fabricated, packaged, electric-driven pumps; with controls and accessories suitable for operation with steam condensate.

    1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Configuration: Duplex pump with basin and float switches; rated to pump 200 deg F (93 deg C) steam condensate.

D. Basin: Cast iron, with hub-type inlets.

1. Cast-iron inlet strainer with vertical self-cleaning bronze screen and large dirt pocket.
2. Discharge pressure gages.
3. Anchor Flange: Cast iron, attached to basin, in location and of size required to anchor basin to concrete slab.

E. Basin Cover: Cast-iron or steel cover for each pump with gasketed openings for access to pumps, pump shafts, control rods, discharge piping, and vent connections.

F. Pumps:

1. Vertical, wet-pit mounted, flexible coupled, and suspended.
2. Cast-iron casing with open inlet.
3. Stainless-steel shaft with oil-lubricated, bronze, intermediate sleeve bearings; 48-inch (1200-mm) maximum intervals where basin depth is more than 48 inches (1200 mm); and grease-lubricated, ball-type, thrust bearings.
4. Shaft Couplings: Flexible, capable of absorbing vibration.
5. Impeller: Bronze
6. Mechanical seals rated at 250 deg F (120 deg C), with carbon rotating ring bearing on a ceramic seat held by a stainless-steel spring and enclosed by a flexible bellows and gasket.

G. Motors:

1. Vertically mounted on cast-iron pedestal.
2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
3. Enclosure: Totally enclosed, fan cooled.
4. Enclosure Materials: [**Cast iron**] [**Cast aluminum**] [**Rolled steel**].
5. Motor Bearings: Permanently lubricated ball bearings.
6. Unusual Service Conditions:

   a. Ambient Temperature: <**Insert deg C**>.
   b. Altitude: <**Insert feet (meters)**> above sea level.
   c. High humidity.

7. Efficiency: Premium efficient.
8. NEMA Design: <**Insert designation**>.
9. Service Factor: <**Insert value**>.

H. Pump Discharge Piping: Manufacturer's standard steel or bronze pipe unless otherwise indicated.

I. Control Panel:

1. Factory wired between pumps and float switches, for single external electrical connection.
2. Provide fused, control-power transformer if voltage exceeds 230 V ac.
3. NEMA 250, [**Type 1**] [**Type 3**] [**Type 12**] enclosure with hinged door and grounding lug, mounted on pump.
4. Motor controller for each pump.

5. Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
6. Manual lead-lag control to override electrical pump alternator and manually select the lead pump.
7. Momentary-contact "TEST" push button on cover for each pump.
8. Numbered terminal strip.
9. Disconnect switch.

J. Capacities and Characteristics:

1. Unit Total Capacity: <**Insert sq. ft. EDR (kW)**>.
2. Capacity, Each Pump:

   a. Flow: <**Insert gpm (L/s)**>.
   b. Discharge Head: <**Insert psig (kPa)**>.
   c. Discharge Size: <**Insert NPS (DN)**>.
   d. Speed: <**Insert rpm**>.
   e. Motor Horsepower: <**Insert value**>.

3. Underground Basin:

   a. Diameter: <**Insert inches (mm)**>.
   b. Depth: <**Insert inches (mm)**>.
   c. Inlet Size: <**Insert NPS (DN)**>.
   d. Bottom to Centerline of Inlet: <**Insert inches (mm)**>.

4. Electrical Characteristics:

   a. Volts: [**120**] [**208**] [**230**] [**480**].
   b. Phase: [**Single**] [**Three**].
   c. Hertz: 60.
   d. Full-Load Amperes: <**Insert value**>.
   e. Minimum Circuit Ampacity: <**Insert value**>.
   f. Maximum Overcurrent Protection: <**Insert amperage**>.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

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

3.2 INSTALLATION

[Delete first paragraph below for pressure-powered steam condensate pumps.]

A. Install pumps according to HI 1.1-1.2, HI 1.3, and HI 1.4.

B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so piping is not supported by pumps.

D. Install thermometers and pressure gages.

E. Equipment Mounting: Install pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**]

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct bases to withstand, without damage to equipment, seismic force required by code.
3. Construct concrete bases [**4 inches (100 mm)**] [**6 inches (150 mm)**] [**8 inches (200 mm)**] high and extend base not less than 6 inches (150 mm) in all directions beyond the maximum dimensions of pumps unless otherwise indicated or unless required for seismic-anchor support.
4. Minimum Compressive Strength: [**5000 psi (34.5 MPa)**] [**4500 psi (31 MPa)**] [**4000 psi (27.6 MPa)**] [**3500 psi (24.1 MPa)**] [**3000 psi (20.7 MPa)**] at 28 days.

F. Equipment Mounting: Install pumps on cast-in-place concrete equipment base(s) using [**elastomeric pads**] [**elastomeric mounts**] [**restrained spring isolators**]. Comply with requirements for equipment bases specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**] Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1 inch (25 mm)**].
2. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of concrete base.
4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.
7. Install on [**4-inch- (100-mm-)**] [**6-inch- (150-mm-)**] high concrete base designed to withstand, without damage to equipment, seismic force required by code.

G. Equipment Mounting: Install pumps using [**elastomeric pads**] [**elastomeric mounts**] [**restrained spring isolators**]. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch** **(6 mm)**] [**1 inch** **(25 mm)**].

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Section 232213 "Steam and Condensate Heating Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to machine, allow space for service and maintenance.

[Retain first paragraph for compressed-air powered pumps.]

C. Install compressed-air supply for pressure-powered pumps as required in Section 221513 "General-Service Compressed-Air Piping."

D. Install a globe and check valve and pressure gage before inlet of each pump and a gate and check valve at pump outlet.

E. Pipe drain to nearest floor drain for overflow and drain piping connections.

F. Install full-size vent piping to outdoors, terminating in 180-degree elbow at point above highest steam system connection or as indicated.

G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Clean strainers.
3. Set steam condensate pump controls.
4. Set pump controls for automatic start, stop, and alarm operation.
5. Perform the following preventive maintenance operations and checks before starting:

a. Set float switches to operate at proper levels.
b. Set throttling valves on pump discharge for specified flow.
c. Check motors for proper rotation.
d. Test pump controls and demonstrate compliance with requirements.
e. Replace damaged or malfunctioning pump controls and equipment.
f. Verify that pump controls are correct for required application.

6. Start steam condensate pumps according to manufacturer's written startup instructions.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain steam condensate pumps.

END OF SECTION 232223

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-22:

1. Suction Lines for Air-Conditioning Applications: 185 psig (1276 kPa).
2. Suction Lines for Heat-Pump Applications: 325 psig (2241 kPa).
3. Hot-Gas and Liquid Lines: 325 psig (2241 kPa).

B. Line Test Pressure for Refrigerant R-134a:

1. Suction Lines for Air-Conditioning Applications: 115 psig (793 kPa).
2. Suction Lines for Heat-Pump Applications: 225 psig (1551 kPa).
3. Hot-Gas and Liquid Lines: 225 psig (1551 kPa).

C. Line Test Pressure for Refrigerant R-407C:

1. Suction Lines for Air-Conditioning Applications: 230 psig (1586 kPa).
2. Suction Lines for Heat-Pump Applications: 380 psig (2620 kPa).
3. Hot-Gas and Liquid Lines: 380 psig (2620 kPa).

D. Line Test Pressure for Refrigerant R-410A:

1. Suction Lines for Air-Conditioning Applications: 300 psig (2068 kPa).
2. Suction Lines for Heat-Pump Applications: 535 psig (3689 kPa).
3. Hot-Gas and Liquid Lines: 535 psig (3689 kPa).

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:

1. Thermostatic expansion valves.
2. Solenoid valves.

3. Hot-gas bypass valves.
4. Filter dryers.
5. Strainers.
6. Pressure-regulating valves.

B. Shop Drawings: Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes, flow capacities, valve arrangements and locations, slopes of horizontal runs, oil traps, double risers, wall and floor penetrations, and equipment connection details. Show interface and spatial relationships between piping and equipment.

1. Shop Drawing Scale: **1/4 inch equals 1 foot** **(1:50)**.

1.5 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.7 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."

C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.8 PRODUCT STORAGE AND HANDLING

A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.9 COORDINATION

A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

A. Copper Tube: [**ASTM B 88, Type K or L (ASTM B 88M, Type A or B)**] [**ASTM B 280, Type ACR**].

B. Wrought-Copper Fittings: ASME B16.22.

C. Wrought-Copper Unions: ASME B16.22.

D. Solder Filler Metals: ASTM B 32. Use silver solder or braze to join copper socket fittings on copper pipe.

E. Brazing Filler Metals: AWS A5.8.

F. Flexible Connectors:

1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
2. End Connections: Socket ends.
3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; Type, Grade, and wall thickness as selected in Part 3 piping applications articles.

B. Wrought-Steel Fittings: ASTM A 234/A 234M, for welded joints.

C. Steel Flanges and Flanged Fittings: ASME B16.5, steel, including bolts, nuts, and gaskets, bevel-welded end connection, and raised face.

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

E. Flanged Unions:

1. Body: Forged-steel flanges for NPS 1 to NPS 1-1/2 (DN 25 to DN 40) and ductile iron for NPS 2 to NPS 3 (DN 50 to DN 80). Apply rust-resistant finish at factory.
2. Gasket: Fiber asbestos free.
3. Fasteners: Four plated-steel bolts, with silicon bronze nuts. Apply rust-resistant finish at factory.
4. End Connections: Brass tailpiece adapters for solder-end connections to copper tubing.
5. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.

6. Pressure Rating: Factory test at minimum 400 psig (2760 kPa).
7. Maximum Operating Temperature: 330 deg F (165 deg C).

F. Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, stainless-steel-wire-reinforced protective jacket
2. End Connections:

a. NPS 2 (DN 50) and Smaller: With threaded-end connections.
b. NPS 2-1/2 (DN 65) and Larger: With flanged-end connections.

3. Offset Performance: Capable of minimum 3/4-inch (20-mm) misalignment in minimum 7-inch- (180-mm-) long assembly.
4. Pressure Rating: Factory test at minimum 500 psig (3450 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

2.3 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 275 deg F (135 deg C).

B. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig (3450 kPa).
8. Maximum Operating Temperature: 275 deg F (135 deg C).

C. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig (3.4 kPa).

8. Working Pressure Rating: 500 psig (3450 kPa).
9. Maximum Operating Temperature: 275 deg F (135 deg C).

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig (3450 kPa).

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and [**24**] [**115**] [**208**]-V ac coil.
6. Working Pressure Rating: 400 psig (2760 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).
8. Manual operator.

F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.

1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
2. Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Seat Disc: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Working Pressure Rating: 400 psig (2760 kPa).
6. Maximum Operating Temperature: 240 deg F (116 deg C).

G. Thermostatic Expansion Valves: Comply with ARI 750.

1. Body, Bonnet, and Seal Cap: Forged brass or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
5. Suction Temperature: **40 deg F (4.4 deg C)**.
6. Superheat: Adjustable.
7. Reverse-flow option (for heat-pump applications).
8. End Connections: Socket, flare, or threaded union.
9. Working Pressure Rating: [**700 psig (4820 kPa)**] [**450 psig (3100 kPa)**].

H. Hot-Gas Bypass Valves: Comply with UL 429; listed and labeled by an NRTL.

1. Body, Bonnet, and Seal Cap: Ductile iron or steel.
2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
3. Packing and Gaskets: Non-asbestos.
4. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.

5. Seat: Polytetrafluoroethylene.
6. Equalizer: [**Internal**] [**External**].
7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch (16-GRC) conduit adapter, and [**24**] [**115**] [**208**]-V ac coil.
8. End Connections: Socket.
9. Set Pressure: <**Insert psig (kPa).**>
10. Throttling Range: Maximum 5 psig (34 kPa).
11. Working Pressure Rating: 500 psig (3450 kPa).
12. Maximum Operating Temperature: 240 deg F (116 deg C).

I. Straight-Type Strainers:

1. Body: Welded steel with corrosion-resistant coating.
2. Screen: 100-mesh stainless steel.
3. End Connections: Socket or flare.
4. Working Pressure Rating: 500 psig (3450 kPa).
5. Maximum Operating Temperature: 275 deg F (135 deg C).

J. Angle-Type Strainers:

1. Body: Forged brass or cast bronze.
2. Drain Plug: Brass hex plug.
3. Screen: 100-mesh monel.
4. End Connections: Socket or flare.
5. Working Pressure Rating: 500 psig (3450 kPa).
6. Maximum Operating Temperature: 275 deg F (135 deg C).

K. Moisture/Liquid Indicators:

1. Body: Forged brass.
2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
3. Indicator: Color coded to show moisture content in ppm.
4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
5. End Connections: Socket or flare.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 240 deg F (116 deg C).

L. Replaceable-Core Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated [**alumina**] [**charcoal**].
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: **2 psig (14 kPa)**.
8. Rated Flow: <**Insert tons (kW).**>
9. Working Pressure Rating: 500 psig (3450 kPa).

10. Maximum Operating Temperature: 240 deg F (116 deg C).

M. Permanent Filter Dryers: Comply with ARI 730.

1. Body and Cover: Painted-steel shell.
2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
3. Desiccant Media: Activated [**alumina**] [**charcoal**].
4. Designed for reverse flow (for heat-pump applications).
5. End Connections: Socket.
6. Access Ports: NPS 1/4 (DN 8) connections at entering and leaving sides for pressure differential measurement.
7. Maximum Pressure Loss: **2 psig (14 kPa)**.
8. Rated Flow: <**Insert tons (kW).**>
9. Working Pressure Rating: 500 psig (3450 kPa).
10. Maximum Operating Temperature: 240 deg F (116 deg C).

N. Mufflers:

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or flare.
3. Working Pressure Rating: 500 psig (3450 kPa).
4. Maximum Operating Temperature: 275 deg F (135 deg C).

O. Receivers: Comply with ARI 495.

1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
2. Comply with UL 207; listed and labeled by an NRTL.
3. Body: Welded steel with corrosion-resistant coating.
4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig (3450 kPa).
7. Maximum Operating Temperature: 275 deg F (135 deg C).

P. Liquid Accumulators: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig (3450 kPa).
4. Maximum Operating Temperature: 275 deg F (135 deg C).

2.4 REFRIGERANTS

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

1. Atofina Chemicals, Inc.
2. DuPont Company; Fluorochemicals Div.
3. Honeywell, Inc.; Genetron Refrigerants.
4. INEOS Fluor Americas LLC.

B. ASHRAE 34, R-22: Monochlorodifluoromethane.

C. ASHRAE 34, R-134a: Tetrafluoroethane.

D. ASHRAE 34, R-407C: Difluoromethane/Pentafluoroethane/1,1,1,2-Tetrafluoroethane.

E. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS FOR REFRIGERANT R-22

A. Suction Lines **NPS 1-1/2 (DN 40)** and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with **brazed** joints.

B. Suction Lines [**NPS 4 (DN 100) and Smaller**] [**NPS 2 to NPS 4 (DN 50 to DN 100)**] for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with **brazed** joints.

C. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]:
1. **NPS 1-1/2 (DN 40)** and Smaller: Copper, Type [**ACR**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with brazed joints.
2. **NPS 2 to NPS 3 (DN 50 to DN 80)**: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.
3. **NPS 4 (DN 100)**: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with brazed joints.

D. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

E. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with brazed joints.

F. Safety-Relief-Valve Discharge Piping:
1. **NPS 1-1/2 (DN 40)** and Smaller: Copper, Type [**ACR**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with brazed joints.
2. **NPS 2 to NPS 3 (DN 50 to DN 80)**: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with **brazed** joints.
3. **NPS 4 (DN 100)**: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with brazed joints.

3.2 PIPING APPLICATIONS FOR REFRIGERANT R-134a

A. Suction Lines **NPS 1-1/2 (DN 40)** and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with **brazed** joints.

B. Suction Lines [**NPS 4 (DN 100) and Smaller**] [**NPS 2 to NPS 4 (DN 50 to DN 100)**] for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with **brazed** joints.

C. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]:
1. **NPS 1-1/2 (DN 40)** and Smaller: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with brazed joints.
2. **NPS 4 (DN 100)**: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with brazed joints.

D. Safety-Relief-Valve Discharge Piping: Schedule 40, black-steel and wrought-steel fittings with welded joints.

E. Safety-Relief-Valve Discharge Piping: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with brazed joints.

F. Safety-Relief-Valve Discharge Piping:
1. **NPS 1-1/2 (DN 40)** and Smaller: Copper, Type [**ACR**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with **brazed** joints.
2. **NPS 4 (DN 100)**: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with **brazed** joints.

3.3 PIPING APPLICATIONS FOR REFRIGERANT R-407C

A. Suction Lines [**NPS 4 (DN 100) and Smaller**] [**NPS 2 to NPS 4 (DN 50 to DN 100)**] for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with **brazed** joints.

B. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]:
1. **NPS 1-1/2 (DN 40)** and Smaller: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with brazed joints.
2. **NPS 4 (DN 100)**: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with brazed joints.

C. Safety-Relief-Valve Discharge Piping:
1. **NPS 1 (DN 25)** and Smaller: Copper, Type [**ACR**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with [**brazed**] [**or**] [**soldered**] joints.
2. **NPS 1-1/4 to NPS 2 (DN 32 to DN 50)**: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with **brazed** joints.
3. **NPS 4 (DN 100)**: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with brazed joints.

3.4 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines **NPS 1-1/2 (DN 40)** and Smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with **brazed** joints.

B. Suction Lines [**NPS 3-1/2 (DN 90) and Smaller**] [**NPS 2 to NPS 3-1/2 (DN 50 to DN 90)**] for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with **brazed** joints.

C. Suction Lines **NPS 4 (DN 100)** and Smaller for Conventional Air-Conditioning Applications: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with soldered joints.

D. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]:

1. **NPS 1-1/2 (DN 40)** and Smaller: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with brazed joints.
2. **NPS 4 (DN 100)**: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with brazed joints.

E. Hot-Gas and Liquid Lines[**, and Suction Lines for Heat-Pump Applications**]

1. **NPS 2 to NPS 4 (DN 50 to DN 100)**: Schedule 40, black-steel and wrought-steel fittings with welded joints.

F. Safety-Relief-Valve Discharge Piping:

1. **NPS 5/8 (DN 18)** and Smaller: Copper, Type [**ACR**] [**L (B)**], annealed- or drawn-temper tubing and wrought-copper fittings with **brazed** joints.
2. **NPS 3/4 to NPS 1 (DN 20 to DN 25)** and Smaller: Copper, Type K (A), annealed- or drawn-temper tubing and wrought-copper fittings with **brazed** joints.
3. **NPS 1-1/4 (DN 32)** and Smaller: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with brazed joints.
4. **NPS 1-1/2 to NPS 2 (DN 40 to DN 50)**: Copper, Type [**ACR**] [**K (A)**] [**L (B)**], drawn-temper tubing and wrought-copper fittings with brazed joints.

G. Safety-Relief-Valve Discharge Piping **NPS 2 to NPS 4 (DN 50 to DN 100)**: Schedule 40, black-steel and wrought-steel fittings with welded joints.

3.5 VALVE AND SPECIALTY APPLICATIONS

A. Install [**diaphragm packless**] [**packed-angle**] valves in suction and discharge lines of compressor.

B. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.

C. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.

D. Except as otherwise indicated, install [**diaphragm packless**] [**packed-angle**] valves on inlet and outlet side of filter dryers.

E. Install a full-sized, three-valve bypass around filter dryers.

F. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top.

G. Install thermostatic expansion valves as close as possible to distributors on evaporators.

1. Install valve so diaphragm case is warmer than bulb.
2. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

H. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.

I. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.

J. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:

1. Solenoid valves.
2. Thermostatic expansion valves.
3. Hot-gas bypass valves.
4. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.

L. Install receivers sized to accommodate pump-down charge.

M. Install flexible connectors at compressors.

3.6 PIPING INSTALLATION

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

B. Install refrigerant piping according to ASHRAE 15.

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

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

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

F. Install piping adjacent to machines to allow service and maintenance.

G. Install piping free of sags and bends.

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

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

J. Refer to Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls" for solenoid valve controllers, control wiring, and sequence of operation.

K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Section 083113 "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.

M. Install refrigerant piping in protective conduit where installed belowground.

N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

O. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Install traps and double risers to entrain oil in vertical runs.
4. Liquid lines may be installed level.

P. When brazing or soldering, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion-valve bulb.

Q. Before installation of steel refrigerant piping, clean pipe and fittings using the following procedures:

1. Shot blast the interior of piping.
2. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through tubing by means of a wire or electrician's tape.
3. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.
4. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.
5. Finally, draw a clean, dry, lintless cloth through the tube or pipe.
6. Safety-relief-valve discharge piping is not required to be cleaned but is required to be open to allow unrestricted flow.

R. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.

S. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

T. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

U. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

V. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.7 PIPE JOINT CONSTRUCTION

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

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

C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.

D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."

1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

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

1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

F. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.

G. Welded Joints: Construct joints according to AWS D10.12/D10.12M.

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

3.8 HANGERS AND SUPPORTS

A. Hanger, support, and anchor products are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet (6 m) long.
2. Roller hangers and spring hangers for individual horizontal runs 20 feet (6 m) or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet (6 m) or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 1/2 (DN 15): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
2. NPS 5/8 (DN 18): Maximum span, 60 inches (1500 mm); minimum rod size, 1/4 inch (6.4 mm).
3. NPS 1 (DN 25): Maximum span, 72 inches (1800 mm); minimum rod size, 1/4 inch (6.4 mm).
4. NPS 1-1/4 (DN 32): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
5. NPS 1-1/2 (DN 40): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
6. NPS 2 (DN 50): Maximum span, 96 inches (2400 mm); minimum rod size, 3/8 inch (9.5 mm).
7. NPS 2-1/2 (DN 65): Maximum span, 108 inches (2700 mm); minimum rod size, 3/8 inch (9.5 mm).
8. NPS 3 (DN 80): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (9.5 mm).
9. NPS 4 (DN 100): Maximum span, 12 feet (3.7 m); minimum rod size, 1/2 inch (13 mm).

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 2 (DN 50): Maximum span, 10 feet (3 m); minimum rod size, 3/8 inch (9.5 mm).
2. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m); minimum rod size, 3/8 inch (9.5 mm).
3. NPS 3 (DN 80): Maximum span, 12 feet (3.7 m); minimum rod size, 3/8 inch (9.5 mm).
4. NPS 4 (DN 100): Maximum span, 14 feet (4.3 m); minimum rod size, 1/2 inch (13 mm).

E. Support multifloor vertical runs at least at each floor.

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.

    a. Fill system with nitrogen to the required test pressure.
    b. System shall maintain test pressure at the manifold gage throughout duration of test.
    c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
    d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.10 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter dryers after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers (67 Pa). If vacuum holds for 12 hours, system is ready for charging.
3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig (14 kPa).
4. Charge system with a new filter-dryer core in charging line.

3.11 ADJUSTING

A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.

B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.

C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.

D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:

1. Open shutoff valves in condenser water circuit.
2. Verify that compressor oil level is correct.
3. Open compressor suction and discharge valves.
4. Open refrigerant valves except bypass valves that are used for other purposes.
5. Check open compressor-motor alignment and verify lubrication for motors and bearings.

E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 232500 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following HVAC water-treatment systems:

1. Bypass chemical-feed equipment and controls.
2. Biocide chemical-feed equipment and controls.
3. Chemical treatment test equipment.
4. HVAC water-treatment chemicals.
5. Makeup water softeners.
6. Water filtration units for HVAC makeup water.

1.3 DEFINITIONS

A. EEPROM: Electrically erasable, programmable read-only memory.

B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

C. RO: Reverse osmosis.

D. TDS: Total dissolved solids.

E. UV: Ultraviolet.

1.4 PERFORMANCE REQUIREMENTS

A. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.

B. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

C. Closed hydronic systems, including [**hot-water heating**] [**chilled water**] [**and**] [**glycol cooling**], shall have the following water qualities:

1. pH: Maintain a value within 9.0 to 10.5.
2. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
3. Nitrite Borate: Maintain a nitrite value within 700 to 1200 ppm.
4. Soluble Copper: Maintain a maximum value of 0.20 ppm.
5. Conductivity: Maintain a maximum value of 2500 to 4000 micro ohms.
6. Microbiological Limits:
    a. Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
    b. Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/ml.
    c. Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.
    d. Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.
    e. Iron Bacteria: Maintain a maximum value of 0 organisms/ml.

D. Steam Boiler and Steam Condensate:

1. Steam Condensate:
    a. pH: Maintain a value within 7.8 to 8.4.
    b. Soluble Copper: Maintain a maximum value of 0.20 ppm.
    c. Conductivity: Maintain a maximum value of 2500 to 4000 micro ohms.
    d. Total Hardness: Maintain a maximum value of .5 ppm.
    e. Iron: Maintain a maximum value of .5 ppm.
2. Steam boiler operating at 15 psig (104 kPa) and less shall have the following water qualities:
    a. "OH" Alkalinity: Maintain a value within 200 to 400 ppm.
    b. Conductivity: Maintain a maximum value of 2500 to 4000 micro ohms.
3. Steam boiler operating at more than 15 psig (104 kPa) shall have the following water qualities:
    a. "OH" Alkalinity: 200 to 400 ppm.
    b. Conductivity: Maintain a maximum value of 2500 to 4000 micro ohms.

E. Open hydronic systems, including [**condenser**] [**fluid-cooler spray**] water, shall have the following water qualities:

1. pH: Maintain a value within 8.0 to 9.1.
2. Soluble Copper: Maintain a maximum value of 0.20 ppm.
3. Conductivity: Maintain a maximum value of 2500 to 4000 micro ohms.
4. Microbiological Limits:
    a. Total Aerobic Plate Count: Maintain a maximum value of 10,000 organisms/ml.
    b. Total Anaerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
    c. Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.
    d. Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.
    e. Iron Bacteria: Maintain a maximum value of 0 organisms/ml.
5. Polymer Testable: Maintain a minimum value within 10 to 40.

F. Passivation for Galvanized Steel: For the first 60 days of operation.

1. pH: Maintain a value within 7 to 8.
2. Calcium Carbonate Hardness: Maintain a value within 100 to 300 ppm.
3. Calcium Carbonate Alkalinity: Maintain a value within 100 to 300 ppm.
4. Phosphate: Feed PO4 to maintain 20 to 30 ppm during passivation period.

1.5 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for the following products:

1. Bypass feeders.
2. Water meters.
3. Inhibitor injection timers.
4. pH controllers.
5. Conductivity controllers.
6. Biocide feeder timers.
7. Chemical solution tanks.
8. Injection pumps.
9. Ozone generators.
10. UV-irradiation units.
11. Chemical test equipment.
12. Chemical material safety data sheets.
13. Water softeners.
14. RO units.
15. Multimedia filters.
16. Self-cleaning strainers.
17. Bag- or cartridge-type filters.
18. Centrifugal separators.

B. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: Power and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control test reports.

B. Manufacturer Seismic Qualification Certification: Submit certification that [**water softeners,**] [**water filtration units,**] and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Other Informational Submittals:

1. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in the "Performance Requirements" Article above.
2. Water Analysis: Illustrate water quality available at Project site.
3. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to Architect.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For sensors, injection pumps, [**water softeners,**] [**water filtration units,**] and controllers to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

A. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Match contractor that is currently serving facility.

2.2 MANUAL CHEMICAL-FEED EQUIPMENT

A. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum 3-1/2-inch (89-mm) fill opening in the top, and NPS 3/4 (DN 20) bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.

1. Capacity: [**2 gal. (7.6 L)**] [**5 gal. (19 L)**] .
2. Minimum Working Pressure: [**125 psig (860 kPa)**] [**175 psig (1210 kPa)**] .

2.3 AUTOMATIC CHEMICAL-FEED EQUIPMENT

A. Water Meter:

1. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: 150 psig (1035 kPa).
4. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
5. Registration: Gallons (Liters) or cubic feet (cubic meters).
6. End Connections: Threaded.
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.

B. Water Meter:

1. AWWA C701, turbine-type, totalization meter.
2. Body: Bronze.
3. Minimum Working-Pressure Rating: 100 psig (690 kPa).
4. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
5. Registration: Gallons (Liters) or cubic feet (cubic meters).
6. End Connections: Threaded.
7. Control: Low-voltage signal capable of transmitting 1000 feet (305 m).

C. Water Meter:

1. AWWA C701, turbine-type, totalization meter.
2. Body: [**Bronze**] [**Epoxy-coated cast iron**].
3. Minimum Working-Pressure Rating: 150 psig (1035 kPa).
4. Maximum Pressure Loss at Design Flow: 3 psig (20 kPa).
5. Registration: Gallons (Liters) or cubic feet (cubic meters).
6. End Connections: Flanged.
7. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.

D. Inhibitor Injection Timers:

1. Microprocessor-based controller with LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door.[**Interface for start/stop and status indication at central workstation as described in Section 230900 "Instrumentation and Control for HVAC."**]
2. Programmable timers with infinite adjustment over full range, and mounted in cabinet with hand-off-auto switches and status lights.
3. Test switch.
4. Hand-off-auto switch for chemical pump.
5. Illuminated legend to indicate feed when pump is activated.
6. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.

7. LCD makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.

E. pH Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door.[**Interface for start/stop and status indication at central workstation as described in Section 230900 "Instrumentation and Control for HVAC."**]
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal pH indication.
5. High or low pH alarm light, trip points field adjustable; with silence switch.
6. Hand-off-auto switch for acid pump.
7. Internal adjustable hysteresis or deadband.

F. Conductivity Controller:

1. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micro ohms. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door.[**Interface for start/stop and status indication at central workstation as described in Section 230900 "Instrumentation and Control for HVAC."**]
2. Digital display and touch pad for input.
3. Sensor probe adaptable to sample stream manifold.
4. High, low, and normal conductance indication.
5. High or low conductance alarm light, trip points field adjustable; with silence switch.
6. Hand-off-auto switch for solenoid bleed-off valve.
7. Bleed-off valve activated indication.
8. Internal adjustable hysteresis or deadband.
9. Bleed Valves:

   a. Cooling Systems: Forged-brass body, globe pattern, general-purpose solenoid with continuous-duty coil, or motorized valve.
   b. Steam Boilers: Motorized ball valve, steel body, and TFE seats and seals.

G. Biocide Feeder Timer:

1. Microprocessor-based controller with digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door.[**Interface for start/stop and status indication at central workstation as described in Section 230900 "Instrumentation and Control for HVAC."**]
2. 24-hour timer with 14-day skip feature to permit activation any hour of day.
3. Precision, solid-state, bleed-off lockout timer and clock-controlled biocide pump timer. Prebleed and bleed lockout timers.
4. Solid-state alternator to enable use of two different formulations.
5. 24-hour display of time of day.
6. 14-day display of day of week.
7. Battery backup so clock is not disturbed by power outages.
8. Hand-off-auto switches for biocide pumps.

9. Biocide A and Biocide B pump running indication.

H. Containment Vessels:

1. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.

I. Chemical Solution Injection Pumps:

1. Self-priming, positive-displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
2. Adjustable flow rate.
3. Metal and thermoplastic construction.
4. Built-in relief valve.
5. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

J. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A 269, Type 304, stainless steel for steam boiler injection assemblies.

K. Injection Assembly:

1. Quill: Minimum NPS 1/2 (DN 15) with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
2. Ball Valve: [**Three**] [**Two**]-piece, stainless steel as described in "Stainless-Steel Pipes and Fittings" Article below; and selected to fit quill.
3. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
4. Assembly Pressure/Temperature Rating: Minimum 600 psig (4137 kPa) at 200 deg F (93 deg C).

2.4 STAINLESS-STEEL PIPES AND FITTINGS

A. Stainless-Steel Tubing: Comply with ASTM A 269, Type 316.

B. Stainless-Steel Fittings: Complying with ASTM A 815/A 815M, Type 316, Grade WP-S.

C. Two-Piece, Full-Port, Stainless-Steel Ball Valves: ASTM A 351, Type 316 stainless-steel body; ASTM A 276, Type 316 stainless-steel stem and vented ball, carbon-filled TFE seats, threaded body design with adjustable stem packing, threaded ends, and 250-psig (1725-kPa) SWP and 600-psig (4140-kPa) CWP ratings.

2.5 CHEMICAL TREATMENT TEST EQUIPMENT

A. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing pH, TDS, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for high-pressure boilers, and oxidizing biocide test for open cooling systems.

B. Sample Cooler:

1. Tube: Sample.

   a. Size: NPS 1/4 (DN 8) tubing.
   b. Material: ASTM A 666, Type 316 stainless steel.
   c. Pressure Rating: Minimum 2000 psig (13 790 kPa).
   d. Temperature Rating: Minimum 850 deg F (454 deg C).

2. Shell: Cooling water.

   a. Material: ASTM A 666, Type 304 stainless steel.
   b. Pressure Rating: Minimum 250 psig (1725 kPa).
   c. Temperature Rating: Minimum 450 deg F (232 deg C).

3. Capacities and Characteristics:

   a. Tube: Sample.

      1) Flow Rate: **0.25 gpm (0.016 L/s)**.
      2) Entering Temperature: **400 deg F (204 deg C)**.
      3) Leaving Temperature: **88 deg F (31 deg C)**.
      4) Pressure Loss: **6.5 psig (44.8 kPa)**.

   b. Shell: Cooling water.

      1) Flow Rate: **3 gpm (0.19 L/s)**.
      2) Entering Temperature: **70 deg F (21 deg C)**.
      3) Pressure Loss: **1.0 psig (6.89 kPa)**.

C. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.

1. Two -station rack for closed-loop systems.
2. Four -station rack for open systems.

2.6 CHEMICALS

A. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in Part 1 "Performance Requirements" Article.

B. Water Softener Chemicals:

1. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock. Size for system.
2. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are not acceptable.

2.7 HVAC MAKEUP WATER SOFTENER

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

1. Siemens Water Technology.
2. Kinetico Incorporated.
3. Western Reserve.

B. Description: Twin mineral tanks and one brine tank, factory mounted on skid.

C. Fabricate supports and attachments to tanks with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure as recommended in writing by manufacturer.

D. Mineral Tanks:

1. Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
2. Pressure Rating: [**100 psig (690 kPa)**] [**125 psig (860 kPa)**] [**150 psig (1035 kPa)**] minimum.
3. Wetted Components: Suitable for water temperatures from 40 to at least 100 deg F (5 to at least 38 deg C).
4. Freeboard: 50 percent, minimum, for backwash expansion above the normal resin bed level.
5. Support Legs or Skirt: Constructed of structural steel, welded or bonded to tank before testing and labeling.
6. Finish: Hot-dip galvanized on exterior and interior of tank after fabrication.
7. Upper Distribution System: Single-point type, fabricated from galvanized-steel pipe and fittings.
8. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, nonclogging PE strainers; arranged for even-flow distribution through resin bed.

E. Controls: Automatic; factory mounted on mineral tanks and factory wired.

1. Adjustable duration of regeneration steps.
2. Push-button start and complete manual operation override.
3. Pointer on pilot-control valve shall indicate cycle of operation.
4. Means of manual operation of pilot-control valve if power fails.
5. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:

a. Slow opening and closing, nonslam operation.
b. Diaphragm guiding on full perimeter from fully open to fully closed.
c. Isolated dissimilar metals within valve.
d. Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
e. Float-operated brine valve to automatically measure the correct amount of brine to the softener and refill with fresh water.
f. Sampling cocks for soft water.

6. Flow Control: Automatic control of backwash and flush rates over variations in operating pressures that do not require field adjustments. Equip mineral tanks with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in gallons (liters), and automatically resets after regeneration to preset total in gallons (liters) for next service run. Include alternator to regenerate one mineral tank with the other in service.

F. Brine Tank: Combination measuring and wet-salt storing system.

1. Tank and Cover Material: Fiberglass a minimum of 3/16 inch (4.8 mm) thick; or molded PE a minimum of 3/8 inch (9.5 mm) thick.
2. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
3. Size: Large enough for at least four regenerations at full salting.

G. Factory-Installed Accessories:

1. Piping, valves, tubing, and drains.
2. Sampling cocks.
3. Main-operating-valve position indicators.
4. Water meters.

H. Water Test Kit: Include water test kit in wall-mounting enclosure for water softener.

I. Capacities and Characteristics:

1. Continuous Service Flow Rate: <**Insert gpm (L/s)**> at 15-psig (104-kPa) pressure loss.
2. Peak Service Flow Rate: <**Insert gpm (L/s)**> at **25-psig (173-kPa)** pressure loss.
3. Water Consumption: <**Insert gal./day (cu. m/day).**>
4. Water Demand: <**Insert number**> hours/day.
5. Electrical Characteristics:

   a. Volts: <**Insert value.**>
   b. Phase: <**Insert value.**>
   c. Hertz: <**Insert value.**>
   d. Full-Load Amperes: <**Insert value.**>
   e. Minimum Circuit Ampacity: <**Insert value.**>
   f. Maximum Overcurrent Protection: <**Insert amperage.**>
   g. Interrupting Capacity: <**Insert amperage.**>

2.8 FILTRATION EQUIPMENT

A. Multimedia Filters:

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

   a. Diamond Water Systems, Inc.
   b. Everfilt.
   c. LAKOS; a div. of Claude Laval Corporation.

d. Miami Filter LLC.
e. PEP Filters, Inc.
f. Puroflux Corporation.
g. United Industries, Inc.

2. Description: Factory-fabricated and -tested, simplex, multimedia filter system of filter tank, media, strainer, circulating pump, piping, and controls for removing particles from water.

a. Filter Tank: Corrosion resistant with distribution system and media.

1) Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2) Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
3) Pipe Connections NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
4) Steel Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.
5) FRP Tank Pipe Connections NPS 2-1/2 (DN 65) and Larger: Type A, integral; Designation [**E, 125-psig (0.862-MPa)**] [**or**] [**F, 150-psig (1.034-MPa)**] pressure category flanges of grade same as tank material according to ASTM D 5421.

b. Motorized Valves: Flanged or grooved-end, ductile-iron butterfly type with EPDM valve seat and stem seal; with ASTM B 148 aluminum bronze disc.
c. Strainer: Basket type mounted on pump suction.
d. Piping: ASTM B 88, Type L (ASTM B 88M, Type B) copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.
e. Safety Valves: Automatic pressure relief.
f. Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.

1) Casing: Radially split, cast iron.
2) Pressure Rating: [**125 psig (860 kPa)**] [**150 psig (1035 kPa)**] minimum.
3) Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
4) Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
5) Seal: Mechanical.
6) Motor: ODP motor supported on the pump-bearing frame. General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

g. Controls: Automatic control of circulating pump and tank backwash; factory wired for single electrical connection.

1) Panel: NEMA 250, Type 4 enclosure with time clock and pressure gages.
2) Pump: Automatic and manual switching; manual switch position bypasses safeties and controls.
3) Backwash: Automatic; with time clock and differential pressure switch.

4) Backwash Valve: Tank mounted with valves interlocked to single actuator.

h. Support: Skid mounting.[**Fabricate supports and base and attachment to tank with reinforcement strong enough to resist filter movement during a seismic event when filter base is anchored to building structure.**]

3. Capacities and Characteristics:

a. Filter Design:

1) Water Flow: <**Insert gpm (L/s).**>
2) Clean Pressure Loss: **5 psig (34.5 kPa)**.
3) Maximum Media Flow Rate: **15 gpm/sq. ft. (10.2 L/s per sq. m)**.
4) Filtration Efficiency: 98 percent.
5) Particle Specific Gravity: 1.8.
6) Particle Size: [**5**] [**10**] [**20**] [**45**] microns.

b. Filter Tank: With internal distribution piping.

1) Pressure Rating: <**Insert psig (kPa).**>
2) Diameter: <**Insert inches (mm).**>
3) Inlet and Outlet Size: <**Insert NPS (DN).**>
4) Blowdown Piping Outlet Size: <**Insert NPS (DN).**>

c. Filter Media: <**Insert material.**>
d. Start Backwash Pressure Loss: [**13 psig (90 kPa)**] .
e. Backwash Period: 10 minutes.
f. Circulating Pump:

1) Capacity: <**Insert gpm (L/s).**>
2) Total Dynamic Head: <**Insert feet (kPa).**>
3) Motor Speed: <**Insert number**> rpm.
4) Inlet Size: <**Insert NPS (DN).**>
5) Outlet Size: <**Insert NPS (DN).**>

g. Pump Motor Size and Electrical Characteristics:

1) Horsepower: <**Insert value.**>
2) Volts: [**120**] [**208**] [**240**] [**277**] [**480**] V.
3) Phase: [**Single**] [**Three**].
4) Hertz: 60 Hz.

h. Unit Electrical Characteristics:

1) Full-Load Amperes: <**Insert value.**>
2) Minimum Circuit Ampacity: <**Insert value.**>
3) Maximum Overcurrent Protection: <**Insert amperage.**>
4) Interrupting Capacity: <**Insert amperage.**>

B. Cartridge-Type Filters:

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

    a. Cycron Corporation.
    b. Eden Equipment Company.
    c. Filter Specialists, Inc.
    d. Filtration Systems; division of Mechanical Mfg. Corporation.
    e. Hayward Industrial Products, Inc.
    f. Krystal Klear Filtration; a div. of Geyer's Mfr. & Design, Inc.
    g. Parker Hannifin Corp.; Process Filtration Div.
    h. PEP Filters, Inc.
    i. Plymouth Products, Inc.
    j. RainSoft Div.; Aquion Partners L. P.
    k. Rosedale Products, Inc.
    l. RPA Process Technologies.
    m. Shelco Filters; division of Tinny Corp.
    n. USFilter.

2. Description: Floor-mounting housing with filter cartridges for removing particles from water.

    a. Housing: Corrosion resistant; designed to separate inlet from outlet and to direct inlet through cartridge-type water filter; with base, feet, or skirt.

        1) Pipe Connections NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
        2) Steel Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.
        3) Plastic Housing Pipe Connections NPS 2-1/2 (DN 65) and Larger: 150-psig (1035-kPa) plastic flanges.

    b. Cartridge: Replaceable; of shape to fit housing.

3. Capacities and Characteristics:

    a. Filter Design:

        1) Water Flow Rate: <**Insert gpm (L/s).**>
        2) Filtration Efficiency: 98 percent.
        3) Particle Size: [**10**] [**20**] microns and larger.
        4) Clean Pressure Loss: **2 psig (14 kPa)** .
        5) Pressure Loss at Replacement: **6 psig (41 kPa)**.

    b. Housing:

        1) Material: [**Carbon steel**] [**Plastic**].
        2) Pressure Rating: <**Insert psig (kPa).**>
        3) Seal Material: NBR.
        4) Diameter: <**Insert inches (mm).**>
        5) Height or Length: <**Insert inches (mm).**>

6) Inlet and Outlet Size: <**Insert NPS (DN).**>
7) Drain Size: [**Not applicable**] <**Insert NPS (DN)**>.
8) Bag Support Basket Material: Stainless steel.

c. Cartridge:

1) Number Required: <**Insert number.**>
2) Nominal Diameter: <**Insert inches (mm).**>
3) Nominal Length: <**Insert inches (mm).**>
4) Media Material: [**Cotton**] [**Polyester**] [**Polypropylene**].

C. Centrifugal Separators:

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

a. Alamo Water Treatment; Ecodyne Water Treatment, Inc.
b. Culligan International.
c. Griswold Controls.
d. LAKOS; a div. of Claude Laval Corporation.
e. PEP Filters, Inc.
f. Puroflux Corporation.
g. Rosedale Products, Inc.
h. USFilter.
i. Spirotherm

2. Description: Simplex separator housing with baffles and chambers for removing particles from water by centrifugal action and gravity.
3. Housing: With manufacturer's proprietary system of baffles and chambers.

a. Construction: Fabricate and label steel separator housing to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
b. Inlet: Designed with tangential entry to produce centrifugal flow of feedwater.
c. Vortex Chamber: Designed for downward vortex flow and gravity separation of particles.
d. Collection Chamber: Designed to hold separated particles.
e. Outlet: Near top of unit.
f. Purge: At bottom of collection chamber.
g. Pipe Connections NPS 2 (DN 50) and Smaller: Threaded according to ASME B1.20.1.
h. Pipe Connections NPS 2-1/2 (DN 65) and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606. Provide stainless-steel flanges if tank is stainless steel.

4. Motorized Purge Valve: Gate or plug pattern valve.

a. Motorized Valves: Butterfly-type, flanged or grooved-end, ductile-iron body, with EPDM valve seat and stem seal; with ASTM B 148 aluminum bronze disc.

5. Strainer: Stainless-steel basket type mounted on pump suction.

6. Piping: ASTM B 88, Type L (ASTM B 88M, Type B) copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.
7. Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.

    a. Casing: Radially split, cast iron.
    b. Pressure Rating: [**125 psig (860 kPa)**] [**150 psig (1035 kPa)**] minimum.
    c. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
    d. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
    e. Seal: Mechanical.
    f. Motor: ODP motor supported on the pump-bearing frame. General requirements for motors are specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

8. Controls: Automatic control of circulating pump and separator purge; factory wired for single electrical connection.

    a. Panel: NEMA 250, Type 4 enclosure.
    b. Pump: Automatic and manual switching; manual switch position bypasses safeties and controls.
    c. Separator Purge: Automatic and manual.
    d. TDS Controller Interlock: Open separator purge valve with bleed-off control.

9. Support: Skid mounting.[**Fabricate supports and base and attachment to separator housing with reinforcement strong enough to resist separator movement during a seismic event when separator base is anchored to building structure.**]
10. Capacities and Characteristics:

    a. Separator Design:

        1) Water Flow Rate: <**Insert gpm (L/s).**>
        2) Pressure Loss: [**5 psig (34.5 kPa)**].
        3) Separator Efficiency: [**98**] percent.
        4) Particle Specific Gravity: [**1.8**].
        5) Particle Size: [**5**] [**10**] [**20**] [**45**] microns.

    b. Housing:

        1) Material: [**Steel**] [**Stainless steel**] [**Plastic**] [**Fiberglass**].
        2) Pressure Rating: <**Insert psig (kPa).**>
        3) Diameter: <**Insert inches (mm).**>
        4) Height: <**Insert inches (mm).**>
        5) Inlet and Outlet Size: <**Insert NPS (DN).**>
        6) Purge Size: <**Insert NPS (DN).**>

    c. Circulating Pump:

        1) Capacity: <**Insert gpm (L/s).**>
        2) Total Dynamic Head: <**Insert feet (kPa).**>
        3) Motor Speed: <**Insert number**> rpm.

4) Inlet Size: <**Insert NPS (DN).**>
5) Outlet Size: <**Insert NPS (DN).**>

d. Pump Motor Size and Electrical Characteristics:

1) Horsepower: <**Insert value.**>
2) Volts: [**120**] [**208**] [**240**] [**277**] [**480**] V.
3) Phase: [**Single**] [**Three**].
4) Hertz: [**60**] Hz.
5) Full-Load Amperes: <**Insert value.**>
6) Minimum Circuit Ampacity: <**Insert value.**>
7) Maximum Overcurrent Protection: <**Insert amperage.**>
8) Interrupting Capacity: <**Insert amperage.**>

PART 3 - EXECUTION

3.1 WATER ANALYSIS

A. Perform an analysis of supply water to determine quality of water available at Project site.

3.2 INSTALLATION

A. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Refer to Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment" for seismic restraints.

C. Install water testing equipment on wall near water chemical application equipment.

D. Install interconnecting control wiring for chemical treatment controls and sensors.

E. Mount sensors and injectors in piping circuits.

F. Bypass Feeders: Install in closed hydronic systems, including [**hot-water heating**] [**chilled water**] [**and**] [**glycol cooling**], and equipped with the following:

1. Install bypass feeder in a bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
2. Install water meter in makeup water supply.
3. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
4. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
5. Install a swing check on inlet after the isolation valve.

G. Install automatic chemical-feed equipment for steam boiler and steam condensate systems and include the following:

1. Install makeup water softener.
2. Install water meter in makeup water supply.
3. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.

    a. Pumps shall operate for timed interval when contacts close at water meter in makeup water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.

4. Install test equipment and furnish test-kit to Owner.
5. Install TDS controller with sensor and bleed valves.

    a. Bleed valves shall cycle to maintain maximum TDS concentration.

6. Install inhibitor injection timer with injection pumps and solution tanks.

    a. Pumps shall operate for timed interval on contact closure at water meter in makeup water supply connection. Injection pump shall discharge into main steam supply header.

H. Install automatic chemical-feed equipment for [**condenser**] [**fluid-cooler spray**] water and include the following:

1. Install centrifugal separator for open condenser water systems.
2. Install water meter in makeup water supply.
3. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.

    a. Pumps shall operate for timed interval on contact closure at water meter in makeup water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.

4. Install test equipment and provide test-kit to Owner. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
5. Install TDS controller with sensor and bleed valves.

    a. Bleed valves shall cycle to maintain maximum TDS concentration.

6. Install pH sensor and controller with injection pumps and solution tanks.

    a. Injector pumps shall operate to maintain required pH.

7. Install biocide feeder alternating timer with two sets of injection pumps and solution tanks.

    a. Injection pumps shall operate to feed biocide on an alternating basis.

3.3 WATER SOFTENER INSTALLATION

A. Install water softener equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.

B. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure. Refer to Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment" for seismic restraints.

C. Install brine lines and fittings furnished by equipment manufacturer but not factory installed.

D. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.

E. Install water-testing sets on wall adjacent to water softeners.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Section 232113 "Hydronic Piping."

D. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Section 230523 "General-Duty Valves for HVAC Piping."

E. Refer to Section 221119 "Domestic Water Piping Specialties" for backflow preventers required in makeup water connections to potable-water systems.

F. Confirm applicable electrical requirements in electrical Sections for connecting electrical equipment.

G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections.
2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
4. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
5. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
6. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
7. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
8. Repair leaks and defects with new materials and retest piping until no leaks exist.

C. Remove and replace malfunctioning units and retest as specified above.

D. Sample boiler water at one-week intervals after boiler startup for a period of five weeks, and prepare test report advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article for each required characteristic. Sample boiler water at one-week intervals following the testing noted above to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section.

E. At one-month intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article.

F. Comply with ASTM D 3370 and with the following standards:

1. Silica: ASTM D 859.
2. Steam System: ASTM D 1066.
3. Acidity and Alkalinity: ASTM D 1067.
4. Iron: ASTM D 1068.
5. Water Hardness: ASTM D 1126.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment. Refer to Section 017900 "Demonstration and Training."

B. Training: Provide a "how-to-use" self-contained breathing apparatus video that details exact operating procedures of equipment.

END OF SECTION 232500

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Single-wall rectangular ducts and fittings.
2. Double-wall rectangular ducts and fittings.
3. Single-wall round[**and flat-oval**] ducts and fittings.
4. Double-wall round[**and flat-oval**] ducts and fittings.
5. Sheet metal materials.
6. Sealants and gaskets.
7. Hangers and supports.
8. Seismic-restraint devices.

B. Related Sections:

1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233116 "Nonmetal Ducts" for fibrous-glass ducts, thermoset fiber-reinforced plastic ducts, thermoplastic ducts, PVC ducts, and concrete ducts.
3. Section 233119 "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
4. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports[**and seismic restraints**] shall withstand the effects of gravity[**and seismic**] loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" [**and**] [**ASCE/SEI 7.**] [**SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."**]**.**

[Retain one of three subparagraphs below if retaining "SMACNA's 'Seismic Restraint Manual: Guidelines for Mechanical Systems'" option in paragraph above. If using other seismic design criteria, delete three subparagraphs below.]

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
3. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."
4. Duct-Cleaning Test Report for Prerequisite IEQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-up."
5. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

C. Shop Drawings:

1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment[**, seismic restraints,**] and vibration isolation.

D. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations[**, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation**] for selecting hangers and supports[**and seismic restraints**].

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:

   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.
   f. Perimeter moldings.

B. Welding certificates.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

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

1. McGill AirFlow LLC.
2. Sheet Metal Connectors, Inc.

B. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

D. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

E. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

F. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: **0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K)** at 75 deg F (24 deg C) mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with UL 181, Class 1.

G. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.

1. Maximum Thermal Conductivity: **0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K)** at 75 deg F (24 deg C) mean temperature.

H. Inner Duct: Minimum 0.028-inch (0.7-mm) **solid sheet steel**.

I. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Traverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

J. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SINGLE-WALL ROUND[**AND FLAT-OVAL**] DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

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

   a. Lindab Inc.
   b. McGill AirFlow LLC.
   c. SEMCO Incorporated.
   d. Sheet Metal Connectors, Inc.
   e. Spiral Manufacturing Co., Inc.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Transverse Joints in Ducts Larger Than **60 Inches (1524 mm)** in Diameter: Flanged.

D. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
2. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.

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

2.4 DOUBLE-WALL ROUND[**AND FLAT-OVAL**] DUCTS AND FITTINGS

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

1. Lindab Inc.
2. McGill AirFlow LLC.
3. SEMCO Incorporated.
4. Sheet Metal Connectors, Inc.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.

1. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

a. Transverse Joints in Ducts Larger Than **60 Inches (1524 mm)** in Diameter: Flanged.

2. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

    a. Fabricate round ducts larger than 90 inches (2286 mm) in diameter with butt-welded longitudinal seams.
    b. Fabricate flat-oval ducts larger than 72 inches (1830 mm) in width (major dimension) with butt-welded longitudinal seams.

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

D. Inner Duct: Minimum 0.028-inch (0.7-mm) **solid sheet steel**.

E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Maximum Thermal Conductivity: **0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K)** at 75 deg F (24 deg C) mean temperature.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with UL 181, Class 1.

F. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.

1. Maximum Thermal Conductivity: **0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K)** at 75 deg F (24 deg C) mean temperature.

2.5 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: [**G60 (Z180)**] [**G90 (Z275)**].
2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: [**G60 (Z180)**] [**G90 (Z275)**].

2. Minimum Thickness for Factory-Applied PVC Coating: 4 mils (0.10 mm) thick[**on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum 1 mil (0.025 mm) thick on opposite surface**].
3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.

D. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

E. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

F. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

G. Factory- or Shop-Applied Antimicrobial Coating:

1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
5. Shop-Applied Coating Color: [**Black**] [**White**].

H. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

I. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.6 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: [**3 inches (76 mm)**] [**4 inches (102 mm)**] [**6 inches (152 mm)**].

3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Water-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Solids Content: Minimum 65 percent.
3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. Solvent-Based Joint and Seam Sealant:

1. Application Method: Brush on.
2. Base: Synthetic rubber resin.
3. Solvent: Toluene and heptane.
4. Solids Content: Minimum 60 percent.
5. Shore A Hardness: Minimum 60.
6. Water resistant.
7. Mold and mildew resistant.
8. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
9. VOC: Maximum 395 g/L.
10. Maximum Static-Pressure Class: 10-inch wg (2500 Pa), positive or negative.
11. Service: Indoor or outdoor.
12. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa) and shall be rated for10-inch wg (2500-Pa) static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.7 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. Trapeze and Riser Supports:

1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.8 SEISMIC-RESTRAINT DEVICES

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

1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Ductmate Industries, Inc.
3. Hilti Corp.
4. Kinetics Noise Control.
5. Loos & Co.; Cableware Division.

6. Mason Industries.
7. TOLCO; a brand of NIBCO INC.
8. Unistrut Corporation; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by [**an evaluation service member of the ICC Evaluation Service**] [**the Office of Statewide Health Planning and Development for the State of California**] [**an agency acceptable to authorities having jurisdiction**].

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: [**ASTM A 603, galvanized**] [**ASTM A 492, stainless**]-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. Hanger Rod Stiffener: [**Steel tube or steel slotted-support-system sleeve with internally bolted connections**] [**Reinforcing steel angle clamped**] to hanger rod.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round[**and flat-oval**] ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials.[**Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."**]

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.

B. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of [**20 feet (6 m)**] [**12 feet (3.7 m)**] in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches (38 mm) from bottom of duct.

C. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.4 DUCT SEALING

A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.
9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg (500 Pa) and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg (500 Pa): Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.5 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 (Table 5-1M), "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches (610 mm) of each elbow and within 48 inches (1200 mm) of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet (5 m).

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with [**SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."**] [**ASCE/SEI 7.**]

1. Space lateral supports a maximum of **40 feet (12 m)** o.c., and longitudinal supports a maximum of **80 feet (24 m)** o.c.
2. Brace a change of direction longer than 12 feet (3.7 m).

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by [**an evaluation service member of the ICC Evaluation Service**] [**the Office of Statewide Health Planning and Development for the State of California**] [**an agency acceptable to authorities having jurisdiction**].

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.

3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.7 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.8 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:

   a. Ducts with a Pressure Class Higher Than 3-Inch wg (750 Pa): Test representative duct sections[**, selected by Architect from sections installed,**] totaling no less than 25 percent of total installed duct area for each designated pressure class.
   b. Supply Ducts with a Pressure Class of [**2-Inch wg (500 Pa)**] [**3-Inch wg (750 Pa)**] [**4-Inch wg (1000 Pa)**] or Higher: Test representative duct sections[**, selected by Architect from sections installed,**] totaling no less than [**50**] [**100**] percent of total installed duct area for each designated pressure class.
   c. Return Ducts with a Pressure Class of [**2-Inch wg (500 Pa)**] [**3-Inch wg (750 Pa)**] [**4-Inch wg (1000 Pa)**] or Higher: Test representative duct sections[**, selected by Architect from sections installed,**] totaling no less than [**50**] [**100**] percent of total installed duct area for each designated pressure class.
   d. Exhaust Ducts with a Pressure Class of [**2-Inch wg (500 Pa)**] [**3-Inch wg (750 Pa)**] [**4-Inch wg (1000 Pa)**] or Higher: Test representative duct sections[**, selected by Architect from sections installed,**] totaling no less than [**50**] [**100**] percent of total installed duct area for each designated pressure class.

e. Outdoor Air Ducts with a Pressure Class of [**2-Inch wg (500 Pa)**] [**3-Inch wg (750 Pa)**] [**4-Inch wg (1000 Pa)**] or Higher: Test representative duct sections[**, selected by Architect from sections installed,**] totaling no less than [**50**] [**100**] percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct System Cleanliness Tests:

1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Cleveland Clinic, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."

a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

D. Duct system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.10 DUCT CLEANING

A. Clean new and existing duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.

1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:

1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:

1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:

1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.11 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.12 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:

1. Underground Ducts: Concrete-encased, [**galvanized sheet steel**] [**PVC-coated, galvanized sheet steel with thicker coating on duct exterior**] [**stainless steel**].

B. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive [**1-inch wg (250 Pa)**] [**2-inch wg (500 Pa)**].
b. Minimum SMACNA Seal Class: [**A**] [**B**] [**C**].
c. SMACNA Leakage Class for Rectangular: [**12**] [**24**].
d. SMACNA Leakage Class for Round and Flat Oval: [**12**] [**24**].

2. Ducts Connected to Constant-Volume Air-Handling Units:

a. Pressure Class: Positive [**2-inch wg (500 Pa)**] [**3-inch wg (750 Pa)**].
b. Minimum SMACNA Seal Class: [**A**] [**B**].
c. SMACNA Leakage Class for Rectangular: [**6**] [**12**] [**24**].
d. SMACNA Leakage Class for Round and Flat Oval: [**6**] [**12**] [**24**].

3. Ducts Connected to Variable-Air-Volume Air-Handling Units:

a. Pressure Class: Positive [**3-inch wg (750 Pa)**] [**4-inch wg (1000 Pa)**].
b. Minimum SMACNA Seal Class: [**A**] [**B**].
c. SMACNA Leakage Class for Rectangular: [**3**] [**6**].
d. SMACNA Leakage Class for Round and Flat Oval: [**3**] [**6**].

4. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive [**2-inch wg (500 Pa)**] [**3-inch wg (750 Pa)**] [**4-inch wg (1000 Pa)**].
b. Minimum SMACNA Seal Class: [**A**] [**B**].
c. SMACNA Leakage Class for Rectangular: [**3**] [**6**] [**12**].
d. SMACNA Leakage Class for Round and Flat Oval: [**3**] [**6**] [**12**].

C. Return Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative [**1-inch wg (250 Pa)**] [**2-inch wg (500 Pa)**].
b. Minimum SMACNA Seal Class: [**A**] [**B**] [**C**].
c. SMACNA Leakage Class for Rectangular: [**12**] [**24**].
d. SMACNA Leakage Class for Round and Flat Oval: [**12**] [**24**].

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative [**2-inch wg (500 Pa)**] [**3-inch wg (750 Pa)**].
b. Minimum SMACNA Seal Class: [**A**] [**B**].
c. SMACNA Leakage Class for Rectangular: [**6**] [**12**] [**24**].
d. SMACNA Leakage Class for Round and Flat Oval: [**6**] [**12**] [**24**].

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative [**2-inch wg (500 Pa)**] [**3-inch wg (750 Pa)**] [**4-inch wg (1000 Pa)**].
b. Minimum SMACNA Seal Class: [**A**] [**B**].
c. SMACNA Leakage Class for Rectangular: [**3**] [**6**] [**12**].
d. SMACNA Leakage Class for Round and Flat Oval: [**3**] [**6**] [**12**].

D. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:

a. Pressure Class: Negative [**1-inch wg (250 Pa)**] [**2-inch wg (500 Pa)**] [**3-inch wg (750 Pa)**].
b. Minimum SMACNA Seal Class: [**A**] [**B**] [**C**] if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: [**12**] [**24**].
d. SMACNA Leakage Class for Round and Flat Oval: [**6**] [**12**] [**24**].

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative [**2-inch wg (500 Pa)**] [**3-inch wg (750 Pa)**].
b. Minimum SMACNA Seal Class: [**A**] [**B**] if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: [**6**] [**12**] [**24**].
d. SMACNA Leakage Class for Round and Flat Oval: [**3**] [**6**] [**12**] [**24**].

3. Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96.

a. Exposed to View: Type 304, stainless-steel sheet, [**No. 4**] [**No. 3**] finish.
b. Concealed: [**Type 304, stainless-steel sheet, No. 2D finish**] [**Carbon-steel sheet**].
c. Welded seams and joints.
d. Pressure Class: Positive or negative [**2-inch wg (500 Pa)**] [**3-inch wg (750 Pa)**] [**4-inch wg (1000 Pa)**].
e. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
f. SMACNA Leakage Class: 3.

4. Ducts Connected to Dishwasher Hoods:

a. Type 304, stainless-steel sheet.
b. Exposed to View: [**No. 4**] [**No. 3**] finish.
c. Concealed: No. 2D finish.
d. Welded seams and flanged joints with watertight EPDM gaskets.
e. Pressure Class: Positive or negative [**2-inch wg (500 Pa)**] [**3-inch wg (750 Pa)**].
f. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
g. SMACNA Leakage Class: 3.

5. Ducts Connected to Fans Exhausting Laboratory and Process (ASHRAE 62.1, Class 3 and 4) Air:

a. [**Type 316**] [**Type 304**], stainless-steel sheet.

1) Exposed to View: [**No. 4**] [**No. 3**] finish.
2) Concealed: [**No. 2B**] [**No. 2D**] finish.

b. PVC-coated, galvanized sheet steel with thicker coating on duct interior.
c. Pressure Class: Positive or negative [**3-inch wg (750 Pa)**] [**4-inch wg (1000 Pa)**] [**6-inch wg (1500 Pa)**].

d. Minimum SMACNA Seal Class: [**A**] [**Welded seams, joints, and penetrations**].
e. SMACNA Leakage Class: 3.

6. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative [**2-inch wg (500 Pa)**] [**3-inch wg (750 Pa)**] [**4-inch wg (1000 Pa)**].
b. Minimum SMACNA Seal Class: [**A**] [**B**] if negative pressure, and A if positive pressure.
c. SMACNA Leakage Class for Rectangular: [**6**] [**12**] [**24**].
d. SMACNA Leakage Class for Round and Flat Oval: [**3**] [**6**] [**12**] [**24**].

E. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

a. Pressure Class: Positive or negative [**1-inch wg (250 Pa)**] [**2-inch wg (500 Pa)**].
b. Minimum SMACNA Seal Class: [**A**] [**B**] [**C**].
c. SMACNA Leakage Class for Rectangular: [**12**] [**24**].
d. SMACNA Leakage Class for Round and Flat Oval: [**6**] [**12**] [**24**].

2. Ducts Connected to Air-Handling Units:

a. Pressure Class: Positive or negative [**2-inch wg (500 Pa)**] [**3-inch wg (750 Pa)**].
b. Minimum SMACNA Seal Class: [**A**] [**B**].
c. SMACNA Leakage Class for Rectangular: [**6**] [**12**] [**24**].
d. SMACNA Leakage Class for Round and Flat Oval: [**3**] [**6**] [**12**] [**24**].

3. Ducts Connected to Equipment Not Listed Above:

a. Pressure Class: Positive or negative [**2-inch wg (500 Pa)**] [**3-inch wg (750 Pa)**] [**4-inch wg (1000 Pa)**].
b. Minimum SMACNA Seal Class: [**A**] [**B**].
c. SMACNA Leakage Class for Rectangular: [**3**] [**6**] [**12**].
d. SMACNA Leakage Class for Round and Flat Oval: [**3**] [**6**] [**12**].

F. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: [**Galvanized steel**] [**Carbon steel coated with zinc-chromate primer**] [**Galvanized steel or carbon steel coated with zinc-chromate primer**].
2. PVC-Coated Ducts:

a. Exposed to Airstream: Match duct material.
b. Not Exposed to Airstream: [**Galvanized**] [**Match duct material**].

3. Stainless-Steel Ducts:

a. Exposed to Airstream: Match duct material.
b. Not Exposed to Airstream: [**Galvanized**] [**Match duct material**].

4. Aluminum Ducts: [**Aluminum**][**or galvanized sheet steel coated with zinc chromate**].

G. Double-Wall Duct Interstitial Insulation:

1. Supply Air Ducts: [**1 inch (25 mm)**] [**1-1/2 inches (38 mm)**] [**2 inches (51 mm)**] thick.
2. Return Air Ducts: [**1 inch (25 mm)**] [**1-1/2 inches (38 mm)**] [**2 inches (51 mm)**] thick.
3. Exhaust Air Ducts: [**1 inch (25 mm)**] [**1-1/2 inches (38 mm)**] [**2 inches (51 mm)**] thick.

H. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

    a. Velocity 1000 fpm (5 m/s) or Lower:

        1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
        2) Mitered Type RE 4 without vanes.

    b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s):

        1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
        2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
        3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

    c. Velocity 1500 fpm (7.6 m/s) or Higher:

        1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
        2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
        3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."

    a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
    b. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
    c. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."

3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."

    a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.

1) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
3) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
4) Radius-to Diameter Ratio: 1.5.

b. Round Elbows, **12 Inches (305 mm)** and Smaller in Diameter: Stamped or pleated.
c. Round Elbows, **14 Inches (356 mm)** and Larger in Diameter: [**Standing seam**] [**Welded**].

I. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."

a. Rectangular Main to Rectangular Branch: 45-degree entry.
b. Rectangular Main to Round Branch: Spin in.

2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.

a. Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
b. Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
c. Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Control dampers.
5. Fire dampers.
6. Ceiling radiation dampers.
7. Smoke dampers.
8. Combination fire and smoke dampers.
9. Corridor dampers.
10. Flange connectors.
11. Duct silencers.
12. Turning vanes.
13. Remote damper operators.
14. Duct-mounted access doors.
15. Flexible connectors.
16. Flexible ducts.
17. Duct security bars.
18. Duct accessory hardware.

B. Related Requirements:

1. Section 233723 "HVAC Gravity Ventilators" for roof-mounted ventilator caps.

[Retain one of two subparagraphs below.]

2. Section 283111 "Digital, Addressable Fire-Alarm System" for duct-mounted fire and smoke detectors.
3. Section 283112 "Zoned (DC-Loop) Fire-Alarm System" for duct-mounted fire and smoke detectors.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct insulation R-values comply with tables in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air Conditioning."

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

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

a. Special fittings.
b. Manual volume damper installations.
c. Control-damper installations.
d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
e. Duct security bars.
f. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

1. Galvanized Coating Designation: [**G60 (Z180)**] [**G90 (Z275)**].
2. Exposed-Surface Finish: Mill phosphatized.

B. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and <**Insert finish designation**> finish for exposed ducts.

C. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

D. Extruded Aluminum: Comply with ASTM B 221 (ASTM B 221M), Alloy 6063, Temper T6.

E. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

F. Tie Rods: Galvanized steel, 1/4-inch (6-mm) minimum diameter for lengths 36 inches (900 mm) or less; 3/8-inch (10-mm) minimum diameter for lengths longer than 36 inches (900 mm).

2.3 BACKDRAFT AND PRESSURE RELIEF DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.
2. American Warming and Ventilating; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.
5. Lloyd Industries, Inc.
6. Nailor Industries Inc.
7. NCA Manufacturing, Inc.
8. Pottorff.
9. Ruskin Company.
10. Vent Products Company, Inc.

B. Description: Gravity balanced.

C. Maximum Air Velocity: [**1000 fpm (5.1 m/s)**] [**1250 fpm (6.4 m/s)**] [**2000 fpm (10 m/s)**] [**3000 fpm (15 m/s)**].

D. Maximum System Pressure: [**1-inch wg (0.25 kPa)**] [**2-inch wg (0.5 kPa)**] [**3-inch wg (0.8 kPa)**] [**6-inch wg (1.5 kPa)**].

E. Frame: Hat-shaped, [**0.05-inch- (1.3-mm-) thick, galvanized sheet steel**] [**0.094-inch- (2.4-mm-) thick, galvanized sheet steel**] [**0.063-inch- (1.6-mm-) thick extruded aluminum**] [**0.03-inch- (0.8-mm-) thick stainless steel**] [**0.05-inch- (1.3-mm-) thick stainless steel**], with welded corners or mechanically attached[**and mounting flange**].

F. Blades: Multiple single-piece blades, [**center pivoted,**] [**off-center pivoted,**] [**end pivoted,**] maximum 6-inch (150-mm) width, [**0.025-inch- (0.6-mm-) thick, roll-formed aluminum**] [**0.050-inch- (1.2-mm-) thick aluminum sheet**] [**noncombustible, tear-resistant, neoprene-coated fiberglass**] with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: [**Felt**] [**Vinyl foam**] [**Extruded vinyl, mechanically locked**] [**Neoprene, mechanically locked**].

I. Blade Axles:

1. Material: [**Nonferrous metal**] [**Galvanized steel**] [**Plated steel**] [**Stainless steel**] [**Nonmetallic**] [**Aluminum**].
2. Diameter: **0.20 inch (5 mm)**.

J. Tie Bars and Brackets: [**Aluminum**] [**Galvanized steel**].

K. Return Spring: Adjustable tension.

L. Bearings: [**Steel ball**] [**or**] [**synthetic pivot bushings**].

M. Accessories:

1. Adjustment device to permit setting for varying differential static pressure.
2. Counterweights and spring-assist kits for vertical airflow installations.
3. Electric actuators.
4. Chain pulls.
5. Screen Mounting: Front mounted in sleeve.
    a. Sleeve Thickness: 20 gage (1.0 mm) minimum.
    b. Sleeve Length: 6 inches (152 mm) minimum.
6. Screen Material: [**Galvanized steel**] [**Aluminum**].
7. Screen Type: [**Bird**].
8. 90-degree stops.

2.4 BAROMETRIC RELIEF DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.
2. American Warming and Ventilating; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.
5. Lloyd Industries, Inc.
6. Nailor Industries Inc.
7. NCA Manufacturing, Inc.
8. Pottorff.
9. Ruskin Company.
10. Vent Products Company, Inc.

B. Suitable for horizontal or vertical mounting.

C. Maximum Air Velocity: [**1000 fpm (5.1 m/s)**] [**1250 fpm (6.4 m/s)**] [**2000 fpm (10 m/s)**] [**2500 fpm (13 m/s)**].

D. Maximum System Pressure: [**2-inch wg (0.5 kPa)**] [**3-inch wg (0.8 kPa)**] [**6-inch wg (1.5 kPa)**] [**10-inch wg (2.5 kPa)**].

E. Frame: Hat-shaped, [**0.05-inch- (1.3-mm-) thick, galvanized sheet steel**] [**0.094-inch- (2.4-mm-) thick, galvanized sheet steel**] [**0.063-inch- (1.6-mm-) thick extruded aluminum**] [**0.03-inch- (0.8-mm-) thick stainless steel**] [**0.05-inch- (1.3-mm-) thick stainless steel**], with welded corners or mechanically attached[**and mounting flange**].

F. Blades:

1. Multiple, [**0.025-inch- (0.6-mm-) thick, roll-formed aluminum**] [**0.050-inch- (1.2-mm-) thick aluminum sheet**].
2. Maximum Width: 6 inches (150 mm).
3. Action: Parallel.
4. Balance: Gravity.
5. [**Eccentrically pivoted**] [**Off-center pivoted**] [**End pivoted**].

G. Blade Seals: [**Vinyl**] [**Neoprene**].

H. Blade Axles: [**Galvanized steel**] [**Nonferrous metal**] [**Plated steel**] [**Stainless steel**] [**Nonmetallic**].

I. Tie Bars and Brackets:

1. Material: [**Aluminum**] [**Galvanized steel**].
2. Rattle free with 90-degree stop.

J. Return Spring: Adjustable tension.

K. Bearings: [**Synthetic**] [**Stainless steel**] [**Bronze**].

L. Accessories:

1. Flange on intake.
2. Adjustment device to permit setting for varying differential static pressures.

2.5 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:

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

a. Air Balance Inc.; a division of Mestek, Inc.
b. American Warming and Ventilating; a division of Mestek, Inc.
c. Flexmaster U.S.A., Inc.
d. McGill AirFlow LLC.
e. Nailor Industries Inc.
f. Pottorff.
g. Ruskin Company.
h. Trox USA Inc.
i. Vent Products Company, Inc.

2. Standard leakage rating[**, with linkage outside airstream**].
3. Suitable for horizontal or vertical applications.
4. Frames:

a. Frame: Hat-shaped, [**0.094-inch- (2.4-mm-) thick, galvanized sheet steel**] [**0.05-inch- (1.3-mm-) thick stainless steel**].
b. Mitered and welded corners.
c. Flanges for attaching to walls and flangeless frames for installing in ducts.

5. Blades:

a. Multiple or single blade.
b. Parallel- or opposed-blade design.
c. Stiffen damper blades for stability.
d. [**Galvanized**] [**Stainless**]-steel, 0.064 inch (1.62 mm) thick.

6. Blade Axles: [**Galvanized steel**] [**Stainless steel**] [**Nonferrous metal**].
7. Bearings:

a. [**Oil-impregnated bronze**] [**Molded synthetic**] [**Oil-impregnated stainless-steel sleeve**] [**Stainless-steel sleeve**].
b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:

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

   a. Air Balance Inc.; a division of Mestek, Inc.
   b. American Warming and Ventilating; a division of Mestek, Inc.
   c. McGill AirFlow LLC.
   d. Nailor Industries Inc.
   e. Pottorff.
   f. Ruskin Company.
   g. Trox USA Inc.
   h. Vent Products Company, Inc.

2. Standard leakage rating[**, with linkage outside airstream**].
3. Suitable for horizontal or vertical applications.
4. Frames: Hat-shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:

   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Roll-Formed Aluminum Blades: 0.10-inch- (2.5-mm-) thick aluminum sheet.
   e. Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.

6. Blade Axles: [**Galvanized steel**] [**Stainless steel**] [**Nonferrous metal**].
7. Bearings:

   a. [**Oil-impregnated bronze**] [**Molded synthetic**] [**Stainless-steel sleeve**].
   b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

8. Tie Bars and Brackets: Aluminum.

C. Low-Leakage, Steel, Manual Volume Dampers:

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

   a. Air Balance Inc.; a division of Mestek, Inc.
   b. American Warming and Ventilating; a division of Mestek, Inc.
   c. McGill AirFlow LLC.
   d. Nailor Industries Inc.
   e. Pottorff.
   f. Ruskin Company.
   g. Trox USA Inc.
   h. Vent Products Company, Inc.

2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating[**, with linkage outside airstream,**] and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.

5. Frames:

   a. [**Hat**] [**U**] [**Angle**] shaped.
   b. [**0.094-inch- (2.4-mm-) thick, galvanized sheet steel**] [**0.05-inch- (1.3-mm-) thick stainless steel**].
   c. Mitered and welded corners.
   d. Flanges for attaching to walls and flangeless frames for installing in ducts.

6. Blades:

   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. [**Galvanized**] [**Stainless**], roll-formed steel, 0.064 inch (1.62 mm) thick.

7. Blade Axles: [**Galvanized steel**] [**Stainless steel**] [**Nonferrous metal**].
8. Bearings:

   a. [**Oil-impregnated bronze**] [**Molded synthetic**] [**Oil-impregnated stainless-steel sleeve**] [**Stainless-steel sleeve**].
   b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.

9. Blade Seals: [**Felt**] [**Vinyl**] [**Neoprene**].
10. Jamb Seals: Cambered [**stainless steel**] [**aluminum**].
11. Tie Bars and Brackets: [**Galvanized steel**] [**Aluminum**].
12. Accessories:

   a. Include locking device to hold single-blade dampers in a fixed position without vibration.

D. Low-Leakage, Aluminum, Manual Volume Dampers:

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

   a. Air Balance Inc.; a division of Mestek, Inc.
   b. American Warming and Ventilating; a division of Mestek, Inc.
   c. McGill AirFlow LLC.
   d. Nailor Industries Inc.
   e. Pottorff.
   f. Ruskin Company.
   g. Trox USA Inc.
   h. Vent Products Company, Inc.

2. Comply with AMCA 500-D testing for damper rating.
3. Low-leakage rating[**, with linkage outside airstream,**] and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
4. Suitable for horizontal or vertical applications.

5. Frames: [**Hat**] [**U**] [**Angle**]-shaped, 0.10-inch- (2.5-mm-) thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:
    a. Multiple or single blade.
    b. Parallel- or opposed-blade design.
    c. Roll-Formed Aluminum Blades: 0.10-inch- (2.5-mm-) thick aluminum sheet.
    d. Extruded-Aluminum Blades: 0.050-inch- (1.2-mm-) thick extruded aluminum.
7. Blade Axles: [**Galvanized steel**] [**Stainless steel**] [**Nonferrous metal**].
8. Bearings:
    a. [**Oil-impregnated bronze**] [**Molded synthetic**] [**Oil-impregnated stainless-steel sleeve**] [**Stainless-steel sleeve**].
    b. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
9. Blade Seals: [**Felt**] [**Vinyl**] [**Neoprene**].
10. Jamb Seals: Cambered [**stainless steel**] [**aluminum**].
11. Tie Bars and Brackets: [**Galvanized steel**] [**Aluminum**].
12. Accessories:
    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

E. Jackshaft:

1. Size: [**0.5-inch (13-mm)**] [**1-inch (25-mm)**] diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

F. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- (2.4-mm-) thick zinc-plated steel, and a 3/4-inch (19-mm) hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.6 CONTROL DAMPERS

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

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Arrow United Industries; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.

5. Lloyd Industries, Inc.
6. McGill AirFlow LLC.
7. Metal Form Manufacturing, Inc.
8. Nailor Industries Inc.
9. NCA Manufacturing, Inc.
10. Pottorff.
11. Ruskin Company.
12. Vent Products Company, Inc.
13. Young Regulator Company.

B. Low-leakage rating[**, with linkage outside airstream,**] and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

C. Frames:

1. [**Hat**] [**U**] [**Angle**] shaped.
2. [**0.094-inch- (2.4-mm-) thick, galvanized sheet steel**] [**0.05-inch- (1.3-mm-) thick stainless steel**].
3. [**Mitered and welded**] [**Interlocking, gusseted**] corners.

D. Blades:

1. Multiple blade with maximum blade width of [**6 inches (152 mm)**] [**8 inches (200 mm)**].
2. [**Parallel**] [**Parallel- and opposed**] [**Opposed**]-blade design.
3. [**Galvanized-steel**] [**Stainless steel**] [**Aluminum**].
4. [**0.064 inch (1.62 mm) thick single skin**] [**or**] [**0.0747-inch- (1.9-mm-) thick dual skin**].
5. Blade Edging: Closed-cell neoprene.

E. Blade Axles: 1/2-inch- (13-mm-) diameter; [**galvanized steel**] [**stainless steel**] [**nonferrous metal**]; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).

F. Bearings:

1. [**Oil-impregnated bronze**] [**Molded synthetic**] [**Oil-impregnated stainless-steel sleeve**] [**Stainless-steel sleeve**].
2. Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.

2.7 FIRE DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.

2. Arrow United Industries; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.
5. Nailor Industries Inc.
6. NCA Manufacturing, Inc.
7. Pottorff.
8. Prefco; Perfect Air Control, Inc.
9. Ruskin Company.
10. Vent Products Company, Inc.
11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Type: Static and dynamic; rated and labeled according to UL 555 by an NRTL.

C. Closing rating in ducts up to **4-inch wg (1-kPa)** static pressure class and minimum **2000-fpm (10-m/s)** velocity.

D. Fire Rating: [**1-1/2**] [**and**] [**3**] hours.

E. Frame: [**Curtain type with blades inside airstream**] [**Curtain type with blades outside airstream**] [**Multiple-blade type**] [**Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream**]; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

1. Minimum Thickness: [**0.05 (1.3 mm)**] [**0.138 inch (3.5 mm)**] [**or**] [**0.39 inch (9.9 mm)**] thick, as indicated, and of length to suit application.
2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, [**0.024-inch- (0.61-mm)**] [**0.034-inch- (0.85-mm-)**] thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Replaceable, [**165 deg F (74 deg C)**] [**212 deg F (100 deg C)**] rated, fusible links.

K. Heat-Responsive Device: [**Electric**] [**Pneumatic**], [**resettable**] [**replaceable**] link and switch package, factory installed, [**165 deg F (74 deg C)**] [**and**] [**212 deg F (100 deg C)**] rated.

2.8 CEILING RADIATION DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Nailor Industries Inc.
4. Pottorff.
5. Prefco; Perfect Air Control, Inc.
6. Ruskin Company.
7. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. General Requirements:

1. Labeled according to UL 555C by an NRTL.
2. Comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."

C. Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction.

D. Blades: Galvanized sheet steel with refractory insulation.

E. Heat-Responsive Device: Replaceable, [**165 deg F (74 deg C)**] [**212 deg F (100 deg C)**] rated, fusible links.

F. Fire Rating: [**1**] [**2**] [**3**] hours.

2.9 SMOKE DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. Pottorff.
6. Ruskin Company.

B. General Requirements: Label according to UL 555S by an NRTL.

C. Smoke Detector: Integral, factory wired for single-point connection.

D. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel, with [**welded**] [**interlocking, gusseted**] [**or**] [**mechanically attached**] corners[**and mounting flange**].

E. Blades: Roll-formed, horizontal, [**interlocking**] [**overlapping**], [**0.034-inch- (0.85-mm-)**] [**0.063-inch- (1.6-mm)**] thick, galvanized sheet steel.

F. Leakage: [**Class I**] [**Class II**].

G. Rated pressure and velocity to exceed design airflow conditions.

H. Mounting Sleeve: Factory-installed, [**0.039-inch- (1.0-mm-)**] [**0.05-inch- (1.3-mm-)**] thick, galvanized sheet steel; length to suit wall or floor application[**with factory-furnished silicone calking**].

I. Damper Motors: [**Modulating**] [**or**] [**two-position**] action.

J. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230900 "Instrumentation and Control for HVAC."
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
7. Electrical Connection: 115 V, single phase, 60 Hz.

K. Accessories:

1. Auxiliary switches for [**signaling**] [**fan control**] [**or**] [**position indication**].
2. [**Momentary test switch**] [**Test and reset switches**], [**damper**] [**remote**] mounted.

2.10 COMBINATION FIRE AND SMOKE DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.
5. Pottorff.
6. Ruskin Company.

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Closing rating in ducts up to **4-inch wg (1-kPa)** static pressure class and minimum **2000-fpm (10-m/s)** velocity.

D. Fire Rating: [**1-1/2**] [**and**] [**3**] hours.

E. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel, with [**welded**] [**interlocking, gusseted**] [**or**] [**mechanically attached**] corners[**and mounting flange**].

F. Heat-Responsive Device: [**Resettable**] [**Replaceable**], [**165 deg F (74 deg C)**] [**212 deg F (100 deg C)**] rated, [**fusible links**] [**fire-closure device**].

G. Heat-Responsive Device: [**Electric**] [**Pneumatic**] resettable [**link**] [**device**] and switch package, factory installed, rated.

H. Smoke Detector: Integral, factory wired for single-point connection.

I. Blades: Roll-formed, horizontal, [**interlocking**] [**overlapping**], [**0.063-inch- (1.6-mm-)**] [**0.034-inch- (0.85-mm-)**] thick, galvanized sheet steel.

J. Leakage: [**Class I**] [**Class II**].

K. Rated pressure and velocity to exceed design airflow conditions.

L. Mounting Sleeve: Factory-installed, [**0.039-inch- (1.0-mm-)**] [**0.05-inch- (1.3-mm-)**] thick, galvanized sheet steel; length to suit wall or floor application[**with factory-furnished silicone calking**].

M. Master control panel for use in dynamic smoke-management systems.

N. Damper Motors: [**Modulating**] [**or**] [**two-position**] action.

O. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230900 "Instrumentation and Control for HVAC."
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
7. Electrical Connection: 115 V, single phase, 60 Hz.

P. Accessories:

1. Auxiliary switches for [**signaling**] [**fan control**] [**or**] [**position indication**].
2. [**Momentary test switch**] [**Test and reset switches**], [**damper**] [**remote**] mounted.

2.11 CORRIDOR DAMPERS

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

1. Air Balance Inc.; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Nailor Industries Inc.
4. Pottorff.
5. Ruskin Company.

B. General Requirements: Label combination fire and smoke dampers according to UL 555 for 1-hour or 1-1/2-hour rating by an NRTL.

C. Heat-Responsive Device: Replaceable, [**165 deg F (74 deg C)**] [**212 deg F (100 deg C)**] rated, fusible links.

D. Heat-Responsive Device: [**Electric**] [**Pneumatic**] resettable [**link**] [**device**] and switch package, factory installed, rated.

E. Frame: Hat-shaped, 0.094-inch- (2.4-mm-) thick, galvanized sheet steel, with [**welded**] [**interlocking, gusseted**] [**or**] [**mechanically attached**] corners[**and mounting flange**].

F. Blades: Roll-formed, horizontal, [**interlocking**] [**overlapping**], 0.034-inch- (0.85-mm-) thick, galvanized sheet steel.

G. Mounting Sleeve: Factory-installed, [**0.039-inch- (1.0-mm-)**] [**0.05-inch- (1.3-mm-)**] thick, galvanized sheet steel; length to suit wall or floor application.

H. Damper Motors: [**Modulating**] [**or**] [**two-position**] action.

I. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 230900 "Instrumentation and Control for HVAC."
3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or

adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).

5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
6. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
7. Electrical Connection: 115 V, single phase, 60 Hz.

2.12 FLANGE CONNECTORS

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

1. Ductmate Industries, Inc.
2. Nexus PDQ; Division of Shilco Holdings Inc.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Description: [**Add-on**] [**or**] [**roll-formed**], factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gage and Shape: Match connecting ductwork.

2.13 DUCT SILENCERS

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

1. Dynasonics.
2. Industrial Noise Control, Inc.
3. McGill AirFlow LLC.
4. Ruskin Company.
5. Vibro-Acoustics.

B. General Requirements:

1. Factory fabricated.
2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Shape:

1. Rectangular straight with splitters or baffles.

2. Round straight with center bodies or pods.
3. Rectangular elbow with splitters or baffles.
4. Round elbow with center bodies or pods.
5. Rectangular transitional with splitters or baffles.

D. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, [**G90 (Z275)**] [**G60 (Z180)**], galvanized sheet steel, [**0.034 inch (0.85 mm)**] [**0.040 inch (1.02 mm)**] thick.

E. Round Silencer Outer Casing: ASTM A 653/A 653M, [**G90 (Z275)**] [**G60 (Z180)**], galvanized sheet steel.

1. Sheet Metal Thickness for Units up to 24 Inches (600 mm) in Diameter: 0.034 inch (0.85 mm) thick.
2. Sheet Metal Thickness for Units 26 through 40 Inches (660 through 1000 mm) in Diameter: 0.040 inch (1.02 mm) thick.
3. Sheet Metal Thickness for Units 42 through 52 Inches (1060 through 1300 mm) in Diameter: 0.05 inch (1.3 mm) thick.
4. Sheet Metal Thickness for Units 54 through 60 Inches (1370 through 1500 mm) in Diameter: 0.064 inch (1.62 mm) thick.

F. Inner Casing and Baffles: ASTM A 653/A 653M, [**G90 (Z275)**] [**G60 (Z180)**] galvanized sheet metal, 0.034 inch (0.85 mm) thick, and with 1/8-inch- (3-mm-) diameter perforations.

G. Special Construction:

1. Suitable for outdoor use.
2. High transmission loss[**to achieve STC 45**].

H. Connection Sizes: Match connecting ductwork unless otherwise indicated.

I. Principal Sound-Absorbing Mechanism:

1. Controlled impedance membranes and broadly tuned resonators without absorptive media.
2. [**Dissipative**] [**Film-lined**] type with fill material.

   a. Fill Material: [**Inert and vermin-proof fibrous material, packed under not less than 5 percent compression**] [**Inert and vermin-proof fibrous material, packed under not less than 15 percent compression**] [**Moisture-proof nonfibrous material**].
   b. Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.

3. Lining: [**None**] [**Mylar**] [**Tedlar**] [**Fiberglas cloth**].

J. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.

1. Joints: [**Lock formed and sealed**] [**continuously welded**] [**or**] [**flanged connections**].
2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
3. Reinforcement: Cross or trapeze angles for rigid suspension.

K. Accessories:

1. Integral [**1-1/2**] [**3**]-hour fire damper with access door.[**Access door to be high transmission loss to match silencer.**]
2. Factory-installed end caps to prevent contamination during shipping.
3. Removable splitters.
4. Airflow measuring devices.

L. Source Quality Control: Test according to ASTM E 477.

1. Testing [**of mockups**]to be witnessed by [**Architect**] [**Cleveland Clinic**].
2. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm (10-m/s) face velocity.
3. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or 6-inch wg (1500-Pa) static pressure, whichever is greater.

M. Capacities and Characteristics:

1. Configuration: [**Straight**] [**90-degree elbow**].
2. Shape: [**Rectangular**] [**Round**].
3. Attenuation Mechanism: [**Acoustical glass fiber**] [**Acoustical glass fiber with protective film liner**] [**Helmholtz resonator mechanism with no internal media**].
4. Maximum Pressure Drop: **0.35-inch wg (0.09 kPa)**.
5. Casing:

   a. Attenuation: [**Standard**] [**High transmission loss**].
   b. Outer Material: [**Galvanized steel**] [**Stainless steel**] [**Aluminum**].
   c. Inner Material: [**Galvanized steel**] [**Stainless steel**] [**Aluminum**].

6. Velocity Range: <**Insert fps (L/s)**> to <**Insert fps (L/s)**>.
7. End Connection: [**1-inch (25-mm) slip joint**] [**Flange**].
8. Length: <**Insert inches (mm)**>.
9. Face Dimension:

   a. Width: <**Insert inches (mm)**>.
   b. Height: <**Insert inches (mm)**>.

10. Face Velocity: <**Insert fpm (m/s)**>.
11. Dynamic Insertion Loss: <**Insert dBA**>.
12. Generated Noise: <**Insert dBA**>.
13. Accessories:

   a. Access door.
   b. Birdscreen.

2.14 TURNING VANES

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

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Elgen Manufacturing.
4. METALAIRE, Inc.
5. SEMCO Incorporated.
6. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

D. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

E. Vane Construction: [**Single**] [**Double**] wall.

F. Vane Construction: Single wall for ducts up to **48 inches** **(1200 mm)** wide and double wall for larger dimensions.

2.15 REMOTE DAMPER OPERATORS

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

1. Pottorff.
2. Ventfabrics, Inc.
3. Young Regulator Company.

B. Description: Cable system designed for remote manual damper adjustment.

C. Tubing: [**Brass**] [**Copper**] [**Aluminum**].

D. Cable: [**Stainless steel**] [**Steel**].

E. Wall-Box Mounting: [**Recessed**] [**Surface**].

F. Wall-Box Cover-Plate Material: [**Steel**] [**Stainless steel**].

2.16 DUCT-MOUNTED ACCESS DOORS

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

1. American Warming and Ventilating; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Ductmate Industries, Inc.
4. Elgen Manufacturing.
5. Flexmaster U.S.A., Inc.
6. Greenheck Fan Corporation.
7. McGill AirFlow LLC.
8. Nailor Industries Inc.
9. Pottorff.
10. Ventfabrics, Inc.
11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

1. Door:

a. Double wall, rectangular.
b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
c. Vision panel.
d. Hinges and Latches: 1-by-1-inch (25-by-25-mm)butt or piano hinge and cam latches.
e. Fabricate doors airtight and suitable for duct pressure class.

2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:

a. Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.
b. Access Doors up to [**18 Inches (460 mm)**] Square: [**Two hinges**] [**Continuous**] and two sash locks.
c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): [**Three hinges**] [**Continuous**] and two compression latches[**with outside and inside handles**].
d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): [**Four hinges**] [**Continuous**] and two compression latches with outside and inside handles.

C. Pressure Relief Access Door:

1. Door and Frame Material: Galvanized sheet steel.
2. Door: [**Single wall**] [**Double wall with insulation fill**] with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at [**3.0- to 8.0-inch wg (800 to 2000 Pa)**] [**10-inch wg (2500 Pa)**].
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch- (25-mm-) thick, fibrous-glass or polystyrene-foam board.

2.17 DUCT ACCESS PANEL ASSEMBLIES

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

1. Ductmate Industries, Inc.
2. Flame Gard, Inc.
3. 3M.

B. Labeled according to UL 1978 by an NRTL.

C. Panel and Frame: Minimum thickness [**0.0528-inch (1.3-mm) carbon**] [**0.0428-inch (1.1-mm) stainless**] steel.

D. Fasteners: [**Carbon**] [**Stainless**] steel. Panel fasteners shall not penetrate duct wall.

E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F (1093 deg C).

F. Minimum Pressure Rating: 10-inch wg (2500 Pa), positive or negative.

2.18 FLEXIBLE CONNECTORS

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

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Elgen Manufacturing.
4. Ventfabrics, Inc.
5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Materials: Flame-retardant or noncombustible fabrics.

C. Coatings and Adhesives: Comply with UL 181, Class 1.

D. Metal-Edged Connectors: Factory fabricated with a fabric strip [**3-1/2 inches (89 mm)**] [**5-3/4 inches (146 mm)**] wide attached to two strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized sheet steel or 0.032-inch- (0.8-mm-) thick aluminum sheets. Provide metal compatible with connected ducts.

E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
2. Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).

F. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd. (810 g/sq. m).
2. Tensile Strength: 530 lbf/inch (93 N/mm) in the warp and 440 lbf/inch (77 N/mm) in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C).

G. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.

1. Minimum Weight: 16 oz./sq. yd. (542 g/sq. m).
2. Tensile Strength: 285 lbf/inch (50 N/mm) in the warp and 185 lbf/inch (32 N/mm) in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).

H. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.

1. Minimum Weight: 14 oz./sq. yd. (474 g/sq. m).
2. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and 340 lbf/inch (60 N/mm) in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).

I. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch (6-mm) movement at start and stop.

2.19 FLEXIBLE DUCTS

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

1. Flexmaster U.S.A., Inc.
2. McGill AirFlow LLC.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

B. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; [**polyethylene**] [**aluminized**] vapor-barrier film.

1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20 m/s).

3. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

C. Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; [**polyethylene**] [**aluminized**] vapor-barrier film.

1. Pressure Rating: 4-inch wg (1000 Pa) positive and 0.5-inch wg (125 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20 m/s).
3. Temperature Range: Minus 20 to plus 175 deg F (Minus 29 to plus 79 deg C).
4. Insulation R-Value: Comply with ASHRAE/IESNA 90.1.

D. Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; [**polyethylene**] [**aluminized**] vapor-barrier film.

1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20 m/s).
3. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

E. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; [**polyethylene**] [**aluminized**] vapor-barrier film.

1. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
2. Maximum Air Velocity: 4000 fpm (20 m/s).
3. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

F. Insulated, Flexible Duct: UL 181, Class 0, interlocking spiral of aluminum foil; fibrous-glass insulation; [**polyethylene**] [**aluminized**] vapor-barrier film.

1. Pressure Rating: 8-inch wg (2280 Pa) positive or negative.
2. Maximum Air Velocity: 5000 fpm (25 m/s).
3. Temperature Range: Minus 20 to plus 250 deg F (Minus 29 to plus 121 deg C).
4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

G. Flexible Duct Connectors:

1. Clamps: [**Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action**] [**Nylon strap**] in sizes 3 through 18 inches (75 through 460 mm), to suit duct size.
2. Non-Clamp Connectors: [**Adhesive**] [**Liquid adhesive plus tape**] [**Adhesive plus sheet metal screws**].

2.20 DUCT SECURITY BARS

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

1. Carnes.
2. KEES, Inc.
3. Lloyd Industries, Inc.
4. Metal Form Manufacturing, Inc.
5. Price Industries.

B. Description: [**Field-fabricated**] [**Factory-fabricated and field-installed**] [**Field- or factory-fabricated and field-installed**] duct security bars.

C. Configuration:

1. Frame: [**2 by 1/4 inch (51 by 6 mm) flat frame**] [**2-1/2 by 2-1/2 by 1/4 inch (64 by 64 by 6 mm) angle**].
2. Sleeve: [**0.1345-inch 3.4-mm**] [**3/16-inch (4.8-mm)**], [**continuously welded**] [**bent**] steel frames with [**1-by-1-by-3/16-inch (25-by-25-by-4.8-mm)**] [**1-1/2-by-1-1/2-by-1/8-inch (38-by-38-by-3.2-mm)**] angle frame [**factory welded to 1 end**] [**furnished loose for field welding on other end**]. To be poured in place or set with concrete block or welded or bolted to wall, one side only. Duct connections on both sides.
3. Horizontal Bars: [**1/2 inch (13 mm)**] [**2 by 1/4 inch (50 by 6 mm)**].
4. Vertical Bars: [**1/2 inch (13 mm)**] [**3/4 inch (19 mm)**] [**1 inch (25 mm)**] [**2 by 1/4 inch (51 by 6 mm)**].
5. Bar Spacing: **6 inches (150 mm)**.
6. Mounting: [**Metal deck or roofing**] [**Bolted or welded**] [**Bolted or welded with masonry anchors**] [**Ductwork or other framing**] [**Poured in place or set with concrete block**] [**Welded or bolted to one wall (one side only**] [**Bar extends 6 inches (150 mm) into wall**].

2.21 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install [**backdraft**] [**control**] dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.

D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.

1. Install steel volume dampers in steel ducts.
2. Install aluminum volume dampers in aluminum ducts.

E. Set dampers to fully open position before testing, adjusting, and balancing.

F. Install test holes at fan inlets and outlets and elsewhere as indicated.

G. Install fire[**and smoke**] dampers according to UL listing.

H. Install duct security bars. Construct duct security bars from 0.164-inch (4.18-mm)steel sleeve, continuously welded at all joints and 1/2-inch- (13-mm-) diameter steel bars, 6 inches (150 mm) o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld 2-1/2-by-2-1/2-by-1/4-inch (63-by-63-by-6-mm) steel angle to 4 sides and both ends of sleeve. Connect duct security bars to ducts with flexible connections. Provide 12-by-12-inch (300-by-300-mm) hinged access panel with cam lock in duct in each side of sleeve.

I. Connect ducts to duct silencers [**with flexible duct connectors**] [**rigidly**].

J. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct coils.
2. Upstream[**and downstream**] from duct filters.
3. At outdoor-air intakes and mixed-air plenums.
4. At drain pans and seals.
5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-foot (15-m) spacing.
8. Upstream[**and downstream**] from turning vanes.
9. Upstream or downstream from duct silencers.
10. Control devices requiring inspection.
11. Elsewhere as indicated.

K. Install access doors with swing against duct static pressure.

L. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).

4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
5. Body Access: 25 by 14 inches (635 by 355 mm).
6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).

M. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

N. Install flexible connectors to connect ducts to equipment.

O. For fans developing static pressures of 5-inch wg (1250 Pa) and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

P. Connect terminal units to supply ducts[**directly or**] with maximum **12-inch (300-mm)** lengths of flexible duct. Do not use flexible ducts to change directions.

Q. Connect diffusers or light troffer boots to ducts[**directly or**] with maximum **60-inch (1500-mm)** lengths of flexible duct clamped or strapped in place.

R. Connect flexible ducts to metal ducts with [**adhesive**] [**liquid adhesive plus tape**] [**draw bands**] [**adhesive plus sheet metal screws**].

S. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 233413 - AXIAL HVAC FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Tubeaxial fans.
2. Vaneaxial fans.
3. Mixed-flow fans.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, furnished specialties, and accessories for each fan.
2. Certified fan performance curves with system operating conditions indicated.
3. Certified fan sound-power ratings.
4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
5. Material thickness and finishes, including color charts.
6. Dampers, including housings, linkages, and operators.
7. Fan speed controllers.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For axial fans to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Belts: One set for each belt-driven unit.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. AMCA Compliance:

1. Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.
2. Operating Limits: Classify according to AMCA 99.

B. Unusual Service Conditions:

1. Ambient Temperature: <**Insert deg C**>.
2. Altitude: <**Insert feet (m)**> above sea level.
3. High humidity.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Capacities and Characteristics:

1. See schedule on drawings

2. Vibration Isolators: [**Spring**] [**Restrained spring**] isolators having a static deflection of **1 inch (25 mm)**.

2.2 TUBEAXIAL FANS

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

1. Greenheck Fan Corporation.
2. Loren Cook Company.
3. Strobic Air Corporation.
4. Trane Inc.; a subsidiary of Ingersoll-Rand company.

B. Description: Fan wheel and housing, factory-mounted motor with [**belt**] [**or**] [**direct**] drive, an inlet cone section, and accessories.

C. Housings: [**Steel**] [**Galvanized steel**] [**Aluminum**] [**Fiberglass-reinforced plastic**] [**Stainless steel**] with flanged inlet and outlet connections.

[Retain one of three "Wheel Assemblies" paragraphs below.]

D. Wheel Assemblies: Cast or extruded aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.

E. Wheel Assemblies: Fiberglass-reinforced plastic cured under pressure with airfoil-shaped blades keyed to stainless-steel shaft.

F. Wheel Assemblies: Cast aluminum, machined and fitted to shaft.

G. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: [**1.2**] [**1.3**] [**1.4**] [**1.5**].
3. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
4. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
5. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
6. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
7. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
8. Motor Mount: Adjustable base.
9. Shaft Bearings: Radial, self-aligning bearings.

[Retain either "Ball-Bearing Rating Life" or "Roller-Bearing Rating Life" Subparagraph below.]

a. Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
b. Roller-Bearing Rating Life: ABMA 11, L10 of 50,000 hours.
c. Extend lubrication lines to outside of casing and terminate with grease fittings.

H. Accessories:

1. Companion Flanges: Rolled flanges of same material as housing.
2. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
3. Propeller Access Section Door: Short duct section bolted to fan [**inlet**] [**and**] [**outlet**] allowing access to internal parts of fan for inspection and cleaning, of same material as housing.

4. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
5. Mounting Clips: [**Horizontal ceiling**] [**Vertical mounting**] clips welded to fan housing, of same material as housing.
6. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
7. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.
8. Inlet Screen: Wire-mesh screen on fans not connected to ductwork, of same material as housing.
9. Outlet Screen: Wire-mesh screen on fans not connected to ductwork, of same material as housing.
10. Backdraft Dampers: Butterfly style, for bolting to the discharge of fan or outlet cone, of same material as housing.
11. Shaft Seal: Elastomeric seal and Teflon wear plate, suitable for up to 300 deg F (149 deg C).
12. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
13. Inlet Vanes: Adjustable; with peripheral control linkage operated from outside of airstream, bronze sleeve bearings on each end of vane support, and provision for manual or automatic operation of same material as housing.
14. Inlet Bell: Curved inlet for when fan is not attached to duct, [**of same material as housing**] [**aluminum**].
15. Inlet Cone: Round-to-round transition of same material as housing.
16. Outlet Cone: Round-to-round transition, of same material as housing.
17. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
18. Direct-Driven Units: Encase motor in housing outside of airstream[**, factory wired to disconnect switch located on outside of fan housing**]. Extend lubrication lines to outside of casing and terminate with grease fittings.

I. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: [**Thermoplastic vinyl**] [**Epoxy**] [**Zinc**] [**Synthetic resin**] [**Phenolic**] [**Color-match enamel**] [**Polytetrafluoroethylene**] [**Vinyl ester**] [**Hot-dip galvanized**] [**Powder-baked enamel**].

    a. Apply to finished housings.
    b. Apply to fan wheels.

2.3 VANEAXIAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Greenheck Fan Corporation.
2. Strobic Air Corporation.
3. Trane Inc.; a subsidiary of Ingersoll-Rand company.

B. Description: Fan wheel and housing, straightening vane section, factory-mounted motor with belt drive or direct drive, an inlet cone section, and accessories.

C. Housings: [**Steel**] [**Galvanized steel**] [**Aluminum**] [**Fiberglass-reinforced plastic**] [**Stainless steel**].

1. Inlet and Outlet Connections: Flanges.
2. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.
3. Sound-Trap Housing: Housing incorporating perforated steel inner liner, 2 inch (50 mm) fiberglass duct liner sandwiched between the inner and outer shell, and steel bands sealing the insulated cavity.

[Retain one of three "Wheel Assemblies" paragraphs below.]

D. Wheel Assemblies: Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.

E. Wheel Assemblies: Fiberglass-reinforced plastic cured under pressure with airfoil-shaped blades keyed to stainless-steel shaft.

F. Wheel Assemblies: Cast-aluminum hub assembly, machined and fitted with threaded bearing wells to receive blade-bearing assemblies with replaceable, cast-aluminum blades; factory mounted and balanced.

G. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: [**1.2**] [**1.3**] [**1.4**] [**1.5**].
2. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
3. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
7. Motor Mount: Adjustable base.
8. Shaft Bearings: Radial, self-aligning bearings.

[Retain either "Ball-Bearing Rating Life" or "Roller-Bearing Rating Life" Subparagraph below.]

a. Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
b. Roller-Bearing Rating Life: ABMA 11, L10 of 100,000 hours.
c. Extend lubrication lines to outside of casing and terminate with grease fittings.

H. Accessories:

1. Companion Flanges: Rolled flanges of same material as housing.
2. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
3. Propeller Access Section Door: Short duct section bolted to fan [**inlet**] [**and**] [**outlet**] allowing access to internal parts of fan for inspection and cleaning, of same material as housing.

4. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
5. Mounting Clips: [**Horizontal ceiling**] [**Vertical mounting**] clips welded to fan housing, of same material as housing.
6. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
7. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.
8. Inlet Screen: Wire-mesh screen on fans not connected to ductwork, of same material as housing.
9. Outlet Screen: Wire-mesh screen on fans not connected to ductwork, of same material as housing.
10. Backdraft Dampers: Butterfly style, for mounting with flexible connection to the discharge of fan or direct mounted to the discharge diffuser section, of same material as housing.
11. Stall Alarm Probe: Sensing probe capable of detecting fan operation in stall and signaling control devices. Control devices and sequence of operation are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls."
12. Flow Measurement Port: Pressure measurement taps installed in the inlet of fan to detect and signal airflow readings to temperature-control systems. Control devices and sequence of operation are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls."
13. Shaft Seal: Elastomeric seal and Teflon wear plate, suitable for up to 300 deg F (148 deg C).
14. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
15. Inlet Vanes: Adjustable; with peripheral control linkage operated from outside of airstream, bronze sleeve bearings on each end of vane support, and provision for manual or automatic operation, of same material as housing.
16. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
17. Inlet Cone: Round-to-round transition, of same material as housing.
18. Outlet Cone: Round-to-round transition, of same material as housing.
19. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
20. Direct-Driven Units: Encase motor in housing outside of airstream[**, factory wired to disconnect switch located on outside of fan housing**]. Extend lubrication lines to outside of casing and terminate with grease fittings.

I. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: [**Thermoplastic vinyl**] [**Epoxy**] [**Zinc**] [**Synthetic resin**] [**Phenolic**] [**Color-match enamel**] [**Polytetrafluoroethylene**] [**Vinyl ester**] [**Hot-dip galvanized**] [**Powder-baked enamel**].

   a. Apply to finished housings.
   b. Apply to fan wheels.

2.4 MIXED-FLOW FANS

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

1. Greenheck Fan Corporation.
2. Loren Cook Company.

B. Description: Fan wheel and housing,[**straightening vane section,**] factory-mounted motor with belt drive, and accessories.

C. Housings: [**Steel**] [**Galvanized steel**] [**Aluminum**].

1. Inlet and Outlet Connections: Outer mounting frame and companion flanges.
2. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.
3. Mixed-Flow Outlet Connection: [**One**] [**Two**] flanged discharge(s) perpendicular to fan inlet.

D. Wheel Assemblies: Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.

E. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

1. Service Factor Based on Fan Motor Size: [**1.2**] [**1.3**] [**1.4**] [**1.5**].
2. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
3. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Motor Mount: Adjustable base.
7. Shaft Bearings: Radial, self-aligning bearings.

[Retain either "Ball-Bearing Rating Life" or "Roller-Bearing Rating Life" Subparagraph below.]

a. Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
b. Roller-Bearing Rating Life: ABMA 11, L10 of 100,000 hours.
c. Extend lubrication lines to outside of casing and terminate with grease fittings.

F. Accessories:

1. Mounting Clips: [**Horizontal ceiling**] [**Vertical mounting**] clips welded to fan housing, of same material as housing.
2. Inlet and Outlet Screens: Wire-mesh screen on fans not connected to ductwork, of same material as housing.
3. Backdraft Dampers: Butterfly style, for mounting with flexible connection to the discharge of fan or direct mounted to the discharge diffuser section, of same material as housing.

4. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
5. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
6. Inlet Cones: Round-to-round transition, of same material as housing.
7. Outlet Cones: Round-to-round transition, of same material as housing.
8. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
9. Direct-Driven Units: Encase motor in housing outside of airstream[**, factory wired to disconnect switch located on outside of fan housing**].

G. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: [**Thermoplastic vinyl**] [**Epoxy**] [**Zinc**] [**Synthetic resin**] [**Phenolic**] [**Color-match enamel**] [**Polytetrafluoroethylene**] [**Vinyl ester**] [**Hot-dip galvanized**] [**Powder-baked enamel**].

    a. Apply to finished housings.
    b. Apply to fan wheels.

2.5 DUCT SILENCERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Greenheck Fan Corporation.
2. Loren Cook Company.
3. Strobic Air Corporation.
4. Trane Inc.; a subsidiary of Ingersoll-Rand company.

B. Description: Tubular [**with center cone**] silencers consisting of a shell with fill material.

C. Housings: [**Steel**] [**Galvanized steel**] [**Aluminum**] [**Fiberglass-reinforced plastic**] [**Stainless steel**] with flanged inlet and outlet connections matching fan or cone sizes.

1. Inner Shell: [**Steel**] [**Galvanized steel**] [**Aluminum**] [**Fiberglass-reinforced plastic**] [**Stainless steel**].
2. Liner: Duct liner.

D. Factory Finishes:

1. Sheet Metal Parts: Prime coat before final assembly.
2. Exterior Surfaces: Baked-enamel finish coat after assembly.
3. Coatings: [**Thermoplastic vinyl**] [**Epoxy**] [**Zinc**] [**Synthetic resin**] [**Phenolic**] [**Color-match enamel**] [**Polytetrafluoroethylene**] [**Vinyl ester**] [**Hot-dip galvanized**] [**Powder-baked enamel**]; applied to finished housings.

E. Capacities and Characteristics:

1. See Schedule on drawings.

2. Vibration Isolators: [**Spring**] [**Restrained spring**] isolators having a static deflection of **1 inch (25 mm)**.

2.6 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210/ASHRAE 51, "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install axial fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting: Install fans on cast-in-place concrete equipment base(s) using [**elastomeric pads**] [**elastomeric mounts**] [**restrained spring isolators**]. Comply with requirements for equipment bases specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**] Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1 inch (25 mm)**].
2. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.
7. Install on [**4-inch- (100-mm-)**] [**6-inch- (150-mm-)**] high concrete base designed to withstand, without damage to equipment, seismic force required by code.

E. Equipment Mounting: Install fans using [**elastomeric pads**] [**elastomeric mounts**] [**restrained spring isolators**]. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1 inch (25 mm)**].

F. Equipment Mounting: Install continuous-thread hanger rods and [**elastomeric hangers**] [**spring hangers**] [**spring hangers with vertical-limit stop**] of size required to support weight of dehumidification unit.

1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

G. Install units with clearances for service and maintenance.

H. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Cleveland Clinic will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.

9. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

END OF SECTION 233413

SECTION 233416 - CENTRIFUGAL HVAC FANS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes: For each product.

1. Airfoil centrifugal fans.
2. Backward-inclined centrifugal fans.
3. Forward-curved centrifugal fans.
4. Plenum fans.
5. Plug fans.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Include rated capacities, furnished specialties, and accessories for each fan.
2. Certified fan performance curves with system operating conditions indicated.
3. Certified fan sound-power ratings.
4. Motor ratings and electrical characteristics, plus motor and electrical accessories.
5. Material thickness and finishes, including color charts.
6. Dampers, including housings, linkages, and operators.

B. Shop Drawings:

1. Include plans, elevations, sections, and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.
4. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.

B. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Belts: One set for each belt-driven unit.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. AMCA Compliance:

1. Comply with AMCA performance requirements and bear the AMCA-Certified Ratings Seal.
2. Operating Limits: Classify according to AMCA 99.

B. Unusual Service Conditions:

1. Ambient Temperature: <**Insert deg C**>.
2. Altitude: <**Insert feet (m)**> above sea level.
3. High humidity.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Capacities and Characteristics:

1. See Schedule on Drawings.

2.2 AIRFOIL CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Greenheck Fan Corporation.
2. Loren Cook Company.
3. Twin City

4. Trane

B. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

C. Housings:

1. Formed panels to make curved-scroll housings with shaped cutoff.
2. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
3. Horizontally split, bolted-flange housing.
4. Spun inlet cone with flange.
5. Outlet flange.

D. Airfoil Wheels:

1. Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange.
2. Heavy backplate.
3. Hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.
4. Cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

E. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

F. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.

[Retain "Ball-Bearing Rating Life" or "Roller-Bearing Rating Life" Subparagraph below.]

2. Ball-Bearing Rating Life: ABMA 9, Ll0 at [**50,000**] [**120,000**] hours.
3. Roller-Bearing Rating Life: ABMA 11, Ll0 at [**50,000**] [**120,000**] hours.

G. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

[Retain "Ball-Bearing Rating Life" or "Roller-Bearing Rating Life" Subparagraph below.]

2. Ball-Bearing Rating Life: ABMA 9, Ll0 at [**50,000**] [**120,000**] hours.
3. Roller-Bearing Rating Life: ABMA 11, Ll0 at [**50,000**] [**120,000**] hours.

H. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: [**1.5**] [**1.4**] [**1.3**] [**1.2**].
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning.

I. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.
3. Companion Flanges: Rolled flanges for duct connections of same material as housing.
4. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
5. Discharge Dampers: Assembly with [**parallel**] [**opposed**] blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
6. Inlet Screens: Grid screen of same material as housing.
7. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
8. Spark-Resistant Construction: AMCA 99.
9. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
10. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

2.3 BACKWARD-INCLINED CENTRIFUGAL FANS

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

1. Aerovent; a Twin City Fan company.
2. Greenheck Fan Corporation.
3. Loren Cook Company.
4. Trane

B. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

C. Housings:

1. Formed panels to make curved-scroll housings with shaped cutoff.
2. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
3. Horizontally split, bolted-flange housing.
4. Spun inlet cone with flange.
5. Outlet flange.

D. Backward-Inclined Wheels:

1. Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades, and fastened to shaft with set screws.
2. Welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate.

E. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

F. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.

[Retain "Ball-Bearing Rating Life" or "Roller-Bearing Rating Life" Subparagraph below.]

2. Ball-Bearing Rating Life: ABMA 9, Ll0 at [**50,000**] [**120,000**] hours.
3. Roller-Bearing Rating Life: ABMA 11, Ll0 at [**50,000**] [**120,000**] hours.

G. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

[Retain "Ball-Bearing Rating Life" or "Roller-Bearing Rating Life" Subparagraph below.]

2. Ball-Bearing Rating Life: ABMA 9, Ll0 at [**50,000**] [**120,000**] hours.
3. Roller-Bearing Rating Life: ABMA 11, Ll0 at [**50,000**] [**120,000**] hours.

H. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: [**1.5**] [**1.4**] [**1.3**] [**1.2**].
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning.

I. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.
3. Companion Flanges: Rolled flanges for duct connections of same material as housing.
4. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
5. Discharge Dampers: Assembly with [**parallel**] [**opposed**] blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
6. Inlet Screens: Grid screen of same material as housing.
7. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
8. Spark-Resistant Construction: AMCA 99.
9. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
10. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

2.4 FORWARD-CURVED CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Greenheck Fan Corporation.
2. Loren Cook Company.
3. Twin City.
4. Trane.

B. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor, drive assembly, and support structure.

2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

C. Housings:

1. Formed panels to make curved-scroll housings with shaped cutoff.
2. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
3. Horizontally split, bolted-flange housing.
4. Spun inlet cone with flange.
5. Outlet flange.

D. Forward-Curved Wheels:

1. Black-enameled or galvanized-steel construction with inlet flange, backplate, shallow blades with inlet and tip curved forward in direction of airflow.
2. Mechanically secured to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.

E. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

F. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.

[Retain "Ball-Bearing Rating Life" or "Roller-Bearing Rating Life" Subparagraph below.]

2. Ball-Bearing Rating Life: ABMA 9, Ll0 at [**50,000**] [**120,000**] hours.
3. Roller-Bearing Rating Life: ABMA 11, Ll0 at [**50,000**] [**120,000**] hours.

G. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

[Retain "Ball-Bearing Rating Life" or "Roller-Bearing Rating Life" Subparagraph below.]

2. Ball-Bearing Rating Life: ABMA 9, Ll0 at [**50,000**] [**120,000**] hours.
3. Roller-Bearing Rating Life: ABMA 11, Ll0 at [**50,000**] [**120,000**] hours.

H. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.

2. Service Factor Based on Fan Motor Size: [**1.5**] [**1.4**] [**1.3**] [**1.2**].
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning.

I. Accessories:

1. Access for Inspection, Cleaning, and Maintenance: Comply with requirements in ASHRAE 62.1.
2. Scroll Drain Connection: NPS 1 (DN 25) steel pipe coupling welded to low point of fan scroll.
3. Companion Flanges: Rolled flanges for duct connections of same material as housing.
4. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
5. Discharge Dampers: Assembly with [**parallel**] [**opposed**] blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
6. Inlet Screens: Grid screen of same material as housing.
7. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
8. Spark-Resistant Construction: AMCA 99.
9. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
10. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.

2.5 PLENUM FANS

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

1. Aerovent; a Twin City Fan company.
2. Greenheck Fan Corporation.
3. Loren Cook Company.
4. Trane.

B. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

C. Airfoil Wheels:

1. Single-width-single-inlet construction with smooth-curved inlet flange.
2. Heavy backplate.
3. Hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.
4. Cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

D. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum-rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.

[Retain "Ball-Bearing Rating Life" or "Roller-Bearing Rating Life" Subparagraph below.]

2. Ball-Bearing Rating Life: ABMA 9, Ll0 at [**50,000**] [**120,000**] hours.
3. Roller-Bearing Rating Life: ABMA 11, Ll0 at [**50,000**] [**120,000**] hours.

F. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

[Retain "Ball-Bearing Rating Life" or "Roller-Bearing Rating Life" Subparagraph below.]

2. Ball-Bearing Rating Life: ABMA 9, Ll0 at [**50,000**] [**120,000**] hours.
3. Roller-Bearing Rating Life: ABMA 11, Ll0 at [**50,000**] [**120,000**] hours.

G. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: [**1.5**] [**1.4**] [**1.3**] [**1.2**].
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.

7. Motor Mount: Adjustable for belt tensioning.

H. Accessories:

1. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
2. Spark-Resistant Construction: AMCA 99.
3. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

2.6 PLUG FANS

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

1. Aerovent; a Twin City Fan company.
2. Greenheck Fan Corporation.
3. Loren Cook Company.
4. Trane.

B. Description:

1. Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of wheel, fan shaft, bearings, motor, drive assembly, and support structure.
2. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations.
3. Factory-installed and -wired disconnect switch.

C. Airfoil Wheels:

1. Single-width-single-inlet construction with smooth-curved inlet flange.
2. Heavy backplate.
3. Hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate.
4. Cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

D. Shafts:

1. Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with adjustable alignment and belt tensioning.
2. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
3. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.

E. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.

[Retain "Ball-Bearing Rating Life" or "Roller-Bearing Rating Life" Subparagraph below.]

2. Ball-Bearing Rating Life: ABMA 9, Ll0 at [**50,000**] [**120,000**] hours.
3. Roller-Bearing Rating Life: ABMA 11, Ll0 at [**50,000**] [**120,000**] hours.

F. Grease-Lubricated Shaft Bearings:

1. Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.

[Retain "Ball-Bearing Rating Life" or "Roller-Bearing Rating Life" Subparagraph below.]

2. Ball-Bearing Rating Life: ABMA 9, Ll0 at [**50,000**] [**120,000**] hours.
3. Roller-Bearing Rating Life: ABMA 11, Ll0 at [**50,000**] [**120,000**] hours.

G. Belt Drives:

1. Factory mounted, with adjustable alignment and belt tensioning.
2. Service Factor Based on Fan Motor Size: [**1.5**] [**1.4**] [**1.3**] [**1.2**].
3. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
4. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
5. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
6. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
7. Motor Mount: Adjustable for belt tensioning.

H. Accessories:

1. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
2. Spark-Resistant Construction: AMCA 99.
3. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.

2.7 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

2.8 SOURCE QUALITY CONTROL

A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210/ASHRAE 51, "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install centrifugal fans level and plumb.

B. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

D. Equipment Mounting: Install centrifugal fans on cast-in-place concrete equipment base(s) using [**elastomeric pads**] [**elastomeric mounts**] [**restrained spring isolators**]. Comply with requirements for equipment bases specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**] Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1 inch (25 mm)**].
2. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.
7. Install on [**4-inch- (100-mm-)**] [**6-inch- (150-mm-)**] high concrete base[**designed to withstand, without damage to equipment, seismic force required by code**].

E. Equipment Mounting: Install centrifugal fans using [**elastomeric pads**] [**elastomeric mounts**] [**restrained spring isolators**]. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1 inch (25 mm)**].

F. Equipment Mounting: Install centrifugal fans on vibration isolation equipment base. Comply with requirements specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

G. Equipment Mounting: Install centrifugal fans with <**Insert seismic-restraint device**>. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

H. Equipment Mounting: Install continuous-thread hanger rods and [**elastomeric hangers**] [**spring hangers**] [**spring hangers with vertical-limit stop**] of size required to support weight of dehumidification unit.

1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

I. Curb Support: Install roof curb on roof structure, level and secure, according to "The NRCA Roofing and Waterproofing Manual," Low-Slope Membrane Roofing Construction Details Section, Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts." Install and secure centrifugal fans on curbs, and coordinate roof penetrations and flashing with roof construction.[**Secure units to curb support with anchor bolts.**]

J. Unit Support: Install centrifugal fans level on structural [**curbs**] [**pilings**]. Coordinate wall penetrations and flashing with wall construction.[**Secure units to structural support with anchor bolts.**]

K. Isolation Curb Support: Install centrifugal fans on isolation curbs, and install[**flexible duct connectors**] and vibration isolation and seismic-control devices.

1. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.
2. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment" for vibration isolation and seismic-control devices.

L. Install units with clearances for service and maintenance.

M. Label fans according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to fans to allow service and maintenance.

C. Install piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain with pipe sizes matching the drain connection.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Cleveland Clinic will engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. See Section 230593 "Testing, Adjusting, and Balancing For HVAC" for testing, adjusting, and balancing procedures.
10. Remove and replace malfunctioning units and retest as specified above.

D. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain centrifugal fans.

END OF SECTION 233416

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Utility set fans.
2. Centrifugal roof ventilators.
3. Axial roof ventilators.
4. Upblast propeller roof exhaust fans.
5. Centrifugal wall ventilators.
6. Ceiling-mounted ventilators.
7. In-line centrifugal fans.
8. Propeller fans.
9. Hood/AIIR fans
10. Roof guy anchors

1.3 PERFORMANCE REQUIREMENTS

A. Project Altitude: Base fan-performance ratings on [**actual Project site elevations**] [**sea level**].

B. Operating Limits: Classify according to AMCA 99.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material thickness and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Roof curbs.
7. Fan speed controllers.

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

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For unit hangars and supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
2. Design Calculations: Calculate requirements for selecting vibration isolators[**and seismic restraints**] and for designing vibration isolation bases.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Roof framing and support members relative to duct penetrations.
2. Ceiling suspension assembly members.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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

1. Belts: One set for each belt-driven unit.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.

C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.9 COORDINATION

A. Coordinate size and location of structural-steel support members.

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

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 UTILITY SET FANS

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

1. Aerovent; a division of Twin City Fan Companies, Ltd.
2. Greenheck Fan Corporation.
3. Loren Cook Company.
4. Trane; a business of American Standard Companies.

B. Housing: Fabricated of [**galvanized**] steel with side sheets fastened with a deep lock seam or welded to scroll sheets.

1. Housing Discharge Arrangement: Adjustable to eight standard positions.

C. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.

1. Blade Materials: [**Steel**] [**Aluminum**].
2. Blade Type: [**Backward inclined**] [**Forward curved**] [**Airfoil**].
3. Spark-Resistant Construction: AMCA 99, Type [**A**] [**B**] [**C**].

D. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.

E. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, [**L_{50} of 200,000 hours**] [**L_{10} of 80,000 hours**].

1. Extend grease fitting to accessible location outside of unit.

F. Belt Drives:

1. Factory mounted, with final alignment and belt adjustment made after installation
2. Service Factor Based on Fan Motor Size: [**1.5**] [**1.4**] [**1.3**] [**1.2**].
3. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
4. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
5. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

G. Accessories:

1. Inlet and Outlet: Flanged.
2. Companion Flanges: Rolled flanges for duct connections of same material as housing.
3. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades with felt edges in steel frame installed on fan discharge.
4. Access Door: Gasketed door in scroll with latch-type handles.
5. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
6. Inlet Screens: Removable wire mesh.
7. Drain Connections: NPS 3/4 (DN 20) threaded coupling drain connection installed at lowest point of housing.
8. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
9. Discharge Dampers: Assembly with [**parallel**] [**opposed**] blades constructed of two plates formed around and to shaft, channel frame, sealed ball bearings, with blades linked outside of airstream to single control lever of same material as housing.
10. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
11. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

H. Capacities and Characteristics:

1. See schedule on drawings.

2.2 CENTRIFUGAL ROOF VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Aerovent; a division of Twin City Fan Companies, Ltd.
2. Greenheck Fan Corporation.
3. Loren Cook Company.
4. Trane.

B. Housing: Removable, [**spun-aluminum, dome top and outlet baffle**] [**extruded-aluminum, rectangular top**] [**galvanized steel, mushroom-domed top**]; square, one-piece, aluminum base with venturi inlet cone.

1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains[**and grease collector**].
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

D. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
5. Fan and motor isolated from exhaust airstream.

E. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted [**inside**] [**outside**] fan housing, factory wired through an internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
4. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
5. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: [**Self-flashing without a cant strip, with mounting flange**] [**Built-in cant and mounting flange**] [**Built-in raised cant and mounting flange**].
2. Overall Height: [**8 inches (200 mm)**] [**9-1/2 inches (240 mm)**] [**12 inches (300 mm)**] [**16 inches (400 mm)**] [**18 inches (450 mm)**].
3. Sound Curb: Curb with sound-absorbing insulation.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.
6. Burglar Bars: [**1/2-inch- (13-mm-)**] [**5/8-inch- (16-mm-)**] [**3/4-inch- (19-mm-)**] thick steel bars welded in place to form 6-inch (150-mm) squares.
7. Mounting Pedestal: Galvanized steel with removable access panel.
8. Vented Curb: Unlined with louvered vents in vertical sides.

G. Capacities and Characteristics:

1. See schedule on drawings.

2.3 AXIAL ROOF VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Aerovent; a division of Twin City Fan Companies, Ltd.
2. Greenheck Fan Corporation.
3. Loren Cook Company.
4. Trane.

B. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; square, one-piece, hinged, aluminum base.

1. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. Fan Wheel: [**Aluminum**] [**Steel**] hub and blades.

D. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
4. Pulleys: Cast-iron, adjustable-pitch motor pulley.

E. Accessories:

1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted [**inside**] [**outside**] fan housing, factory wired through an internal aluminum conduit.
2. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
4. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

F. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: [**Self-flashing without a cant strip, with mounting flange**] [**Built-in cant and mounting flange**] [**Built-in raised cant and mounting flange**].
2. Overall Height: [**8 inches (200 mm)**] [**9-1/2 inches (240 mm)**] [**12 inches (300 mm)**] [**16 inches (400 mm)**] [**18 inches (450 mm)**].
3. Sound Curb: Curb with sound-absorbing insulation.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.
6. Burglar Bars: [**1/2-inch- (13-mm-)**] [**5/8-inch- (16-mm-)**] [**3/4-inch- (19-mm-)**] thick steel bars welded in place to form 6-inch (150-mm) squares.
7. Mounting Pedestal: Galvanized steel with removable access panel.

G. Capacities and Characteristics:

1. See schedule on drawings.

2.4 UPBLAST PROPELLER ROOF EXHAUST FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Aerovent; a division of Twin City Fan Companies, Ltd.
2. Greenheck Fan Corporation.

3. Loren Cook Company.
4. Trane.

B. Wind Band, Fan Housing, and Base: Reinforced and braced [**galvanized steel**] [**aluminum**], containing [**galvanized-steel**] [**aluminum**] butterfly dampers and rain trough, motor and drive assembly, and fan wheel.

1. Damper Rods: Steel with [**bronze**] [**nylon**] bearings.
2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.

C. Fan Wheel: Replaceable, [**cast**] [**extruded**]-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

D. Belt Drives:

1. Resiliently mounted to housing.
2. Weatherproof housing of same material as fan housing.
3. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
4. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings.
5. Pulleys: Cast-iron, adjustable-pitch motor pulley.
6. Motor Mount: On outside of fan cabinet, adjustable base for belt tensioning.

E. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: [**Self-flashing without a cant strip, with mounting flange**] [**Built-in cant and mounting flange**] [**Built-in raised cant and mounting flange**].
2. Overall Height: [**8 inches (200 mm)**] [**9-1/2 inches (240 mm)**] [**12 inches (300 mm)**] [**16 inches (400 mm)**] [**18 inches (450 mm)**].
3. Sound Curb: Curb with sound-absorbing insulation.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.
6. Burglar Bars: [**1/2-inch- (13-mm-)**] [**5/8-inch- (16-mm-)**] [**3/4-inch- (19-mm-)**] thick steel bars welded in place to form 6-inch (150-mm) squares.
7. Mounting Pedestal: Galvanized steel with removable access panel.

F. Capacities and Characteristics:

1. See schedule on drawings.

2.5 CENTRIFUGAL WALL VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Aerovent; a division of Twin City Fan Companies, Ltd.
2. Greenheck Fan Corporation.
3. Loren Cook Company.
4. Trane.

B. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; venturi inlet cone.

C. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.

D. Belt Drives:

1. Resiliently mounted to housing.
2. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
3. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
4. Pulleys: Cast-iron, adjustable-pitch motor pulley.
5. Fan and motor isolated from exhaust airstream.

E. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through internal aluminum conduit.
3. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
4. Wall Grille: Ring type for flush mounting.
5. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in wall sleeve; factory set to close when fan stops.
6. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

F. Capacities and Characteristics:

1. See schedule on drawings.

2.6 CEILING-MOUNTED VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Greenheck Fan Corporation.
2. Loren Cook Company.

B. Housing: Steel, lined with acoustical insulation.

C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

D. Grille: [**Stainless steel**] [**Aluminum**] [**Painted aluminum**], louvered grille with flange on intake and thumbscrew attachment to fan housing.

E. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.

F. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
3. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
4. Motion Sensor: Motion detector with adjustable shutoff timer.
5. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless-steel springs, and fusible link.
6. Filter: Washable aluminum to fit between fan and grille.
7. Isolation: Rubber-in-shear vibration isolators.
8. Manufacturer's standard roof jack or wall cap, and transition fittings.

G. Capacities and Characteristics:

1. See schedule on drawings.

2.7 IN-LINE CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Greenheck Fan Corporation.
2. Loren Cook Company.
3. Twin City.
4. Trane.

B. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

C. Direct-Drive Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing[**; with wheel, inlet cone, and motor on swing-out service door**].

D. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.

E. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

F. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
3. Companion Flanges: For inlet and outlet duct connections.
4. Fan Guards: 1/2- by 1-inch (13- by 25-mm) mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

G. Capacities and Characteristics:

1. See schedule on drawings.

2.8 HOOD/AIIR FANS

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

1. Greenheck: Vektor
2. Strobic Air:
3. Twin City

B. Description: Belt-driven centrifugal fans for indoor mounting consisting of housing, wheel, fan shaft, bearings, motor, disconnect switch, drive assembly, floor base, factory tapered discharge stack or wind band, optional separate roof extension and accessories.

C. Housing: Welded steel, access door for fan/motor impeller removal, housing drain connection, stainless steel fasteners

D. Fan Wheels: Corrosion resistant, coated aluminum wheel with backward-inclined blades.

E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:

1. Fan Shaft: Turned, ground, and polished 316 stainless steel; keyed to wheel hub.
2. Shaft Bearings: L-10 lubricating type with extended grease fittings..
3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
4. Fan and motor isolated from exhaust airstream.
5. AMCA type “B” spark resistant construction. (Motor to Explosion Proof)

F. Accessories:

1. Disconnect Switch: Non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
2. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
3. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
4. Finish: Hi-Pro polyester coating (or equal)
5. Side inlet arrangement as where indicated on plans for field connected HEPA filter inlet connection.

G. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: Self-flashing without a cant strip, with mounting flange
2. Overall Height: 12 inches (400 mm)
3. Metal Liner: Galvanized steel.
4. Matching Greenheck curb, Model GPF-LE-21.5/21.5-G12

2.9 PROPELLER FANS

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

1. Aerovent; a division of Twin City Fan Companies, Ltd.
2. Greenheck Fan Corporation.
3. Loren Cook Company.

B. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.

C. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.

D. Fan Wheel: Replaceable, [**cast**] [**extruded**]-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.

E. Fan Drive:

1. Resiliently mounted to housing.
2. Statically and dynamically balanced.
3. Selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
4. Extend grease fitting to accessible location outside of unit.
5. Service Factor Based on Fan Motor Size: 1.4.
6. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
7. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.

   a. Ball-Bearing Rating Life: ABMA 9, L_{10} of 100,000 hours.

8. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
9. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
10. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
11. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

F. Accessories:

1. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.
2. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
3. Wall Sleeve: Galvanized steel to match fan and accessory size.
4. Weathershield Hood: Galvanized steel to match fan and accessory size.
5. Weathershield Front Guard: Galvanized steel with expanded metal screen.
6. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
7. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

G. Capacities and Characteristics:

1. See schedule on drawings.

2.10 ROOF GUY ANCHORS

A. Shall be prefabricated anchor ties constructed of hot galvanized steel pipe, base plate and eye. Unit shall be insulated with molded urethane.
   1. Manufacturer
      a. Summit Anchor SM-1

2.11 MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

   1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

B. Enclosure Type: Totally enclosed, fan cooled.

2.12 SOURCE QUALITY CONTROL

A. Certify sound-power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.

B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install power ventilators level and plumb.

B. Support units using [**elastomeric mounts**] [**restrained elastomeric mounts**] [**spring isolators**] [**restrained spring isolators**] having a static deflection of **1 inch** **(25 mm)**. Vibration- and seismic-control devices are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

   1. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.

C. Install floor-mounted units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Section 033000 "Cast-in-Place Concrete."

D. Install floor-mounted units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code. Concrete, reinforcement, and formwork requirements are specified in Section 033000 "Cast-in-Place Concrete."

E. Secure roof-mounted fans to roof curbs with cadmium-plated hardware. See Section 077200 "Roof Accessories" for installation of roof curbs.

F. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

G. Support suspended units from structure using threaded steel rods and [**elastomeric hangers**] [**spring hangers**] [**spring hangers with vertical-limit stops**] having a static deflection of **1 inch (25 mm)**. Vibration-control devices are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

H. Install units with clearances for service and maintenance.

I. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.2 CONNECTIONS

A. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

B. Install ducts adjacent to power ventilators to allow service and maintenance.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.

4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
5. Adjust belt tension.
6. Adjust damper linkages for proper damper operation.
7. Verify lubrication for bearings and other moving parts.
8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
10. Shut unit down and reconnect automatic temperature-control operators.
11. Remove and replace malfunctioning units and retest as specified above.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Prepare test and inspection reports.

3.4 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.

D. Replace fan and motor pulleys as required to achieve design airflow.

E. Lubricate bearings.

END OF SECTION 233423

SECTION 233433 - AIR CURTAINS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes air curtains with [**hot-water heat**] [**steam heat**] [**electric heat**] .

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties, and accessories.

B. Shop Drawings: For air curtains. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For air curtains indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of air-curtain mounting assemblies.
2. Design Calculations: Calculate requirements for selecting vibration isolators[**and seismic restraints**].

1.4 INFORMATIONAL SUBMITTALS

A. Warranties: Sample of special warranties.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air curtains to include in maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1. Furnish one set of filters.
2. Furnish one set of fan belts for each unit.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with AMCA 220, "Laboratory Methods of Testing Air Curtains for Aerodynamic Performance Ratings," for airflow, outlet velocity, and power consumption.

C. Comply with ARI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils," for components, construction, and rating.

1. Certify coils according to ARI 410.

D. Comply with NSF 37, "Air Curtains for Entranceways in Food and Food Service Establishments."

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air curtains that fail in materials or workmanship within specified warranty period.

1. Warranty Period (Nonheating Units): 24 months.
2. Warranty Period (Water or Steam Heating Units): 24 months.
3. Warranty Period (Gas Heating Units): 24 months.

PART 2 - PRODUCTS

2.1 AIR-CURTAIN UNIT<**Insert drawing designation**>

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Berner International.
2. Mars Air Products; Dynaforce Division.
3. Mars Air Products; Mars Air Door Division.
4. Powered Aire, Inc.

B. Housing:

[Retain one of first five subparagraphs below.]

1. Materials: Galvanized steel with electrostatically-applied epoxy-enamel finish over powdered mirror.
2. Materials: One-piece, molded, high-impact, white polymer material.
3. Materials: Heavy-gage, electroplated-zinc steel with welded construction and polyester-coated finish.
4. Materials: Heavy-gage, aluminum construction.

    a. Anodized Finish: Match finish and color of adjacent architectural metals. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
    b. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.

        1) Class II, Clear Anodic Finish: AA-M12C22A31 (Mechanical Finish: Nonspecular as fabricated; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 611.
        2) Class II, Color Anodic Finish: AA-M12C22A32/A34 (Mechanical Finish: Nonspecular as fabricated; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class II, integrally colored or electrolytically deposited color coating 0.010 mm or thicker).

5. Materials: Stainless steel.

    [Retain one of three subparagraphs below.]

6. Discharge Nozzle: Integral part of the housing, containing fixed air-directional vanes.
7. Discharge Nozzle: Integral part of the housing, containing adjustable air-directional vanes with [**40**] [**20**] [**15**] -degree sweep front to back.
8. Discharge Nozzle: Integral part of the housing, containing air-directional vanes adjustable in 5-degree increments through a 45-degree sweep front to back.

C. Mounting Brackets: Steel, for [**wall**] [**ceiling**] mounting.

[Retain one of first two paragraphs below.]

D. Air-Intake Louvers: Comply with requirements in Section 089000 "Louvers and Vents."

E. Air-Intake [**Louvers**] [**Grille**]:

[Retain one of first two subparagraphs below.]

1. Louvers: Integral part of and same material as the housing, mechanically field adjustable and capable of reducing air-outlet velocity by 60 percent with louver in totally closed position.
2. Grille: Integral part of and same material as the housing.

F. Fans:

1. [**Centrifugal, forward curved, double width, double inlet**] [**Vane axial**].

2. [**Galvanized steel**] [**Painted steel**] [**Aluminum**].
3. Statically and dynamically balanced.
4. [**Direct drive**] [**Belt drive and equipped with belt guards and adjustable sheaves and pulleys**].

G. Motors: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. [**Single speed**] [**Two speed**] [**Multispeed**].
3. Resiliently mounted.
4. Continuous duty.
5. [**Totally enclosed, air over**] [**Totally enclosed, fan cooled**] [**Open, dripproof**] [**Explosion proof**].
6. Integral thermal-overload protection.
7. Bearings: Permanently sealed, lifetime, prelubricated, ball bearings.
8. Disconnect: Internal power cord with plug and receptacle.

H. Water Coils:

1. Type: [**Continuous-circuit**] [**Self-draining**] [**Cleanable**].
2. Piping Connections: Threaded on [**same end**] [**opposite ends**].
3. Tube Material: Copper, complying with ASTM B 75 (ASTM B 75M).

   a. Tube Diameter: 0.625 inch (15.9 mm).

4. Fins: [**Aluminum**] [**Copper**] with fin spacing [**0.167 inch (4.23 mm)**] [**0.125 inch (3.18 mm)**] [**0.091 inch (2.31 mm)**] [**0.071 inch (1.80 mm)**] [**0.067 inch (1.70 mm)**] [**0.056 inch (1.42 mm)**] [**0.0075 inch (0.19 mm)**].
5. Fin and Tube Joint: [**Mechanical bond**] [**Silver brazed**].
6. Headers: [**Cast iron with drain and air vent tappings**] [**Cast iron with cleaning plugs, and drain and air vent tappings**] [**Seamless copper tube with brazed joints, prime coated**] [**Fabricated steel with brazed joints, prime coated**].
7. Frames: Galvanized-steel channel frame, [**0.052 inch (1.3 mm)**] [**0.064 inch (1.6 mm)**] [**0.079 inch (2.0 mm)**] [**0.0625 inch (1.59 mm)**].
8. Ratings: According to ASHRAE 33.
9. Working-Pressure Ratings: 200 psig (1380 kPa), 325 deg F (163 deg C).

I. Steam Coils: [**Distribution-header**] [**Single-tube**] coil, with threaded steam supply and condensate connections.

1. Piping Connections: [**Same end**] [**Opposite ends**] [**Steam supply on both ends; condensate on one end**].
2. Tube Material: Copper, complying with ASTM B 75 (ASTM B 75M).
3. Tube Diameter: 0.625 inch (15.9 mm).
4. Fins: [**Aluminum**] [**Copper**] with fin spacing [**0.167 inch (4.23 mm)**] [**0.125 inch (3.18 mm)**] [**0.091 inch (2.31 mm)**] [**0.071 inch (1.80 mm)**] [**0.067 inch (1.70 mm)**] [**0.056 inch (1.42 mm)**] [**0.0075 inch (0.19 mm)**].
5. Fin and Tube Joint: [**Mechanical bond**] [**Silver brazed**].

6. Headers: [**Cast iron with drain and air vent tappings**] [**Cast iron with cleaning plugs, and drain and air vent tappings**] [**Seamless copper tube with brazed joints, prime coated**] [**Fabricated steel with brazed joints, prime coated**].
7. Frames: Galvanized-steel channel frame, [**0.052 inch (1.3 mm)**] [**0.064 inch (1.6 mm)**] [**0.079 inch (2.0 mm)**] [**0.0625 inch (1.59 mm)**].
8. Pressure and Temperature Ratings: 100 psig (690 kPa), 400 deg F (205 deg C)according to ASHRAE 33.

J. Electric-Resistance Coils:

1. Coil Assembly: Comply with UL 1995.
2. Frame: Galvanized-steel frame.
3. Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
4. Overtemperature Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or unit.

   a. Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.

5. Control Panel: [**Unit**] [**Remote**] mounted with disconnecting means and overcurrent protection. Include the following controls:

   a. Magnetic contactor.
   b. Mercury contactor.
   c. Solid-state stepless pulse controller.
   d. Toggle switches; one per step.
   e. Step controller.
   f. Time-delay relay.
   g. Pilot lights; one per step.
   h. Airflow-proving switch.

K. Filters:

1. Disposable Panel Filters: Factory-fabricated, viscous-coated, flat-panel-type, disposable air filters with glass-fiber media sprayed with nonflammable adhesive in [**cardboard**] [**galvanized-steel**] frame.
2. Washable Panel Filters: Removable, stainless-steel, baffle-type filters with spring-loaded fastening; with minimum 0.0781-inch- (1.984-mm-) thick, stainless-steel filter frame.
3. Mounting Frames: Welded, galvanized steel with gaskets and fasteners and suitable for bolting together into built-up filter banks.

L. Controls:

1. [**Built-in**] [**Field-Installed**] Thermostat: Line voltage, factory installed and wired to the [**junction box on air curtain**] [**motor-control panel**].
2. Automatic Door Switch: [**Roller type**] [**Combination roller-plunger type**] [**Plunger type**] installed in door area to activate air curtain when door opens and to deactivate air curtain when door closes.
3. Start-Stop, Push-Button Switch: Manually activates and deactivates air curtain.

4. Three-Speed Switch: Manually activates, deactivates, and controls air-curtain fan speed.
5. Time-Delay Relay: Factory installed and adjustable to allow air curtain to operate from 0.5 seconds to 10 hours.
6. Motor-Control Panel: Complete with motor starter, 115-V ac transformer with primary and secondary fuses, terminal strip, and NEMA 250, [**Type 1**] [**Type 12**] enclosure[**with door-mounted hands-off-auto switch**].

M. Accessories:

1. Mounting Brackets: Adjustable mounting brackets for drum-type roll-up doors.
2. Discharge Extension Neck: For ceiling-recessed installation.

N. Capacities and Characteristics:

1. See schedule on drawings.

2.2 SOURCE QUALITY CONTROL

A. Source Quality Control: Test to 300 psig (2070 kPa) and to 200 psig (1380 kPa) underwater.

B. Testing: Test and inspect steam coils according to ASHRAE 33.

C. Steam coils will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

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

3.2 INSTALLATION

A. Install air curtains with clearance for equipment service and maintenance.

B. Equipment Installation: Install air curtains[**with seismic-restraint devices**]. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.3 CONNECTIONS

A. Comply with requirements for heating hot water piping specified in Section 232113 "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements for steam piping specified in Section 232213 "Steam and Condensate Heating Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

C. Comply with requirements for natural gas piping specified in Section 231123 "Facility Natural-Gas Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

D. Comply with requirements for LP gas piping specified in Section 231126 "Facility Liquefied-Petroleum Gas Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

E. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.

F. Breeching: Comply with applicable requirements in Section 235100 "Breechings, Chimneys, and Stacks." Connect breeching to full size at flue outlet.

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

   1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

   1. After installing air curtains completely, perform visual and mechanical check of individual components.
   2. After electrical circuitry has been energized, start unit to confirm motor rotation and unit operation. Certify compliance with test parameters.
   3. Inspect for water leaks.
   4. Test gas train and verify that there are no gas leaks.
   5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air-curtain unit will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust belt tension.

B. Adjust motor and fan speed to achieve specified airflow.

C. Adjust discharge louver and dampers to regulate airflow.

D. Adjust air-directional vanes.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain air curtains.

END OF SECTION 233433

SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Shutoff, single-duct air terminal units.

1.3 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers and supports[**and seismic restraints**] shall withstand the effects of gravity[**and seismic**] loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" [**and**] [**ASCE/SEI 7**] [**SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems"**].

[Retain one of three subparagraphs below if retaining "SMACNA's 'Seismic Restraint Manual: Guidelines for Mechanical Systems'" option in paragraph above. If using other seismic design criteria, delete three subparagraphs below.]

1. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
2. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
3. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

1.4 SUBMITTALS

A. Product Data: For each type of the following products, including rated capacities, furnished specialties, sound-power ratings, and accessories.

1. Air terminal units.
2. Liners and adhesives.
3. Sealants and gaskets.
4. Seismic-restraint devices.

B. LEED Submittals:

1. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.
3. Hangers and supports, including methods for duct and building attachment[**, seismic restraints,**] and vibration isolation.

D. Delegated-Design Submittal:

1. Materials, fabrication, assembly, and spacing of hangers and supports.
2. Design Calculations: Calculations[**, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation**] for selecting hangers and supports[**and seismic restraints**].

E. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Ceiling suspension assembly members.
2. Size and location of initial access modules for acoustic tile.
3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.

F. Field quality-control reports.

G. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Instructions for resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

1.6 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

PART 2 - PRODUCTS

2.1 SHUTOFF, SINGLE-DUCT AIR TERMINAL UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Nailor Industries Inc.
2. Price Industries.
3. Titus.

B. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.

C. Casing: [**0.034-inch (0.85-mm) steel**] [**0.032-inch (0.8-mm) aluminum**], **double** wall.

1. Casing Lining: Adhesive attached, [**1/2-inch- (13-mm-)**] [**3/4-inch- (19-mm-)**] [**1-inch- (25-mm-)**] thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

    a. Inner lining shall be solid metal.

2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
3. Air Outlet: S-slip and drive connections[**, size matching inlet size**].
4. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.

1. Maximum Damper Leakage: ARI 880 rated, [**2**] [**3**] percent of nominal airflow at [**3-inch wg (750-Pa)**] [**6-inch wg (1500-Pa)**] inlet static pressure.
2. Damper Position: Normally [**open**] [**closed**].

E. Attenuator Section: [**0.034-inch (0.85-mm) steel**] [**0.032-inch (0.8-mm) aluminum**] sheet.

1. Lining: perforated no media.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

F. Multioutlet Attenuator Section: With [**two**] [**three**] [**four**] [**6-inch- (150-mm-)**] [**8-inch- (200-mm-)**] [**10-inch- (250-mm-)**] diameter collars, each with locking butterfly balancing damper.

G. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

H. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

1. Access door interlocked disconnect switch.
2. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
3. Nickel chrome 80/20 heating elements.
4. Airflow switch for proof of airflow.
5. Fan interlock contacts.
6. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
7. Mercury contactors.
8. Pneumatic-electric switches and relays.
9. Magnetic contactor for each step of control (for three-phase coils).

2.2 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Steel Cables: [**Galvanized steel complying with ASTM A 603**] [**Stainless steel complying with ASTM A 492**].

D. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

E. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

2.3 SEISMIC-RESTRAINT DEVICES

A. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by [**an evaluation service member of the ICC Evaluation Service**] [**the Office of Statewide Health Planning and Development for the State of California**] [**an agency acceptable to authorities having jurisdiction**].

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

B. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

C. Restraint Cables: [**ASTM A 603, galvanized**] [**ASTM A 492, stainless**]-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; with an automatic-locking and clamping device or double-cable clips.

D. Hanger Rod Stiffener: [**Steel tube or steel slotted-support-system sleeve with internally bolted connections**] [**Reinforcing steel angle clamped**] to hanger rod.

E. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.4 SOURCE QUALITY CONTROL

A. Factory Tests: Test assembled air terminal units according to ARI 880.

1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, [**coil type,**] and ARI certification seal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

B. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

C. Install wall-mounted thermostats.

3.2 HANGER AND SUPPORT INSTALLATION

A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches (100 mm) thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches (100 mm) thick.

5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.3 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install hangers and braces designed to support the air terminal units and to restrain against seismic forces required by applicable building codes. Comply with [**SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."**] [**ASCE/SEI 7.**]

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on air terminal units that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by [**an evaluation service member of the ICC Evaluation Service**] [**the Office of Statewide Health Planning and Development for the State of California**] [**an agency acceptable to authorities having jurisdiction**].

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:

1. Identify position of reinforcing steel and other embedded items before drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Install heavy-duty sleeve anchors with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.4 CONNECTIONS

A. Install piping adjacent to air terminal unit to allow service and maintenance.

B. Hot-Water Piping: In addition to requirements in Section 232113 "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.

C. Connect ducts to air terminal units according to [**Section 233113 "Metal Ducts."**]

D. Make connections to air terminal units with flexible connectors complying with requirements in Section 233300 "Air Duct Accessories."

3.5 IDENTIFICATION

A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and warning signs and labels.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: Cleveland Clinic will engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:

1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
2. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air terminal unit will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.7 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
3. Verify that controls and control enclosure are accessible.
4. Verify that control connections are complete.
5. Verify that nameplate and identification tag are visible.
6. Verify that controls respond to inputs as specified.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Round ceiling diffusers.
2. Rectangular and square ceiling diffusers.
3. Louver face diffusers.
4. Linear bar diffusers.
5. Linear slot diffusers.
6. Ceiling-integral continuous diffusers.
7. Round induction diffusers.
8. Linear floor diffuser plenums.
9. Drum louvers.
10. Modular core supply grilles.
11. Continuous tubular diffusers.
12. Adjustable bar [**registers**] [**grilles**] [**registers and grilles**].
13. Security [**registers**] [**grilles**] [**registers and grilles**].
14. Fixed face [**registers**] [**grilles**] [**registers and grilles**].
15. Linear bar grilles.

B. Related Sections:

1. Section 089000 "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
2. Section 233300 "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

B. Samples for Initial Selection: For diffusers, registers, and grilles with factory-applied color finishes.

C. Samples for Verification: For diffusers, registers, and grilles, in manufacturer's standard sizes to verify color selected.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Size and location of initial access modules for acoustical tile.
4. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
5. Duct access panels.

B. Source quality-control reports.

PART 2 - PRODUCTS

2.1 CEILING DIFFUSERS

A. Round Ceiling Diffuser <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anemostat Products; a Mestek company.
    b. Price Industries.
    c. Titus.

2. Devices shall be specifically designed for variable-air-volume flows.
3. See schedule on drawings for capacities, characteristics, and accessories.

B. Rectangular and Square Ceiling Diffusers <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anemostat Products; a Mestek company.
    b. Price Industries.
    c. Titus.

2. Devices shall be specifically designed for variable-air-volume flows.
3. See schedule on drawings for capacities, characteristics, and accessories.

C. Louver Face Diffuser <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anemostat Products; a Mestek company.
   b. Price Industries.
   c. Titus.
2. Devices shall be specifically designed for variable-air-volume flows.
3. See schedule on drawings for capacities, characteristics, and accessories.

2.2 CEILING LINEAR SLOT OUTLETS

A. Linear Bar Diffuser <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anemostat Products; a Mestek company.
   b. Price Industries.
   c. Titus.
2. Devices shall be specifically designed for variable-air-volume flows.
3. See schedule on drawings for capacities, characteristics, and accessories.
4. Finish: Baked enamel, white.
5. Narrow Core Spacing Arrangement: 1/8-inch- (3-mm-) thick blades spaced 1/4 inch (6 mm) apart, [**zero**] [**15**]-degree deflection.
6. Wide Core Spacing Arrangement: 1/8-inch- (3-mm-) thick blades spaced 1/2 inch (13 mm) apart, [**zero**] [**15**]-degree deflection.
7. Wide Core Spacing Arrangement: 3/16-inch- (5-mm-) thick blades spaced 1/2 inch (13 mm) apart, [**zero**] [**15**] [**30**]-degree deflection.
8. Pencil-Proof Core Spacing Arrangement: 3/16-inch- (5-mm-) thick blades spaced 7/16 inch (11 mm) apart, [**zero**] [**15**] [**30**]-degree deflection.
9. [**One**] [**Two**]-Way Deflection Vanes: Extruded construction fixed louvers with removable core.
10. Frame: [**1-1/4 inches (32 mm)**] [**1 inch (25 mm)**] [**3/4 inch (19 mm)**] [**1/2 inch (13 mm)**] [**3/16 inch (5 mm)**] wide.
11. Mounting Frame: [**Filter**] <**Insert frame size and style**>.
12. Mounting: [**Countersunk screw**] [**Concealed bracket**] [**Spring clip**].
13. Damper Type: [**Adjustable opposed-blade assembly**] [**Hinged single blade**].
14. Accessories: [**Plaster frame**] [**Directional vanes**] [**Alignment pins**] [**Core clips**] [**Blank-off strips**].

B. Linear Slot Diffuser <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Anemostat Products; a Mestek company.

b. Price Industries.
c. Titus.

2. Devices shall be specifically designed for variable-air-volume flows.
3. See schedule on drawings for capacities, characteristics, and accessories.

C. Ceiling-Integral Continuous Diffuser <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anemostat Products; a Mestek company.
b. Price Industries.
c. Titus.

2. See schedule on drawings for capacities, characteristics, and accessories.

2.3 UNDERFLOOR AIR DISTRIBUTION DIFFUSERS

A. Round Induction Diffusers <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anemostat Products; a Mestek company.
b. Price Industries.
c. Titus.

2. Airflow Principle: Swirl-pattern induction.
3. Material: Plastic, high impact, and resistant to cart and foot traffic.
4. See schedule on drawings for capacities, characteristics, and accessories.

B. Linear Floor Diffuser Plenums <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Anemostat Products; a Mestek company.
b. Price Industries.
c. Titus.

2. Material: Steel.
3. Finish: White baked acrylic.
4. See schedule on drawings for capacities, characteristics, and accessories.

2.4 HIGH-CAPACITY DIFFUSERS

A. Drum Louver <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anemostat Products; a Mestek company.
    b. Price Industries.
    c. Titus.

2. Airflow Principle: Extended distance for high airflow rates.
3. Material: Aluminum, heavy gage extruded.
4. See schedule on drawings for capacities, characteristics, and accessories.

B. Modular Core Supply Grilles <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anemostat Products; a Mestek company.
    b. Price Industries.
    c. Titus.

2. Throw: Extended distance for airflow rates.
3. Material: Steel.
4. See schedule on drawings for capacities, characteristics, and accessories.

2.5 FLEXIBLE DIFFUSION OUTLETS

A. Continuous Tubular Diffuser <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. DuctSox Corp.

2. Material: [**Flame-retardant, woven polyethylene fabric**] [**Flame-retardant, coated polyester and fiberglass fabric**] [**Flame-retardant, permeable polyester and fiberglass fabric**] [**Polyethylene**].
3. Duct Connection: Round.
4. See schedule on drawings for capacities, characteristics, and accessories.

2.6 REGISTERS AND GRILLES

A. Adjustable Bar Register <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Anemostat Products; a Mestek company.
    b. Price Industries.
    c. Titus.

2. Material: Aluminum.
3. Finish: Baked enamel, white.
4. See schedule on drawings for capacities, characteristics, and accessories.

B. Adjustable Bar Grille <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anemostat Products; a Mestek company.
   b. Price Industries.
   c. Titus.

2. Material: Aluminum.
3. Finish: Baked enamel, white.
4. See schedule on drawings for capacities, characteristics, and accessories.

C. Security Register <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anemostat Products; a Mestek company.
   b. Price Industries.
   c. Titus.

2. Security Level: [**Maximum**] [**Medium**] [**Minimum**] [**and suicide deterrent**].
3. Application: [**Ducted return**] [**Air transfer**] [**Barrier**].
4. See schedule on drawings for capacities, characteristics, and accessories.

D. Security Grille <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anemostat Products; a Mestek company.
   b. Price Industries.
   c. Titus.

2. Security Level: [**Maximum**] [**Medium**] [**Minimum**] [**and suicide deterrent**].
3. Application: [**Ducted return**] [**Air transfer**] [**Barrier**].
4. See schedule on drawings for capacities, characteristics, and accessories.

E. Fixed Face Register <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anemostat Products; a Mestek company.
   b. Price Industries.
   c. Titus.

2. Material: Aluminum.
3. Finish: [**Baked enamel, white**] [**Baked enamel, color selected by Architect**].
4. See schedule on drawings for capacities, characteristics, and accessories.

F. Fixed Face Grille <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anemostat Products; a Mestek company.
   b. Price Industries.
   c. Titus.

2. Material: Aluminum.
3. Finish: Baked enamel, white.
4. See schedule on drawings for capacities, characteristics, and accessories.

G. Linear Bar Grille <**Insert drawing designation**>:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Anemostat Products; a Mestek company.
   b. Price Industries.
   c. Titus.

2. Material: Aluminum.
3. Finish: Baked enamel, white.
4. See schedule on drawings for capacities, characteristics, and accessories.

2.7 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install diffusers, registers, and grilles level and plumb.

B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

C. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

3.3 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233713

SECTION 233723 - HVAC GRAVITY VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Louvered-penthouse ventilators.
2. Roof hoods.
3. Goosenecks.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design ventilators, including comprehensive engineering analysis by a qualified professional engineer, using structural[**and seismic**] performance requirements and design criteria indicated.

B. Structural Performance: Ventilators shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.

1. Wind Loads: Determine loads based on pressures as indicated on Drawings.
2. Wind Loads: Determine loads based on a uniform pressure of [**20 lbf/sq. ft. (960 Pa)**] [**30 lbf/sq. ft. (1440 Pa)**], acting inward or outward.
3. Wind Loads: Determine loads based on pressures indicated below:

   a. Corner Zone: Within <**Insert distance**> of building corners, uniform pressure of <**Insert design wind pressure**>, acting inward, and <**Insert design wind pressure**>, acting outward.
   b. Other Than Corner Zone: Uniform pressure of <**Insert design wind pressure**>, acting inward, and <**Insert design wind pressure**>, acting outward.

C. Seismic Performance: Ventilators, including attachments to other construction, shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

D. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes, without buckling, opening of joints, overstressing of components, failure of connections, or other detrimental effects.

1. Temperature Change (Range): **120 deg F (67 deg C)**, ambient; **180 deg F (100 deg C)**, material surfaces.

E. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.[**For louvered-penthouse ventilators specified to bear AMCA seal, include printed catalog pages showing specified models with appropriate AMCA Certified Ratings Seals.**]

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings: For gravity ventilators. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.

1. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.

D. Samples: For each exposed product and for each color and texture specified.

E. Samples for Initial Selection: For units with factory-applied color finishes.

F. Samples for Verification: For each type of louvered-penthouse ventilator indicated, in manufacturer's standard size.

G. Delegated-Design Submittal: For shop-fabricated ventilators indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of shop-fabricated ventilators.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Roof framing plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members to which roof curbs and ventilators will be attached.
2. Sizes and locations of roof openings.

B. Seismic Qualification Certificates: For ventilators, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
2. AWS D1.3, "Structural Welding Code - Sheet Steel."

1.7 COORDINATION

A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aluminum Extrusions: ASTM B 221 (ASTM B 221M), Alloy 6063-T5 or T-52.

B. Aluminum Sheet: ASTM B 209 (ASTM B 209M), Alloy 3003 or 5005 with temper as required for forming or as otherwise recommended by metal producer for required finish.

C. Galvanized-Steel Sheet: ASTM A 653/A 653M, G90 (Z275) zinc coating, mill phosphatized.

D. Stainless-Steel Sheet: ASTM A 666, Type 304, with No. [**4**] [**6**] finish.

E. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.

1. Use types and sizes to suit unit installation conditions.
2. Use [**Phillips flat**] [**hex-head or Phillips pan**]-head screws for exposed fasteners unless otherwise indicated.

F. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.

G. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D 1187.

2.2 FABRICATION, GENERAL

A. Factory or shop fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.

B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.

C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.

D. Fabricate supports, anchorages, and accessories required for complete assembly.

E. Perform shop welding by AWS-certified procedures and personnel.

2.3 LOUVERED-PENTHOUSE VENTILATORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Acme Engineering & Mfg. Corporation.
2. Aerovent.
3. Carnes.
4. Greenheck Fan Corporation.
5. JencoFan.
6. Loren Cook Company.
7. PennBarry.

B. Construction: All-welded assembly with [**4-inch (100-mm)**] [**6-inch (150-mm)**]-deep louvers, mitered corners, and [**aluminum**] [**galvanized-steel**] [**stainless-steel**] sheet roof[**with mineral-fiber insulation and vapor barrier**].

C. Frame and Blade Material and Nominal Thickness: Extruded aluminum, of thickness required to comply with structural performance requirements, but not less than 0.080 inch (2.0 mm) for frames and [**0.080 inch (2.0 mm)**] [**0.060 inch (1.5 mm)**] for blades[**with condensate deflectors**].

1. Blade Spacing: <**Insert inches (mm)**>.
2. Blade Angle: <**Insert number**> degrees.
3. AMCA Seal: Mark units with the AMCA Certified Ratings Seal.

4. Exterior Corners: Prefabricated corner units with [**mitered and welded blades**] [**mitered blades with concealed close-fitting splices**] and with [**fully recessed**] [**semirecessed**] mullions at corners.

D. Frame and Blade Material and Nominal Thickness: Galvanized-steel sheet, of thickness required to comply with structural performance requirements, but not less than 0.052 inch (1.3 mm) for frames and [**0.040 inch (1.0 mm)**] [**0.052 inch (1.3 mm)**] [**0.064 inch (1.6 mm)**] for blades[**with condensate deflectors**].

1. Blade Spacing: <**Insert inches (mm)**>.
2. Blade Angle: <**Insert number**> degrees.
3. AMCA Seal: Mark units with the AMCA Certified Ratings Seal.
4. Exterior Corners: Prefabricated corner units with [**mitered and welded blades**] [**mitered blades with concealed close-fitting splices**] and with [**fully recessed**] [**semirecessed**] mullions at corners.

E. Frame and Blade Material and Nominal Thickness: Stainless-steel sheet, of thickness required to comply with structural performance requirements, but not less than [**0.050 inch (1.27 mm)**] [**0.062 inch (1.57 mm)**], with grain running [**parallel**] [**perpendicular**] to length of blades and frame members[**with condensate deflectors**].

1. Blade Spacing: <**Insert inches (mm)**>.
2. Blade Angle: <**Insert number**> degrees.
3. AMCA Seal: Mark units with the AMCA Certified Ratings Seal.
4. Exterior Corners: Prefabricated corner units with [**mitered and welded blades**] [**mitered blades with concealed close-fitting splices**] and with [**fully recessed**] [**semirecessed**] mullions at corners.

F. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to fit roof opening and ventilator base.

1. Configuration: [**Self-flashing without a cant strip, with**] [**Built-in cant and**] [**Built-in raised cant and**] mounting flange.
2. Overall Height: [**8 inches (200 mm)**] [**9-1/2 inches (240 mm)**] [**12 inches (300 mm)**] [**16 inches (400 mm)**] [**18 inches (450 mm)**].

G. Bird Screening: [**Galvanized-steel, 1/2-inch- (12.7-mm-) square mesh, 0.041-inch (1.04-mm) wire**] [**Aluminum, 1/2-inch- (12.7-mm-) square mesh, 0.063-inch (1.6-mm) wire**] [**Flattened, expanded aluminum, 3/4 by 0.050 inch (19 by 1.27 mm) thick**] [**Stainless-steel, 1/2-inch- (12.7-mm-) square mesh, 0.047-inch (1.19-mm) wire**].

H. Galvanized-Steel Sheet Finish:

1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.
2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.

3. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat and an overall minimum dry film thickness of 2 mils (0.05 mm).

   a. Color and Gloss: [**As indicated by manufacturer's designations**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range**].

I. Accessories:

1. Dampers:

   a. Location: [**Penthouse neck**] [**Inside louver face**].
   b. Control: [**Manual**] [**Motorized**].

J. Capacities and Characteristics:

1. See schedule on drawings.

2.4 ROOF HOODS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Acme Engineering & Mfg. Corporation.
2. Aerovent.
3. Carnes.
4. Greenheck Fan Corporation.
5. JencoFan.
6. Loren Cook Company.
7. PennBarry.

B. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figures 6-6 and 6-7.

C. Materials: [**Galvanized-steel sheet, minimum 0.064-inch- (1.62-mm-) thick base and 0.040-inch- (1.0-mm-) thick hood**] [**Aluminum sheet, minimum 0.063-inch- (1.6-mm-) thick base and 0.050-inch- (1.27-mm-) thick hood**]; suitably reinforced.

D. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to fit roof opening and ventilator base.

1. Configuration: [**Self-flashing without a cant strip, with**] [**Built-in cant and**] [**Built-in raised cant and**] mounting flange.
2. Overall Height: [**8 inches (200 mm)**] [**9-1/2 inches (240 mm)**] [**12 inches (300 mm)**] [**16 inches (400 mm)**] [**18 inches (450 mm)**].

E. Bird Screening: [**Galvanized-steel, 1/2-inch- (12.7-mm-) square mesh, 0.041-inch (1.04-mm) wire**] [**Aluminum, 1/2-inch- (12.7-mm-) square mesh, 0.063-inch (1.6-mm) wire**]

[**Flattened, expanded aluminum, 3/4 by 0.050 inch (19 by 1.27 mm) thick**] [**Stainless-steel, 1/2-inch- (12.7-mm-) square mesh, 0.047-inch (1.19-mm) wire**].

F. Galvanized-Steel Sheet Finish:

1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.
2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
3. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat and an overall minimum dry film thickness of 2 mils (0.05 mm).

a. Color and Gloss: [**As indicated by manufacturer's designations**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range**].

G. Capacities and Characteristics:

1. See schedule on drawings.

2.5 GOOSENECKS

A. Factory or shop fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 6-5; with a minimum of 0.052-inch- (1.3-mm-) thick, galvanized-steel sheet.

B. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to fit roof opening and ventilator base.

1. Configuration: [**Self-flashing without a cant strip, with**] [**Built-in cant and**] [**Built-in raised cant and**] mounting flange.
2. Overall Height: [**8 inches (200 mm)**] [**9-1/2 inches (240 mm)**] [**12 inches (300 mm)**] [**16 inches (400 mm)**] [**18 inches (450 mm)**].

C. Bird Screening: [**Galvanized-steel, 1/2-inch- (12.7-mm-) square mesh, 0.041-inch (1.04-mm) wire**] [**Aluminum, 1/2-inch- (12.7-mm-) square mesh, 0.063-inch (1.6-mm) wire**] [**Flattened, expanded aluminum, 3/4 by 0.050 inch (19 by 1.27 mm) thick**] [**Stainless-steel, 1/2-inch- (12.7-mm-) square mesh, 0.047-inch (1.19-mm) wire**].

D. Galvanized-Steel Sheet Finish:

1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas and repair galvanizing according to ASTM A 780. Apply a conversion coating suited to the organic coating to be applied over it.

2. Factory Priming for Field-Painted Finish: Where field painting after installation is indicated, apply an air-dried primer immediately after cleaning and pretreating.
3. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil (0.025 mm) for topcoat and an overall minimum dry film thickness of 2 mils (0.05 mm).

    a. Color and Gloss: [**As indicated by manufacturer's designations**] [**Match Architect's sample**] [**As selected by Architect from manufacturer's full range**].

E. Capacities and Characteristics:

1. See schedule on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.

B. Install goosenecks on curb base where throat size exceeds **9 by 9 inches** **(230 by 230 mm)**.

C. Install gravity ventilators with clearances for service and maintenance.

D. Install perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

E. Install concealed gaskets, flashings, joint fillers, and insulation as installation progresses. Comply with Section 079200 "Joint Sealants" for sealants applied during installation.

F. Label gravity ventilators according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

G. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.

H. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.

3.2 CONNECTIONS

A. Duct installation and connection requirements are specified in Section 233113 "Metal Ducts" and Section 233116 "Nonmetal Ducts." Drawings indicate general arrangement of ducts and duct accessories.

3.3 ADJUSTING

A. Adjust damper linkages for proper damper operation.

END OF SECTION 233723

SECTION 234100 - PARTICULATE AIR FILTRATION & GAS PHASE (CARBON) FILTRATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Prefilter MERV 9 Nonsupported bag filters.
2. MERV 14 Rigid cell box filters. (Prefilter to Carbon Filter)
3. Gas Phase (Carbon Filters)
4. Filter Holding Frame for MERV 14 and Carbon Filters
5. MERV 14 Final Filters
6. MERV 14 Final Filter and MERV 9 Prefilter Holding Frames
7. Filter gages.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.

C. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.

1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
3. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Provide one complete set of filters for each filter bank. If system includes prefilters, provide only prefilters.
2. Provide one container of red oil for inclined manometer filter gage.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
2. Comply with ASHRAE 52.1 for arrestance and ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.

C. Comply with NFPA 90A and NFPA 90B.

1.7 COORDINATION

A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

PART 2 - PRODUCTS

2.1 PREFILTER MERV 9 NONSUPPORTED BAG FILTERS

A. Description: Factory-fabricated, dry, extended-surface, nonsupported filters with header frames.

1. Air filters shall be high efficiency ASHRAE extended surface pocket style filters consisting of high loft air laid microfine glass media, a galvanized steel header, galvanized steel pocket retainers, and bonding agent to prevent air bypass and ensure leak free performance.

2. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil Farr MERV 9 Hi Flo (Size 24 x 24 x 22 – 10 Pockets) or comparable product by one of the following:

   a. Camfil Farr
   b. Flanders Precisionaire

B. Filter media shall consist of high-density air laid lofted microfine glass media that is chemically bonded to a permeable media support backing forming a lofted blanket.

C. Individual pockets shall contain a minimum of 40 stitching support points per square foot of media area. All stitching centers shall be sealed using a foam-based solvent that shall remain pliable throughout the life of the filter. The sides and ends of each pocket shall be sewn with a chain-link over lock stitch

D. Pockets shall be formed into tapered pleats, supported by controlled media space stitching, to promote uniform airflow across the surface of the media. At any point, the sizes of the upstream and downstream passages shall be proportional to the volume of filtered air.

E. Support members shall include a galvanized steel header and galvanized steel pocket retainers. The header shall be bonded to the media to prevent air bypass. Individual pocket retainers shall be fastened with a mechanical crimp to lock individual pockets together. The media pockets shall be bonded to the pocket retainers to prevent air bypass. The frame shall form a rigid and durable support assembly.

F. The filter shall have a Minimum Efficiency Reporting Value of MERV 9 per ASHRAE Standard 52.2-2007. It shall have a MERV-A of 9 when tested under Appendix J of that standard.

G. The filter shall be capable of withstanding 5.0” w.g. without failure of the filter.

H. The filter shall have an Energy Cost Index (ECI) value of five stars

I. The filter shall be classified by Underwriters Laboratories as UL Class 2.

J. Manufacturer shall provide evidence of facility certification to ISO 9001:2000.

K. Capacities and Characteristics:

   1. Face Dimensions: Nominal 24 inches x 24 inches
   2. Depth: 22 inches
   3. Surface Area: 73 sq. ft.
   4. Number of Pockets: 10 Pockets
   5. Rated Face Velocity: 500 FPM
   6. Efficiency: MERV 9 per ASHRAE 52.2-2007
   7. Initial Resistance: .18” w.g.
   8. Recommended Final Resistance: 1.0” w.g.

2.2 MERV 14 RIGID CELL BOX FILTERS (Prefilter to Gas Phase/Carbon Filter)

A. Description: Factory-fabricated, extended surface MERV 14 box style filters.

1. Air filters shall be high efficiency ASHRAE high lofted supported media disposable type assembled in a compact and secure enclosing frame.

2. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil Farr MERV 14 Riga Flo (Prefilter to Gas Phase/Carbon Filter) or comparable product by one of the following:

a. Camfil Farr.
b. Flanders Precisionaire.

B. Filter media shall be microfine glass laminated to a reinforced backing to form a uniform lofted media blanket.

C. The media blanket shall be formed into uniform tapered radial pleats and bonded to stiffened backing that is bonded to the downstream side of the media to preclude media oscillation.

D. The media shall be mechanically and chemically bonded within the frame to prevent air bypass.

E. The enclosing frame shall be maintained by bridge style plastic contour stabilizers. There shall be a minimum of four contour stabilizers on the air entering side and four on the air exiting side.

F. The filter shall have a Minimum Efficiency Reporting Value of MERV 14 per ASHRAE Standard 52.2-2007. It shall have a MERV-A of 14 when tested under Appendix J of that standard.

G. Initial resistance to airflow shall not exceed 0.53” w.g. at an airflow of 500 FPM for filters having a nominal depth of 12”.

H. The filter shall be capable of withstanding 10” w.g. without failure to the media pack

I. The filter shall be classified by Underwriters Laboratories as UL Class 2

J. Manufacturer shall provide evidence of facility certification to ISO 9001:2000.

K. Capacities and Characteristics:

1. Face Dimensions: Nominal 24 inches x 24 inches
2. Depth: Nominal 12 inches
3. Surface Area: 53 sq. ft.
4. Rated Face Velocity: 500 FPM
5. Efficiency: MERV 14 per ASHRAE 52.2-2007
6. Initial Resistance: .53” w.g.
7. Recommended Final Resistance: 1.5” w.g.

2.3 GAS PHASE CARBON FILTERS

A. Description: Gas Phase filter shall be adsorbent-type, high lofted supported media assembled in a compact and secure enclosing frame.

1. Basis-of-Design Product: Subject to compliance with requirements, Flanders Vaporclean 1501 Gas Phase filter or comparable product by one of the following:

a. Flanders Precisionaire
b. Camfil Farr

B. Filter media shall be Flanders Vaporclean 1501 activated carbon adsorbent media specifically designed for the removal of gas mixtures consisting of aldehyde, acid gases, and hydrocarbons. The carbon media is manufactured with a dry processed carbon composite of ultrafine 30 x 30 mesh activated carbon with a minimum carbon tetrachloride activity of 90% per ASTM D-3467. The high efficiency carbon granules are thermally bonded to polyester nonwoven bicomponent fibers.

C. The media blanket shall be formed into uniform tapered radial pleats and bonded to a stiffened backing that is bonded to the downstream side of the media to preclude media oscillation.

D. The media shall be mechanically and chemically bonded within the frame to prevent air bypass.

E. The enclosing frame shall be constructed of corrosion resistant galvanized steel. Media support contour stabilizers, shall be mechanically fastened to the diagonal support members to create a rigid and durable filter enclosure.

F. Capacities and Characteristics:

1. Face Dimensions: Nominal 24 inches x 24 inches
2. Depth: Nominal 12 inches
3. Rated Face Velocity: 500 FPM
4. Initial Resistance: .25” w.g.

2.4 FILTER HOLDING FRAME – MERV 14 PREFILTER & CARBON FILTER BANK

A. Description: Factory-fabricated, filter holding frame to house both the MERV 14 and Gas Phase (Carbon Filter) in one frame.

1. Basis-of-Design Product: Subject to compliance with requirements, Camfil Farr Type 8 Universal Filter Holding Frame or comparable product by one of the following:

a. Camfil Farr
b. Flanders Precisionaire
.

B. Air filter holding frames shall be 16-gauge galvanized steel with filter sealing flange, centering dimples, sealing gasket and lances for Camfil Farr C-80 (PN 061180-000) filter retaining clips.

C. Filter holding frame shall be constructed of 16-gauge galvanized steel. The frame shall be assembled from two corner sections and welded to assure a rigid and durable frame assembly.

D. The frame shall include a variety of pre-punched lances for filter fastener attachment. Fastener shall be capable of being installed without the use of tools, nuts or bolts. Lance penetration shall be upstream of filter flange to assure leak-free integrity.

E. The frame shall include filter-centering dimples on each frame wall to facilitate ease of filter installation and assure filter centering against filter sealing flange.

F. A ¾” filter-sealing flange shall be an integral component of the holding frame. All corners shall be flush mitered and a permanently mounted polyurethane foam gasket shall be mounted on the sealing flange to assure filter to frame sealing integrity.

G. Headered Carbon filter to be installed into frame with Box Style MERV 14 prefilter utilizing a quantity of four (4) Camfil Farr C-80 (PN 061180-000) filter retaining clips, per frame, to secure the two filters into the one holding frame.

2.5 FINAL FILTER – MERV 14 RIGID CELL BOX OR HEADERED FILTERS

A. Description: Factory-fabricated, extended surface MERV 14 box style filters.

1. Air filters shall be high efficiency ASHRAE high lofted supported media disposable type assembled in a compact and secure enclosing frame.
2. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil Farr MERV 14 Riga Flo or comparable product by one of the following:

   a. Camfil Farr.
   b. Flanders Precisionaire.

B. Filter media shall be microfine glass laminated to a reinforced backing to form a uniform lofted media blanket.

C. The media blanket shall be formed into uniform tapered radial pleats and bonded to stiffened backing that is bonded to the downstream side of the media to preclude media oscillation.

D. The media shall be mechanically and chemically bonded within the frame to prevent air bypass.

E. The enclosing frame shall be maintained by bridge style plastic contour stabilizers. There shall be a minimum of four contour stabilizers on the air entering side and four on the air exiting side.

F. The filter shall have a Minimum Efficiency Reporting Value of MERV 14 per ASHRAE Standard 52.2-2007. It shall have a MERV-A of 14 when tested under Appendix J of that standard.

G. Initial resistance to airflow shall not exceed 0.53” w.g. for the box style (.70” for headered style filter) at an airflow of 500 FPM for filters having a nominal depth of 12”.

H. The filter shall be capable of withstanding 10” w.g. without failure to the media pack

I. The filter shall be classified by Underwriters Laboratories as UL Class 2

J. Manufacturer shall provide evidence of facility certification to ISO 9001:2000.

K. Capacities and Characteristics:

1. Face Dimensions: Nominal 24 inches x 24 inches
2. Depth: Nominal 12 inches
3. Surface Area: 53 sq. ft.
4. Rated Face Velocity: 500 FPM
5. Efficiency: MERV 14 per ASHRAE 52.2-2007
6. Initial Resistance: .53” w.g. Box Style - .70” w.g. Headered Style
7. Recommended Final Resistance: 1.5” w.g.

2.6 ALTERNATE MERV 14 FINAL FILTER – V CELL RIGID FILTER

A. Description: MERV 14 V Cell Rigid Filter shall be v-bank mini-pleated fiberglass disposable type with pleat separators, polyurethane pack-to-frame sealant, polystyrene enclosing frame and have and ECI value of five stars.

B. Basis-of-Design Product**:** Subject to compliance with requirements, provide Camfil Farr Durafil 4V-ES MERV 14, or comparable product from one of the following:

a. Camfil Farr
b. Flanders Precisionaire

C. Filter media shall be a special grade of microfine glass fibers. No charged or synthetic media shall be used.

D. Eight media packs containing no less than 200 square feet of media shall be assembled into a v-bank configuration. Computer-optimized pleat to height ratio shall create a radial air exiting and entering design. The filter outlet shall be radial in shape with a maximum of 60% open area.

E. The media packs shall be completely sealed and bonded to the inside periphery of a polystyrene enclosing frame with a polyurethane sealant. The enclosing frame shall include top and bottom molded tracks as an integral part of the frame to ensure a proper seal.

F. Media packs shall be recessed at least 1” from the headered side of the enclosing frame to allow uniform airflow when a prefilter is mounted directly to the enclosing frame. The header shall include a gasket on the vertical side to create a filter to filter seal in side-access housing applications.

G. The filter shall have a Minimum Efficiency Reporting Value of MERV 14 when evaluated under the guidelines of ASHRAE Standard 52.2-2007-B with appendix J. It shall also have a

MERV-A rating of 14 when evaluated under ASHRAE Standard 52.2-2007-B Appendix J. Filter must be tested at 500 FPM.

H. Initial resistance to airflow shall not exceed .31 inches w.g. at an airflow of 500 FPM. Filter shall have a minimum Dust Holding Capacity to 1.5” w.g. final resistance of 358 grams.

I. Filter shall have a 5-Star rating when evaluated per Energy Cost Index. Filter shall be listed by Underwriters Laboratories as UL Class 2. The filter shall be capable of withstanding 10” w.g. without failure of the media pack. Manufacturer shall provide evidence of facility certification to ISO 9001:2000.

2.7 FINAL FILTER HOLDING FRAME (Box Style or Headered Style)

A. Description: Factory-fabricated, filter holding frame to house Final Filter MERV 14 either box style or headered style.

1. Basis-of-Design Product: Subject to compliance with requirements, Camfil Farr Type 8 Universal Filter Holding Frame or comparable product by one of the following:

a. Camfil Farr

B. Air filter holding frames shall be 16-gauge galvanized steel with filter sealing flange, centering dimples, sealing gasket and lances for Camfil Farr C-80 (PN 061180-000) filter retaining clips.

C. Filter holding frame shall be constructed of 16-gauge galvanized steel. The frame shall be assembled from two corner sections and welded to assure a rigid and durable frame assembly.

D. The frame shall include a variety of pre-punched lances for filter fastener attachment. Fastener shall be capable of being installed without the use of tools, nuts or bolts. Lance penetration shall be upstream of filter flange to assure leak-free integrity.

E. The frame shall include filter-centering dimples on each frame wall to facilitate ease of filter installation and assure filter centering against filter sealing flange.

F. A ¾” filter-sealing flange shall be an integral component of the holding frame. All corners shall be flush mitered and a permanently mounted polyurethane foam gasket shall be mounted on the sealing flange to assure filter to frame sealing integrity.

G. Box Style MERV 14 final filter requires a quantity of four (4) Camfil Farr C-80 (PN 061180-000) filter retaining clips per filter. Headered Style MERV 14 requires a quantity of four (4) Camfil Farr C-70 (PN 050025-000) filter retaining clips per filter.

2.8 FILTER GAGES

A. Diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Airguard.
   b. Dwyer Instruments, Inc.

2. Diameter: [**4-1/2 inches (115 mm)**] [**2 inches (50 mm)**].

[Revise scale range in first subparagraph below to match expected pressure differences.]

3. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg (125 Pa) or Less: 0- to 0.5-inch wg (0 to 125 Pa).
4. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg (125 to 250 Pa) or Less: 0- to 1.0-inch wg (0 to 250 Pa).
5. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg (250 to 500 Pa) or Less: 0- to 2.0-inch wg (0 to 500 Pa).
6. Scale Range for Filter Media Having a Recommended Final Resistance of 2.0- to 3.0-Inch wg (500 to 750 Pa) or Less: 0- to 3.0-inch wg (0 to 750 Pa).
7. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg (750 to 1000 Pa) or Less: 0- to 4.0-inch wg (0 to 1000 Pa).

B. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale and logarithmic-curve tube gage with integral leveling gage, graduated to read from 0- to 3.0-inch wg (0 to 750 Pa), and accurate within 3 percent of the full scale range.

C. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

B. Install filters in position to prevent passage of unfiltered air.

C. Install filter gage for each filter bank.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.

E. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

F. Coordinate filter installations with duct and air-handling-unit installations.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:

1. Operate automatic roll filters to demonstrate compliance with requirements.
2. Test for leakage of unfiltered air while system is operating.

C. Air filter will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.3 CLEANING

A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 234100

SECTION 234133 - HIGH-EFFICIENCY PARTICULATE FILTRATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. High Capacity V Bank HEPA Filter
2. High Capacity V Bank 95% DOP Filter
3. Standard 95% DOP Filter
4. HEPA Filter and 95% DOP Filter Holding Frame
5. Filter gages.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.

1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
3. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Provide one complete set(s) of filters for each filter bank. If system includes prefilters, provide only prefilters.
2. Provide one container(s) of red oil for inclined manometer filter gage.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended use.

B. ASHRAE Compliance:

1. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

C. Comply with IEST-RP-CC001.3.

D. Comply with UL 586.

E. Comply with IEST-RP-CC007.1.

F. Comply with NFPA 90A and NFPA 90B.

1.8 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

PART 2 - PRODUCTS

2.1 HIGH CAPACITY V-BANK 99.99% on 0.3 Micron HEPA FILTER

A. Description: Factory-fabricated, HEPA filters consisting of pleated media packs assembled in a V-Bank configuration, polyurethane sealant, anodized aluminum enclosure and seamless sealing gasket.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil Farr Filtra 2000 FA 1560-01-01 or comparable product by one of the following:

a. Camfil Farr Co.
b. Flanders-Precisionaire.

B. Air filters shall be absolute grade HEPA filters consisting of pleated media packs assembled in a V-bank configuration, polyurethane sealant, anodized aluminum enclosure and seamless sealing gasket.

C. Filter media shall be micro fiber glass formed into minipleat pleat-in-pleat V-bank design.

D. The media packs shall be potted into the enclosing frame with fire retardant polyurethane sealant.

E. An enclosing frame of anodized extruded aluminum shall form a rugged and durable enclosure.

F. A seamless sealing gasket shall be included on the downstream side of the filter to form a positive seal upon installation.

G. Filter efficiency at 0.3 micron size particles shall be 99.99% when evaluated according to the IEST Recommended Practice for applicable type. Each filter shall be labeled as to tested performance.

H. Initial resistance target shall not exceed 0.80” w.g. at rated airflow of 500 FPM.

I. Filter must be listed as UL 586 and UL 900 Class 2 per Underwriters Laboratories.

J. Manufacturer shall provide evidence of facility certification to ISO 9001:2000.

2.2 HIGH CAPACITY V-BANK 95% (DOP) on 0.3 Micron HEPA FILTER

A. Description: Factory-fabricated, 95% DOP filters consisting of pleated media packs assembled in a V-Bank configuration, polyurethane sealant, anodized aluminum enclosure and seamless sealing gasket.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil Farr Filtra 2000 FA 1560-03-01 or comparable product by one of the following:

a. Camfil Farr Co.
b. Flanders-Precisionaire.

B. Air filters shall be 95% DOP filters consisting of pleated media packs assembled in a V-bank configuration, polyurethane sealant, anodized aluminum enclosure and seamless sealing gasket.

C. Filter media shall be micro fiber glass formed into minipleat pleat-in-pleat V-bank design.

D. The media packs shall be potted into the enclosing frame with fire retardant polyurethane sealant.

E. An enclosing frame of anodized extruded aluminum shall form a rugged and durable enclosure.

F. A seamless sealing gasket shall be included on the downstream side of the filter to form a positive seal upon installation.

G. Filter efficiency at 0.3 micron size particles shall be 95% when evaluated according to the IEST Recommended Practice for applicable type. Each filter shall be labeled as to tested performance.

H. Initial resistance target shall not exceed 0.50" w.g. at rated airflow of 500 FPM.

I. Filter must be listed as UL 586 and UL 900 Class 2 per Underwriters Laboratories.

J. Manufacturer shall provide evidence of facility certification to ISO 9001:2000.

2.3 STANDARD 95% DOP FILTERS

A. Description: Factory-fabricated, 95 percent DOP filters shall be extended media separator type filters.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Flanders Alpha 95 Filters (PN 0-00J-C-08-IU-12-00-GG-F) or comparable product by one of the following:

    a. Camfil Farr Co.
    b. Flanders-Precisionaire.

B. Filters shall be extended media separator type filter 95% DOP Efficiency.

C. The filter pack shall be constructed by pleating a continuous sheet of non-woven water-resistant fiberglass media around hemmed-edge corrugated aluminum separators.

D. The filter pack shall be sealed into a 16 gauge galvanneal frame with a fire retardant urethane sealant.

E. A 40-durometer closed cell neoprene gasket shall be provided on the downstream side to seal the filter in the mounting device.

F. Initial resistance at a velocity of 500 FPM shall be 1.0" w.g.

G. The rated minimum efficiency of 95% on 0.3 micron size particles shall be as determined by the DOP Test Method.

2.4 HEPA AND 95% DOP FILTER HOLDING FRAME

A. Framing System: HEPA and 95% DOP holding frames shall be constructed of 14 GA galvanized steel. Frames shall be welded and include centering dimples, pre-drilled mounting holes, filter sealing flange and swing bolt assemblies.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Camfil Farr Magna Frame II or comparable product by one of the following:

    a. Camfil Farr Co.
    b. Flanders-Precisionaire.

B. Filter frame shall be all-welded construction of 14 GA galvanized steel. The frame shall include pre-drilled mounting holes to align frame-to-frame and ensure built-up bank support.

C. Annular based centering dimples shall be an integral component to assist in proper seating of filter gasket to filter sealing flange. Assembly holes shall be within dimples to recess assembly bolts.

D. Filter securing swing bolt assemblies, of the same construction as the frame, shall be offset to facilitate multiple filter installations. The assembly shall include appropriate swing bolts to match filter depth and equi-bearing clamps to allow uniform filter gasket sealing.

E. The sealing assembly shall be capable of sealing each element with 30 inch/lbs. of torque to 50% filter gasket compression.

F. Manufacturer shall provide evidence of facility certification to ISO 9001:2000.

2.5 FILTER GAGES

A. Diaphragm type with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Airguard.
    b. Dwyer Instruments, Inc.

2. Diameter: [**4-1/2 inches (115 mm)**] [**2 inches (50 mm)**].

    [Revise scale range in first subparagraph below to match expected pressure differences.]

3. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5-Inch wg (125 Pa) or Less: 0- to 0.5-inch wg (0 to 125 Pa).
4. Scale Range for Filter Media Having a Recommended Final Resistance of 0.5- to 1.0-Inch wg (125 to 250 Pa) or Less: 0- to 1.0-inch wg (0 to 250 Pa).
5. Scale Range for Filter Media Having a Recommended Final Resistance of 1.0- to 2.0-Inch wg (250 to 500 Pa) or Less: 0- to 2.0-inch wg (0 to 500 Pa).
6. Scale Range for Filter Media Having a Recommended Final Resistance of 2.0- to 3.0-Inch wg (500 to 750 Pa) or Less: 0- to 3.0-inch wg (0 to 750 Pa).
7. Scale Range for Filter Media Having a Recommended Final Resistance of 3.0- to 4.0-Inch wg (750 to 1000 Pa) or Less: 0- to 4.0-inch wg (0 to 1000 Pa).

B. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale, logarithmic-curve tube gage with integral leveling gage; graduated to read from 0- to 3.0-inch wg (0 to 750 Pa) and accurate within 3 percent of full-scale range.

C. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

2.6 CAPACITIES AND CHARACTERISTICS

A. Face Area: <**Insert sq. ft. (sq. m)**>.

B. Depth: <**Insert inches (mm)**>.

C. Surface Area: <**Insert sq. ft. (sq. m)**>.

D. Module Size: <**Insert size**>.

E. Number of Filters/Modules: <**Insert number**>.

F. Frame Access Location: <**Insert location**>.

G. System Airflow: <**Insert cfm (L/s)**>.

H. Maximum or Rated Face Velocity: <**Insert fpm (m/s)**>.

I. Initial Resistance: <**Insert inches wg (Pa)**>.

J. Recommended Final Resistance: <**Insert inches wg (Pa)**>.

K. Performance Level: [**HEPA**] [**ULPA**] [**95 percent as tested according to MIL-STD 282**].

PART 3 - EXECUTION

3.1 INSTALLATION

A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

B. Install filters in position to prevent passage of unfiltered air.

C. Install filter gage for each filter bank.

D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters that were used during construction and testing with new, clean filters.

E. Install filter-gage static-pressure tips upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

F. Coordinate filter installations with duct and air-handling unit installations.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installation, including connections.

B. Tests and Inspections:

1. Operate automatic roll filters to demonstrate compliance with requirements.
2. Test for leakage of unfiltered air while system is operating.
3. HEPA Filters: Pressurize housing to a minimum of 3.0-inch wg (750 Pa) or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.
4. HEPA Filters: Pressurize housing to a minimum of 3.0-inch wg (750 Pa) or to designed operating pressure, whichever is higher; and test housing joints, door seals, and sealing edges of filter for air leaks according to pressure-decay method in ASME N510.

C. Air filter will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.3 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 234133

SECTION 235100 - BREECHINGS, CHIMNEYS, AND STACKS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Listed chimney liners.
2. Listed [**single**] [**double**]-wall [**vents**] [**chimneys**].
3. Listed, refractory-lined[**breechings and**] stacks.
4. Field-fabricated metal breechings[**and chimneys**].
5. Listed [**grease**] [**dishwasher**] [**grease and dishwasher**] ducts.

B. Related Sections include the following:

1. Section 235113 "Draft Control Devices" for induced-draft and mechanical fans and for motorized and barometric dampers.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Chimney liners.
2. Type B and BW vents.
3. Type L vents.
4. Special gas vents.
5. Building-heating-appliance chimneys.
6. Grease ducts.
7. Refractory-lined metal breechings and chimneys.
8. Guy wires and connectors.

B. Shop Drawings: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers and seismic restraints, and location and size of each field connection.
2. For installed products indicated to comply with design loads, include calculations required for selecting seismic restraints and structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Manufacturer Seismic Qualification Certification: Submit certification that factory-fabricated breeching, chimneys, and stacks; accessories; and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Breeching, Chimneys, and Stacks: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of anchorage devices on which the certification is based and their installation requirements.

C. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain listed system components through one source from a single manufacturer.

B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents, breechings, and stacks.

C. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 077200 "Roof Accessories."

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within specified warranty period. Failures include, but are not limited to, structural failures caused by expansion and contraction.

1. Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LISTED CHIMNEY LINERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Metal-Fab, Inc.
2. Selkirk Inc.; Selkirk Metalbestos and Air Mate.

B. Description: [**Straight**] [**Corrugated**], single-wall chimney liner tested according to UL 1777 and rated for 1000 deg F (538 deg C) continuously, or 2100 deg F (1150 deg C) for 10 minutes; with negative or positive flue pressure complying with NFPA 211.

C. Straight Liner Materials: ASTM A 666, **Type 316** stainless steel.

D. Corrugated Liner Materials: [**ASTM A 240/A 240M, Type 321**] [**ASTM A 240/A 240M, Type 430**] [**ASTM A 959, Type 29-4C**] stainless steel.

E. Accessories:

1. Fittings: Tees, elbows, increasers, draft-hood connectors, metal caps with bird barriers, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar or compatible materials and designs.
2. Sealant: Manufacturer's standard high-temperature sealant.
3. Insulating Fill: Manufacturer's standard high-temperature insulation fill material in annular space surrounding chimney liner including high-temperature, ceramic-fiber insulation required to seal chimney at top and bottom.

2.2 LISTED TYPE B AND BW VENTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Metal-Fab, Inc.
2. Selkirk Inc.; Selkirk Metalbestos and Air Mate.

B. Description: Double-wall metal vents tested according to UL 441 and rated for 480 deg F (248 deg C) continuously for Type B, or 550 deg F (288 deg C) continuously for Type BW; with neutral or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 1/4-inch (6-mm) airspace.

D. Inner Shell: [**ASTM B 209 (ASTM B 209M), Type 1100 aluminum**] [**ASTM B 209 (ASTM B 209M), Type 3003 aluminum**] [**ASTM B 209 (ASTM B 209M), Type 3105 aluminum**] [**ASTM A 666, Type 430 stainless steel**].

E. Outer Jacket: Stainless steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

[Retain one of first four "Termination" subparagraphs below or insert type to suit Project.]

1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
3. Termination: Exit cone with drain section incorporated into riser.
4. Termination: Antibackdraft.

2.3 LISTED TYPE L VENTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Metal-Fab, Inc.
2. Selkirk Inc.; Selkirk Metalbestos and Air Mate.

B. Description: Double-wall metal vents tested according to UL 641 and rated for 570 deg F (300 deg C) continuously, or 1700 deg F (926 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a [**1/4-inch (6-mm)**] [**1-inch (25-mm)**] [**2-inch (50-mm)**] [**4-inch (100-mm)**] airspace filled with high-temperature, [**ceramic-fiber**] [**mineral-wool**] insulation.

D. Inner Shell: ASTM A 666, **Type 316** stainless steel.

E. Outer Jacket: **Stainless** steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

[Retain one of first three "Termination" subparagraphs below or insert type to suit Project.]

1. Termination: Stack cap designed to exclude 90 percent of rainfall.
2. Termination: Round chimney top designed to exclude 98 percent of rainfall.
3. Termination: Exit cone with drain section incorporated into riser.

2.4 LISTED SPECIAL GAS VENTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Metal-Fab, Inc.

2. Selkirk Inc.; Selkirk Metalbestos and Air Mate.

B. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F (248 deg C) continuously, with positive or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 1/2-inch (13-mm) airspace.

D. Inner Shell: ASTM A 959, Type 29-4C stainless steel.

E. Outer Jacket: **Stainless** steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

[Retain one of first three "Termination" subparagraphs below or insert type to suit Project.]

1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
3. Termination: Exit cone with drain section incorporated into riser.

2.5 LISTED BUILDING-HEATING-APPLIANCE CHIMNEYS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Metal-Fab, Inc.
2. Selkirk Inc.; Selkirk Metalbestos and Air Mate.

[Retain three paragraphs below for building-heating-appliance chimneys suitable for dual-fuel boilers, oven vents, water heaters, or exhaust for engines.]

B. Description: Double-wall metal vents tested according to UL 103 and rated for 1000 deg F (538 deg C) continuously, or 1700 deg F (926 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a [**1/2-inch (25-mm)**] [**1-inch (50-mm)**] [**2-inch (50-mm)**] [**3-inch (75-mm)**] [**4-inch (100-mm)**] annular space[**filled with high-temperature, ceramic-fiber insulation**].

D. Inner Shell: ASTM A 666, **Type 316** stainless steel.

[Retain three paragraphs below for 1400 deg F (760 deg C) chimneys suitable for dual-fuel boilers, oven vents, water heaters, or exhaust for engines.]

E. Description: Double-wall metal vents tested according to UL 103 and UL 959 and rated for 1400 deg F (760 deg C) continuously, or 1800 deg F (982 deg C) for 10 minutes; with positive or negative flue pressure complying with NFPA 211.

F. Construction: Inner shell and outer jacket separated by at least a [**1-inch (25-mm)**] [**2-inch (50-mm)**] [**3-inch (75-mm)**] [**4-inch (100-mm)**] annular space filled with high-temperature, ceramic-fiber insulation.

G. Inner Shell: ASTM A 666, **Type 316** stainless steel.

[Retain first three paragraphs below for Type HT chimneys suitable for fireplaces and other solid-fuel-burning appliances.]

H. Description: Double-wall metal vents tested according to UL 103 and rated for 1000 deg F (538 deg C) continuously, or 2100 deg F (1150 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.

I. Construction: Inner shell and outer jacket separated by at least a [**1-inch (25-mm)**] [**1-1/2-inch (38-mm)**] [**2-inch (50-mm)**] [**4-inch (100-mm)**] annular space filled with high-temperature, ceramic-fiber insulation.

J. Inner Shell: **ASTM A 666, Type 316**stainless steel.

K. Outer Jacket: **Stainless** steel.

L. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

[Retain one of first three "Termination" subparagraphs below or insert type to suit Project.]

1. Termination: Stack cap designed to exclude minimum 90 percent of rainfall.
2. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.
3. Termination: Exit cone with drain section incorporated into riser.

2.6 LISTED GREASE DUCTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Metal-Fab, Inc.
2. Selkirk Inc.; Selkirk Metalbestos and Air Mate.

B. Description: Double-wall metal vents tested according to UL 1978 and rated for 500 deg F (260 deg C) continuously, or 2000 deg F (1093 deg C) for 30 minutes; with positive or negative duct pressure and complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a [**1-inch (25-mm)**] [**2-inch (50-mm)**] [**3-inch (75-mm)**] [**4-inch (100-mm)**] annular space filled with high-temperature, ceramic-fiber insulation.

D. Inner Shell: ASTM A 666, **Type 316** stainless steel.

E. Outer Jacket: **Stainless** steel where concealed. Stainless steel where exposed.

F. Accessories: Tees, elbows, increasers, hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly. Include unique components required to comply with NFPA 96 including cleanouts, transitions, adapters and drain fittings.

2.7 LISTED, REFRACTORY-LINED METAL BREECHINGS AND CHIMNEYS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Van-Packer Company, Inc.
2. Warren Environment, Inc.

B. Comply with ASME STS-1.

C. Design Wind Loads: **150 mph (241 km/h)**.

D. Design for seismic conditions at Project site.

E. Chimney Outer Jacket: Stainless steel with [**riveted**] [**welded**] seams.

F. Refractory Lining: Tested according to UL 959 for temperature and acid resistance, and bearing the testing laboratory label.

1. Temperature Rating: 1800 deg F (982 deg C) continuously, and 2000 deg F (1093 deg C) intermittently.
2. Acid Extraction: Maximum of 0.2 percent.
3. Cold Crushing Strength: Minimum of 3200 psig (22 MPa).
4. Thickness: Minimum of 2 inches (50 mm).

G. Finish: Factory-applied, high-heat-resistant paint; color as selected by Architect.

H. Base Section: Acid-resistant-coated, cast-iron anchor lugs for securing stack to foundation[**with anchorage designed by manufacturer**].

I. Reinforced Cleanout Section: Smoke-tight connection, with gasketed and bolt-tightened inspection plate; neck shall be welded to stack section.

J. T or Y Sections: Smoke-tight connection, with welded joints and refractory lining; finished with smooth transition and with no exposed metal on inside.

K. Spark Screen: ASTM A 666, Type 316 stainless steel, 0.0625 inch (1.6 mm) thick, maximum 1/2-by-1/2-inch (13-by-13-mm) mesh, with ASTM A 666, Type 304 stainless-steel rolled angle and drawband.

L. Guy Bands: 8-inch- (200-mm-) wide bands of same material as jacket, with bolted fasteners.

M. Roof Penetration: Factory-fabricated thimbles, flashings, and counterflashings.

N. Fabricate sections, fittings, and accessories as individual pieces or in combination lengths for field handling.

O. Fabricate components with centrifugally cast refractory lining in lengths suitable for connection with drawbands.

P. Bond refractory to steel jacket with calcium aluminate cement to prevent separation in finished product during shipping, handling, and installation.

Q. Fabricate stacks with anchor lugs; cleanout; T sections; flashings and counterflashings; and provisions for support, expansion, and contraction.

2.8 FIELD-FABRICATED METAL BREECHINGS AND CHIMNEYS

A. Fabricate freestanding chimneys according to SMACNA's "Guide for Steel Stack Design and Construction." Design for minimum <**Insert feet (meters)**> high and <**Insert inches (mm)**> in diameter.

[Retain paragraph and subparagraphs below for low-heat appliances.]

B. Fabricate breechings and chimneys from ASTM A 1011/A 1011M hot-rolled steel with continuously welded joints, complying with NFPA 211 for minimum metal thickness.

1. Equal to or Less Than 1.069 Sq. Ft. (0.099 Sq. m.) or 14 Inches (356 mm) in Diameter: 0.053 inch (1.35 mm).
2. Up to 1.396 Sq. Ft. (0.129 Sq. m) or 16 Inches (406 mm) in Diameter: 0.067 inch (1.7 mm).
3. Up to 1.764 Sq. Ft. (0.164 Sq. m.) or 18 Inches (457 mm) in Diameter: 0.093 inch (2.36 mm).
4. Larger Than Above: 0.123 inch (3.12 mm).

[Retain paragraph and subparagraphs below for oil-fired appliances, solid-fuel-burning appliances, or appliances listed for venting with Type L vents.]

C. Fabricate chimneys and vent connectors from galvanized steel, complying with NFPA 211 for minimum metal thickness.

1. Equal to or Less Than 6 Inches (152 mm) in Diameter: 0.019 inch (0.48 mm).
2. Up to 10 Inches (254 mm) in Diameter: 0.024 inch (0.61 mm).
3. Up to 16 Inches (406 mm) in Diameter: 0.029 inch (0.74 mm).
4. Larger Than Above: 0.056 inch (1.42 mm).

[Retain two paragraphs and subparagraphs below for appliances not installed in attics that are listed to be vented by Type B or L vents.]

D. Fabricate chimneys and vent connectors from ASTM B 209 (ASTM B 209M), Type 1100 or 3003, aluminum or stainless steel, complying with NFPA 211 for the following minimum metal thicknesses:

1. Aluminum: 0.027 inch (0.69 mm).

2. Stainless Steel: 0.012 inch (0.31 mm).

E. Fabricate cleanout doors from compatible material, same thickness as breeching, bolted and gasketed.

[Retain paragraph and subparagraphs below for engine exhaust applications that use steel pipe.]

F. Fabricate engine exhaust from ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, [**Schedule 40**] [**Schedule 80**] pipe; with welded joints and carbon-steel fittings and flanges.

1. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
2. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150, including bolts, nuts, and gaskets.

2.9 GUYING AND BRACING MATERIALS

A. Cable: [**Three**] [**Four**] galvanized, stranded wires of the following thickness:

1. Minimum Size: 1/4 inch (6 mm) in diameter.
2. For ID Sizes 4 to 15 Inches (100 to 381 mm): 5/16 inch (8 mm).
3. For ID Sizes 18 to 24 Inches (457 to 610 mm): 3/8 inch (9.5 mm).
4. For ID Sizes 27 to 30 Inches (685 to 762 mm): 7/16 inch (11 mm).
5. For ID Sizes 33 to 36 Inches (838 to 915 mm): 1/2 inch (13 mm).
6. For ID Sizes 39 to 48 Inches (990 to 1220 mm): 9/16 inch (14.3 mm).
7. For ID Sizes 51 to 60 Inches (1295 to 1524 mm): 5/8 inch (16 mm).

B. Pipe: [**Two**] [**Three**] galvanized steel, NPS 1-1/4 (DN 32).

C. Angle Iron: [**Two**] [**Three**] galvanized steel, 2 by 2 by 0.25 inch (50 by 50 by 6 mm).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATION

A. Listed Chimney Liners: High-efficiency boiler or furnace vents in masonry chimney, dishwasher exhaust, or Type II commercial kitchen hood.

B. Listed Type B and BW Vents: Vents for certified gas appliances.

C. Listed Type L Vent: Vents for low-heat appliances.

D. Listed Special Gas Vent: Condensing gas appliances.

E. Listed Building-Heating-Appliance Chimneys: Dual-fuel boilers, oven vents, water heaters, and exhaust for engines. Fireplaces and other solid-fuel-burning appliances.

F. Listed Grease Ducts: Type I commercial kitchen grease duct.

G. Listed, Refractory-Lined Metal Breechings and Chimneys: Freestanding dual-fuel boiler vents, oven vents, water heaters, exhaust for engines, fireplaces, and other solid-fuel-burning appliances.

H. Field-Fabricated Metal Breechings and Chimneys: Dual-fuel boilers, oven vents, water heaters, exhaust for engines, fireplaces, and other solid-fuel-burning appliances.

I. Field-Fabricated Metal Breechings and Chimneys: Steel pipe for use with engine exhaust.

3.3 INSTALLATION OF LISTED VENTS AND CHIMNEYS

A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

B. Seal between sections of positive-pressure vents and grease exhaust ducts according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

E. Lap joints in direction of flow.

F. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.

G. Join sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.

H. Erect stacks plumb to finished tolerance of no more than 1 inch (25 mm) out of plumb from top to bottom.

3.4 INSTALLATION OF UNLISTED, FIELD-FABRICATED BREECHINGS AND CHIMNEYS

A. Suspend breechings and chimneys independent of their appliance connections.

B. Install, support, and restrain according to seismic requirements.

C. Align breechings at connections, with smooth internal surface and a maximum 1/8-inch (3-mm) misalignment tolerance.

D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

E. Lap joints in direction of flow.

F. Support breechings and chimneys from building structure with bolts, concrete inserts, steel expansion anchors, welded studs, C-clamps, or beam clamps according to manufacturer's written instructions.

3.5 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

B. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.

C. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

END OF SECTION 235100

SECTION 235216 - CONDENSING HOT WATER BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes packaged full condensing hot water boiler(s), and accessories for producting hydronic hot water with the following configurations, burners, and outputs:

1. Factory packaged and assembled boiler.
2. Integral natural gas and/or propane forced draft premix burner.

1.3 ACTION SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.

1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.

a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.

2. Wiring Diagrams: Power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control test reports.

C. Field quality-control test reports.

D. Warranty: Special warranty specified in this Section.

E. Other Informational Submittals:

1. ASME "A" Stamp Certification and Report: Submit "A" stamp certificate of authorization as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
2. Startup service reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For boilers, components, and accessories to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."

E. I=B=R Compliance: Boilers shall be tested and rated according to HI's "Rating Procedure for Heating Boilers" and "Testing Standard for Commercial Boilers," with I=B=R emblem on a nameplate affixed to boiler.

F. CSA or UL Compliance: Test boilers for compliance with [**UL 795, "Commercial-Industrial Gas Heating Equipment."**] Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

G. ASME CSD-1 Certification, in the form of completed data sheet.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace pressure vessel damaged by thermal shock that fail in materials or workmanship within specified warranty period.

   A. Warranty Period for Heat Exchangers: 20 years from date of Substantial Completion when utilized in a closed loop hydronic heating system with a temperature differential of 120 °F or less. The boiler pressure vessel shall be guaranteed accordingly without a minimum flow rate or return water temperature requirement. The boiler shall not require the use of flow switches or other devices to ensure minimum flow.

   B. The pressure vessel, tubes and tube sheets (heat exchanger) shall be guaranteed against flue gas corrosion and materials/workmanship for a period of 10 years. The condensate collection box shall be guaranteed for 20 years. The burner cylinder shall be warranted for a period of 5 years.

   C. All parts not covered by the above warranties shall carry a 1 year warranty from startup, or 18 months from shipment, whichever occurs first. This shall include all electrical components and burner components.

PART 2 - PRODUCTS

2.1 FINNED WATER-TUBE BOILERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   1. Cleaver-Brooks.
   2. Buderus.
   3. Viessmann.

B. Description: Each unit shall be a Down-fired Firetube type complete with boiler fittings and automatic controls. The boiler, with all piping and wiring, shall be factory package. Each boiler shall be neatly finished, thoroughly tested and properly packaged for shipping. Boiler design and construction shall be in accordance with Section IV of the ASME Code for hot water heating boilers with a maximum working pressure of 125 PSIG. The boiler shall be CSA or cULus certified as an indirect or direct vent boiler and comply with ASME CSD-1 Code requirements.

C. Boiler Design:

1. Boiler shall be a compact, single-pass, vertical down-fired Firetube type, with Duplex stainless steel tubes, tube sheets, and combustion chamber. The boiler pressure vessel shall be completely insulated with a minimum of 2" of insulation and shall be encased in an 18 gauge metal cabinet with powder coated finish. To prevent installation damage, the casing shall be packaged separately and shall ship loose for field installation by the manufacturer's service representative.

2. The tubes shall be Duplex Stainless Steel and shall be fitted with Aluminum Alloy internal heat transfer fins creating no less than 10 square feet of fireside heating surface per boiler horsepower.

3. The Vessel shall be mounted on a structural steel stand with exhaust gasses collected in a polymer drain collection box complete with drain fitting for draining condensation from the products of combustion. A condensate neutralizing box complete with limestone chips shall be shipped loose for field installation by contractor. Note: A condensate trap assembly shall be furnished if a condensate collection tray is not provided due to operating conditions.

4. The top tubesheet shall be fully accessible without burner disassembly or removal from the boiler. The burner assembly shall be complete with lifting hinges and pneumatic lifters. The boiler shall have a built in hinged platform allowing the operator to access the tubesheet, burner, ignition assembly and flame rod without the use of a ladder.

5. The vessel shall be fully insulated with a minimum of 2" of insulation, guaranteeing external convection and radiation heat losses to the boiler room from the boiler shall be less than 0.5% of the rated input.

6. The condensing capability shall allow the boiler to be operated without the use of a 3-way valve for the boiler supply water temperature reset. No minimum boiler return water temperature or secondary pump or minimum flow rate shall be required to protect the boiler against thermal shock or for minimum temperature water.

7. Boiler shall be built to seismic zone ___ requirements and manufacturer shall provide seismic calculations showing tie-down requirements for bolt diameters. Bolts and tie-down shall be by contractor.

8. Each boiler shall be constructed in accordance with the A.S.M.E. Section IV Code and bear the "H" stamp and shall be manufactured within an ISO 9001 Certified facility to ensure high quality standards.

9. The boiler shall be designed for top rear water outlet and bottom rear water inlet; the water inlet [return] shall be equipped with internal baffling. Inlet connection size shall be _______ flanged. Outlet connection size shall be _______ flanged. The maximum pressure drop through the boiler shall not exceed 0.45 psi with a 20-degree differential and less than 0.05 psi with a 60-degree differential.

10. The boiler shall be equipped with a second water return connection that will permit low temperature returns to be utilized for condensing, regardless of the primary return temperature water above condensing conditions.

11. A threaded air vent connection shall be furnished at the top rear of the boiler for field piping to an expansion tank or for the addition of an auto-vent valve when a bladder type expansion tank is utilized.

12. To drain the boiler, a bottom-threaded connection shall be provided at the front of the boiler and field piped by the installing contractor with a manual full size shutoff valve to drain.

13. Boiler design shall permit operation with a water condition of 8.0 - 9.5 pH range.

D. Burner Design:

1. General: Forced draft burner mounted in and integral with the boiler hinged top door so when the door is opened the burner head, furnace, tubesheet, and tubes are exposed. The burner door shall utilize easy removable threaded handles, and the burner shall swing upward on hydraulic piston arms, one on each side to provide open support of the burner assembly.

2. A drop down hinged service platform shall be furnished to provide service personnel an easy means of accessing the burner and controls for service and maintenance. When out of use, this platform shall fold up beneath the front service boiler panel.

3. The burner shall be of the Unitized Venturi, Gas Valve, Blower, and burner head design. This pre-mix design shall utilize a variable speed fan connected to a venturi to simultaneously modulate fuel and air for a minimum a 5:1 turndown ratio. The venturi design shall also act as a method for compensating for changes in barometric pressure, temperature and humidity so the excess air levels are not adversely affected by changes in atmospheric conditions. External linkages, damper motor drives and single speed fans shall not be acceptable.

4. Burner head shall be constructed of a Fecralloy-metal fiber for solid body radiation of the burner flame. Combustion shall take place on the surface of the burner mantle, which shall be constructed of a woven fecralloy material creating a 360 degree low temperature radiant flame.

5. Emissions: The equipment shall be guaranteed to limit NOx emissions to 20 PPM or less, as certified by an independent testing lab. NOx emission levels shall not be exceeded at full operating conditions and at designed turndown of the burner. Proof of such emissions certification shall be made available to the engineer and purchaser and demonstrated at the time of start-up. External flue gas recirculation shall not be accepted for emission control.

6. Gas Train – As a minimum, the gas train shall meet the requirements of CSA/UL and ASME CSD-1 and shall include:

a. Low Gas Pressure Interlock, manual reset.
b. High Gas Pressure Interlock, manual reset.
c. Upstream and downstream manual test cocks.
d. Ball Type manual shutoff valve upstream of the main gas valve.
e. Unibody double safety gas valve assembly.
f. Gas Pressure Regulator
g. Union connection to permit burner servicing.

7. Combustion Air Proving Switch shall be furnished to ensure sufficient combustion airflow is present for burner ignition firing.

8. To ensure that proper draft is not blocked in the stack, the burner shall include a High Air Pressure Switch sensing the outlet pressure connection relative to stack back draft.

E. Boiler Trim

1. Temperature and pressure gauge shall be mounted on the water outlet.
2. Solid State Low water cut-off probe with manual reset and test switch.

3. Manual Reset High Limit Temperature sensor; range not to exceed 210 ^{0} F and shall be an integral device of the Boiler Burner Control and UL recognized as a limit control.

4. Outlet water supply sensing probe for operating water limit setpoint.

5. Return water-sensing probe for operating water limit setpoint.

F. Boiler Controls:

1. Refer to Section 230900 "Instrumentation and Control for HVAC."

2. The Boiler shall include a Falcon Computerized Boiler Burner control which shall be an integrated, solid state digital micro-processing modulating device, complete with sequence indication, fault reset, mode selection, and parameter set-point. It shall be mounted at the front of the boiler panel for easy access and viewing.

3. Controller shall provide for both flame safeguard and boiler control through separate power supplied CPU’s (to meet NFPA) and shall perform the following functions:

   a. Burner sequencing with safe start check, pre-purge, Electronic direct spark ignition or pilot ignition (CFC-3300) and post purge. Flame rod or UV scanner (CFC 3300) to prove combustion.
   b. Flame Supervision. The control shall provide pre-purge and post-purge and shall maintain a running history of operating hours, number of cycles, and the most recent six faults. The control shall be connected to a keyboard display module that will retrieve this information.

c. Safety Shutdown with display of error.

d. Modulating control of the variable speed fan for fuel/air input relative to load requirements.

e. Gas pressure supervision, high and low.

f. Combustion Air Proving Supervision.

g. High Air Pressure [back draft too high] Supervision.

h. The supply temperature and set-point temperature shall be displayed at all times on the touch screen display.

i. Controller shall be equipped with a touch screen display for set up, trouble shooting, and operational display, and shall include ModBus communication capability of this information.

j. Include the programming of system circulating pump and provide the programming of 2 heating loops.

4. All parameter input control set-points shall be factory downloaded with jobsite conditions programmed at the time of initial jobsite operation.

5. All controls to be panel mounted and so located on the boiler as to provide ease of servicing the boiler without disturbing the controls and also located to prevent possible damage by water according to CSA requirements.

6. Electrical power supply shall be 120 volts, 60 cycle single phase (CFC 500-2500) or 208-230/3/50-60 Hz (CFC 3300) for the fan and 120 volts for control circuit requirements.

7. When multiple boilers are to be installed together, a system integration control shall be provided to stage up to 8 boilers. The control shall include automatic selection of needed boilers based on energy demand, an adjustable outdoor reset schedule, domestic hot water priority, and a system digital display. The control shall force each boiler to a lower fire, before allowing any boiler to operate at high fire. This allows for inverse efficiency (lower fire rate, higher efficiency). The control shall monitor supply water temperature, return water temperature and shall communicate between boilers via RS-485 wiring.

8. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms. Unit shall communicate through Modbus.

a. Monitoring: On/off status, [**common trouble alarm**] [**low water level alarm**].
b. Control: On/off operation, [**hot water supply temperature set-point adjustment**].
c. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

G. Condensate Treatment:
   1. Provide flue gas condensate neutralization assembly adequately sized for all boilers at full condensing mode, including tank, cover, and neutralization mineral.

2.2 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

   1. House in NEMA 250, Type 1 enclosure.
   2. Wiring shall be numbered and color-coded to match wiring diagram.
   3. Install factory wiring outside of an enclosure in a [**metal**]raceway.
   4. Field power interface shall be to fused disconnect switch.
   5. Provide branch power circuit to each motor and to controls[**with disconnect switch or circuit breaker**].
   6. Provide each motor with overcurrent protection.

2.3 VENTING

A. The Boiler shall be UL certified as an indirect or direct vent boiler. Venting shall be accomplished with a stainless steel, double-wall, vent piping installed in accordance with applicable national and local codes. In some cases, PVC/CPVC material meeting ULC Type BH Class IIB specifications may be used. Use of PVC/CPVC depends on operating conditions, specific vent suppliers, and any local codes having jurisdiction. Refer to vent manufacturer’s specifications for applicability.

B. For direct venting, the boiler shall have the combustion air intake supply ducted with PVC pipe from the outside. Vibration isolation components are not required.

2.4 CAPACITIES AND CHARACTERISTICS

A. Heating Medium: Hydronic Hot Water.

B. Design Pressure and Temperature Rating: **125 psig (862 kPa), 195 deg F (90.5 deg C)**.

C. Safety Relief Valve Setting: <**Insert psig (kPa).**>

D. Steam Operating Pressure: <**Insert psig (kPa).**>

E. Minimum Efficiency AFUE: <**Insert number**> percent.

F. Minimum Thermal Efficiency: <**Insert number**> percent.

G. Minimum Combustion Efficiency: <**Insert number**> percent.

H. Minimum Supply Gas Pressure: <**Insert psig or in w.c. (kPa).**>

I. Number of Passes: One

J. AGA Input: <**Insert MBh (kW).**>

K. I=B=R Input: <**Insert MBh (kW).**>

L. Gas Input: <**Insert cfh (mL/s).**>

M. Turndown and NOx Emmissions: 5:1, 30 PPM Nox

N. Maximum CO: 10 PPM (corrected to 3% O2)

O. DOE Output Capacity: <**Insert MBh (kW).**>

P. AGA Output Capacity: <**Insert MBh (kW).**>

Q. Net I=B=R Output Capacity: <**Insert MBh (kW).**>

R. Gross I=B=R Output Capacity: <**Insert MBh (kW).**>

S. Equivalent Direct Radiation: <**Insert EDR (W).**>

T. Maximum Noise Level: 70 dBA Max

U. Burner Blower:

1. Motor Horsepower: <**Insert value.**>
2. RPM: <**Insert value.**>

V. Electrical Characteristics:

1. Volts: [**115**] [**208**] [**230**] [**460**] V.
2. Phase: [**Single**] [**Three**].
3. Hertz: [**50**] [**60**].
4. Full-Load Amperes: <**Insert value.**>
5. Minimum Circuit Ampacity: <**Insert value.**>
6. Maximum Overcurrent Protection: <**Insert amperage.**>

2.5 SOURCE QUALITY CONTROL

A. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

B. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

C. Allow Cleveland Clinic access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Install boilers level on concrete base. Concrete materials and installation requirements are specified with concrete.

B. Vibration Isolation: Elastomeric isolator pads with a minimum static deflection of **0.25 inch (6.35 mm)**. Vibration isolation devices and installation requirements are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Install gas-fired boilers according to NFPA 54.

D. Assemble casing panels per manufacturer’s instructions.

E. Assemble and install boiler trim.

F. Install electrical devices furnished with boiler but not specified to be factory mounted.

G. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Connect gas piping to boiler gas-train inlet with union. Piping size shall per installation instructions not size of gas train connection. Provide a reducer if required.

D. Connect hot water supply-, return-, and drain tappings with shutoff valve and union or flange at each connection.

E. Install piping from safety valves to nearest floor drain to a safe point of discharge.

F. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

G. Boiler Flue Venting:

1. Install venting kit and combustion-air intake.
2. Connect full size to boiler connections.[**Comply with requirements in Section 235100 "Breechings, Chimneys, and Stacks."**]

H. Connect breeching to full size of boiler outlet. Comply with requirements in Section 235100 "Breechings, Chimneys, and Stacks" for venting materials.

I. Install flue gas condensate PVC drain piping to condensate neutralization assembly including loop trap seal.

J. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

K. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

a. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.
b. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and [**water temperature**] [**steam pressure**].
c. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Remove and replace malfunctioning units and retest as specified above.

D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

E. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment in order to comply.
3. Perform field performance tests to determine the capacity and efficiency of the boilers.

a. For dual-fuel boilers, perform tests for each fuel.
b. Test for full capacity.
c. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40 and 20 percent of full capacity. Determine efficiency at each test point.

4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
7. Notify Architect in advance of test dates.
8. Document test results in a report and submit to Architect.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain boilers. Video training sessions. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 235233

SECTION 235233 - WATER-TUBE BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes packaged, water-tube boilers, trim, and accessories for generating steam with the following configurations, burners, and outputs:

1. [**Factory**] [**Field**] assembled.
2. [**Atmospheric gas**] [**Forced-draft gas**] [**Oil**] [**Combination gas and oil**] burner.

1.3 ACTION SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.

1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.

   a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
   b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.

2. Wiring Diagrams: Power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control test reports.

C. Field quality-control test reports.

D. Warranty: Special warranty specified in this Section.

E. Other Informational Submittals:

1. ASME "A" Stamp Certification and Report: Submit "A" stamp certificate of authorization as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
2. Startup service reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For boilers, components, and accessories to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."

E. I=B=R Compliance: Boilers shall be tested and rated according to HI's "Rating Procedure for Heating Boilers" and "Testing Standard for Commercial Boilers," with I=B=R emblem on a nameplate affixed to boiler.

F. UL Compliance: Test boilers for compliance with [**UL 726, "Oil-Fired Boiler Assemblies."**] [**UL 726, "Oil-Fired Boiler Assemblies" and UL 795, "Commercial-Industrial Gas**

Heating Equipment."] [**UL 795, "Commercial-Industrial Gas Heating Equipment."**] Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace heat exchangers damaged by thermal shock and vent dampers of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Heat Exchangers: 20 years from date of Substantial Completion.
2. Warranty Period for Vent Dampers: Five years from date of Substantial Completion.

B. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace drums, tubes, headers, cabinets, atmospheric gas burners, and pressure vessels of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Drums, Tubes, Headers, Cabinets, and Atmospheric Gas Burner: Five years from date of Substantial Completion, pro rata.
2. Warranty Period for Pressure Vessel: 20 years from date of Substantial Completion, for thermal shock.

PART 2 - PRODUCTS

2.1 FINNED WATER-TUBE BOILERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Lochinvar Corporation.
2. Patterson-Kelley.
3. Smith, A. O. Water Products Company.

B. Description: Factory-fabricated, -assembled, and -tested boiler with tubes sealed into headers pressure tight, and set on a steel base; including insulated jacket, flue-gas vent, combustion-air intake connections, water supply and return connections, and controls.

C. Heat Exchanger:

1. Finned [**copper**] [**steel**] [**copper-nickel**] tubing with stainless-steel baffles.

2. [**Bronze**] [**Cast-iron**] [**Steel**] headers.
3. [**Single**] [**Two**]-pass, [**horizontal**] [**vertical**] [**coil**] configuration.
4. Tubes shall be sealed in header [**with silicone O-ring gaskets**] [**by welding**] [**by mechanically rolling tubes in header**].

D. Combustion Chamber Internal Insulation: Interlocking panels of refractory insulation, high-temperature cements, mineral fiber, and ceramic refractory tile for service temperatures to 2000 deg F (1100 deg C).

E. Casing:

1. Jacket: [**Sheet metal**] [**Stainless steel**], with snap-in or interlocking closures.
2. Control Compartment Enclosure: NEMA 250, Type 1A.
3. Finish: [**Baked enamel over primer**] [**Baked enamel over galvanizing**] [**Powder coated**].
4. Insulation: Minimum [**1-inch- (25-mm-)**] [**2-inch- (50-mm-)**] thick, mineral-fiber insulation surrounding the heat exchanger.
5. Draft Hood: [**Integral**] [**External**].
6. Combustion-Air Connection: Inlet duct collar and sheet metal closure over burner compartment.
7. Mounting base to secure boiler[**with accessory for mounting on combustible surface**].

a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment" when mounting base is anchored to building structure.

F. Burner:

1. Burner Tubes and Orifices: Stainless steel, for [**natural**] [**propane**] gas.[**Mount burner tubes in a slide-out burner drawer for ease of inspection.**]

a. Sealed Combustion: Factory-mounted centrifugal fan to draw outside air into boiler and discharge into burner compartment.
b. Direct Vent: Factory-mounted centrifugal fan to draw flue gas out of boiler and discharge into boiler vent.

2. Vertical Burner:

a. [**High-temperature stainless steel**] [**Ceramic**] to fire in a 360-degree pattern.
b. Burner shall have a viewing port for observation of burner operation and a factory-mounted centrifugal fan to supply [**room**] [**outside**] air[**through a replaceable 99 percent efficient (1-micrometer particles) filter**] to boiler burner.
c. Fan shall be controlled to prepurge and postpurge the combustion chamber before firing.

3. Gas Train: Control devices and [**full-modulation**] [**on-off**] [**low-high-low**] [**proportional**] control sequence shall comply with requirements in [**AGA**]

[**ASME CSD-1**] [**FMG**] [**IRI**] [**UL**]. In addition to these requirements, include shutoff cock, pressure regulator, and control valve.

4. Gas Train: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
5. Pilot: [**Standing**] [**Intermittent-electric-spark**] [**Hot-surface**] pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
6. Flue-Gas Recirculation Fans: Centrifugal fans on burner assembly to recirculate flue gas to decrease oxides of nitrogen emissions to less than 30 ppm.

a. Motors: Comply with requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

G. Trim:

1. Aquastat Controllers: Operating[**, firing rate,**] and high limit.
2. Safety Relief Valve: ASME rated.
3. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
4. Boiler Air Vent: [**Automatic**] [**Manual**].
5. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.
6. Circulation Pump: Non-overloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.

H. Controls:

1. Refer to Section 230900 "Instrumentation and Control for HVAC."
2. Boiler operating controls shall include the following devices and features:

a. Control transformer.
b. Motorized Vent Damper: Interlocked with burner to open before burner starts. If damper fails to open, stop burner operation.
c. Set-Point Adjust: Set points shall be adjustable.
d. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.
e. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At **0 deg F (minus 17 deg C)** outside-air temperature, set supply-water temperature at **200 deg F (93 deg C)**; at **60 deg F (15 deg C)** outside-air temperature, set supply-water temperature at **140 deg F (60 deg C)**.
f. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

3. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

a. High Cutoff: [**Manual**] [**Automatic**] reset stops burner if operating conditions rise above maximum boiler design temperature.
b. Water Flow Switch: Automatic-reset paddle-switch shall prevent burner operation on low water flow.
c. Blocked Vent Safety Switch: Manual-reset switch factory mounted on draft diverter.
d. Rollout Safety Switch: Factory mounted on boiler combustion chamber.
e. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

4. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

a. Monitoring: On/off status, [**common trouble alarm**] [**low water level alarm**].
b. Control: On/off operation, [**hot water supply temperature set-point adjustment**].
c. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

2.2 [**STEEL**] [**FLEXIBLE**] WATER-TUBE BOILERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Babcock & Wilcox.
2. Cleaver-Brooks

B. Description: Factory-fabricated and [**field**]-assembled, water-tube boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket, flue-gas vent, supply and return connections, and controls.

C. Heat-Exchanger Design: Bent tangent steel tubes swaged into steel headers.

1. 20 year thermal shock warranty on pressure vessel and tubes.
2. Handholes[**or couplings**] in headers for water-side inspections.
3. Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
4. Lifting lugs on top of boiler.
5. Built-in air separator.

D. Heat-Exchanger Design: Bent steel tubes **swaged** into steel drums
1. Five pass combustion gas design.Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
2. Accessible inspection ports in drum, mud legs, and tube manifolds.
3. Downcomer external to fire zone to to provide positive natural circulation.
4. Lifting lugs on top of boiler.

5. Built-in air separator.

E. Combustion Chamber: Combustion chamber top, bottom, side walls shall be completely water walled with tangent tubes. [[Equipped with minimum [**2-1/2-inch (64-mm)**] [**3-inch (75-mm)**] [**4-inch (100-mm)**], 2700 deg F (1482 deg C) poured refractory on floor and minimum [**2-inch (50-mm)**] [**3-1/2-inch (89-mm)**] lap-jointed cast refractory with fiber-blanket joint seals on side walls.] Combustion chamber shall have flame observation ports in front [**and**] [**or**] back.]

F. Casing:

1. Insulation: 1.5” of insulation over tubes, under steel gas-tight removable inner casing panels with 2” insulation over and steel outer removable jacket panels.
2. Top Flue Connection: Constructed of flanged steel located at the rear top centerline of boiler inlcuding flue gas thermometer
3. Jacket: Removable sheet metal panels, with screw-fastened closures and hard enamel protective finish.
4. Mounting base to secure boiler to concrete base.

a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment" when mounting base is anchored to building structure.

5. Control Compartment Enclosure: NEMA 250, Type 1A.

G. Burner:

1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for [**natural**] [**propane**] gas. Mount burner on hinged access door to permit access to combustion chamber.
2. Blower: Backward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.

a. Motors: Comply with requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

3. Burner Turndown Ratio: 10:1 with standard emmissions on gas.

4. Gas Train: Control devices and modulating control sequence shall comply with requirements in [**AGA**] [**ASME CSD-1**] [**FMG**] [**IRI**] [**UL**].
5. Pilot: Intermittent-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
6. [Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.

a. Maximum Oxides of Nitrogen Emissions: [**20**] [**30**] ppm.]

[Retain first paragraph below for oil burners.]

H. Burner:

1. Burner: Pressure atomomizing nozzle construction with multivane, stainless-steel, flame-retention diffuser for fuel oil. Mount burner on hinged access door to permit access to combustion chamber.
2. Blower: Backward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.

a. Motors: Comply with requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

3. Oil Supply: Control devices and modulating control sequence shall comply with requirements in [**ASME CSD-1**] [**FMG**] [**IRI**] [**UL**].

a. Oil Pump: Two-stage, gear-type oil pump[**integral to and directly driven by blower**] shall be capable of producing 300-psig (2070-kPa) discharge pressure and 10-inch Hg (50.7-kPa) vacuum.
b. Oil Piping Specialties:

1) Suction-line, manual, gate valve.
2) Removable-mesh oil strainer.
3) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
4) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
5) Nozzle-line, solenoid-safety-shutoff oil valve.

4. Pilot: Intermittent-electric-spark pilot ignition with 100 percent main-valve, pilot-safety shutoff solenoid using [**cadmium sulfide**] [**UV scanner**] flame-safety control, and propane backup.

[Retain first paragraph below for combination gas and oil burners.]

I. Burner:

1. Burner: Welded gas multiport and oil pressure atomizing construction with multivane, stainless-steel, flame-retention diffuser for fuel oil and [**natural**] [**propane**] gas. Mount burner on hinged access door to permit access to combustion chamber.
2. Blower: Backward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.

a. Motors: Comply with requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

3. Oil Supply: Control devices and modulating control sequence shall comply with requirements in [**ASME CSD-1**] [**FMG**] [**IRI**].

a. Oil Pump: Two-stage, gear-type oil pump[**integral to and directly driven by blower**] shall be capable of producing 300-psig (2070-kPa) discharge pressure and 10-inch Hg (50.7-kPa) vacuum.
b. Oil Piping Specialties:

1) Suction-line, manual, gate valve.
2) Removable-mesh oil strainer.
3) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
4) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
5) Nozzle-line, solenoid-safety-shutoff oil valve.

4. Burner Turndown Ratio: 10:1 with standard emmissions on gas.

5. Gas Train: Control devices and modulating control sequence shall comply with requirements in [**ASME CSD-1**] [**FMG**] [**IRI**] [**UL**].
6. Gas Pilot: Intermittent-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
7. Flue-Gas Recirculation gas only: Burner connections shall be equipped for recirculating flue gas.

a. Maximum Oxides of Nitrogen Emissions: [**20**] [**30**] ppm.

J. Trim:

1. Include devices sized to comply with [**ANSI B31.1, "Power Piping**] [**ANSI B31.9, "Building Services Piping**]."
2. Pressure Controllers: Operating[**, firing rate,**] and high limit.
3. Safety Relief Valve:

a. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
b. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.

1) Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.

4. Pressure Gage: Minimum 3-1/2-inch (89-mm) diameter. Gage shall have normal operating pressure about 50 percent of full range.
5. Water Column: Minimum 12-inch (300-mm) glass gage with shutoff cocks.
6. Drain Valves: Minimum NPS 3/4 (DN 20) or nozzle size with hose-end connection.

7. Blowdown Valves: Factory-installed bottom and surface, slow-acting blowdown valves same size as boiler nozzle.[**Blowdown valves shall be combination of slow and quick acting as required by ANSI B31.1.**]
8. Stop Valves: Boiler inlets and outlets, except safety relief valves or preheater inlet and outlet, shall be equipped with stop valve in an accessible location as near as practical to boiler nozzle and same size or larger than nozzle. Valves larger than NPS 2 (DN 50) shall have rising stem.
9. Stop-Check Valves: Factory-installed, stop-check valve and stop valve at boiler outlet with free-blow drain valve factory installed between the two valves and visible when operating stop-check valve.

K. Controls:

1. Refer to Section 230900 "Instrumentation and Control for HVAC."
2. Boiler operating controls shall include the following devices and features:

a. Control transformer.
b. Set-Point Adjust: Set points shall be adjustable.
c. Operating Pressure Control: Factory wired and mounted to cycle burner.
d. Low-Water Cutoff and Pump Control: Cycle feedwater pump(s) for makeup water control.
e. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent.
f. Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.

3. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.

a. The burner shall utilize an automatic solid state flame safeguard programmer including indicator lights to annuciate the operating status of the burner.

b. Electronic safety combustion controls shall be supplied, complete with ultra-violet flame scanner to monitor the pilot and main flame. It shall be so utilized as to provide intermittent type gas-electric ignition and pre-ignition timer.

c. High Cutoff: Manual reset stops burner if operating conditions rise above maximum boiler design pressure.
d. Low-Water Cutoff Switch: Float and electronic probe shall prevent burner operation on low water. Cutoff switch shall be manual-reset type.
e. .
f. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.

4. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.

a. Monitoring: On/off status, common trouble alarm, and low water level alarm.

b. Control: On/off operation, hot water supply temperature set-point adjustment, and steam pressure adjustment.

c. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

2.3 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type 1 enclosure.
2. Wiring shall be numbered and color-coded to match wiring diagram.
3. Install factory wiring outside of an enclosure in a [**metal**]raceway.
4. Field power interface shall be to fused disconnect switch.
5. Provide branch power circuit to each motor and to controls[**with disconnect switch or circuit breaker**].
6. Provide each motor with overcurrent protection.

2.4 VENTING KITS

A. Vent Damper: Motorized, UL listed for use on atmospheric burner boiler equipped with draft hood; motor to open and close damper; stainless-steel vent coupling and damper blade; keyed wiring harness connector plug; and dual-position switches to permit burner operation.

B. Kit: Complete system, [**ASTM A 959, Type 29-4C**]stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap, and sealant.

C. Combustion-Air Intake: Stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

2.5 CAPACITIES AND CHARACTERISTICS

A. Heating Medium: Steam.

B. Design Pressure and Temperature Rating: **160 psig (1100 kPa), 250 deg F (120 deg C)**.

C. Design Pressure Rating: [**15 psig (104 kPa)**] [**150 psig (1035 kPa)**] [**250 psig (1725 kPa)**].

D. Safety Relief Valve Setting: <**Insert psig (kPa).**>

E. Steam Operating Pressure: <**Insert psig (kPa).**>

F. Steam Flow Rate: <**Insert lb/h (kg/s).**>

G. Minimum Efficiency AFUE: <**Insert number**> percent.

H. Minimum Thermal Efficiency: <**Insert number**> percent.

I. Minimum Combustion Efficiency: <**Insert number**> percent.

J. Number of Passes: [**One**] [**Two**].

K. AGA Input: <**Insert MBh (kW).**>

L. I=B=R Input: <**Insert MBh (kW).**>

M. Gas Input: <**Insert cfh (mL/s).**>

N. Oil Input: <**Insert gph (mL/s).**>

O. DOE Output Capacity: <**Insert MBh (kW).**>

P. AGA Output Capacity: <**Insert MBh (kW).**>

Q. Net I=B=R Output Capacity: <**Insert MBh (kW).**>

R. Gross I=B=R Output Capacity: <**Insert MBh (kW).**>

S. Equivalent Direct Radiation: <**Insert EDR (W).**>

T. Burner Blower:

1. Motor Horsepower: <**Insert value.**>
2. RPM: <**Insert value.**>

U. Electrical Characteristics:

1. Volts: [**115**] [**208**] [**230**] [**460**] V.
2. Phase: [**Single**] [**Three**].
3. Hertz: [**50**] [**60**].
4. Full-Load Amperes: <**Insert value.**>
5. Minimum Circuit Ampacity: <**Insert value.**>
6. Maximum Overcurrent Protection: <**Insert amperage.**>

2.6 SOURCE QUALITY CONTROL

A. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

B. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

C. Allow Cleveland Clinic access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Install boilers level on concrete base. Concrete materials and installation requirements are specified with concrete.

B. Vibration Isolation: Elastomeric isolator pads with a minimum static deflection of **0.25 inch (6.35 mm)**. Vibration isolation devices and installation requirements are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Install gas-fired boilers according to NFPA 54.

D. Install oil-fired boilers according to NFPA 31.

E. Assemble boiler tubes in sequence and seal each tube joint.

F. Assemble and install boiler trim.

G. Install electrical devices furnished with boiler but not specified to be factory mounted.

H. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.

D. Connect oil piping full size to burner inlet with shutoff valve and union.

E. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tappings with shutoff valve and union or flange at each connection.

F. Install piping from safety valves to drip-pan elbow and to nearest floor drain.

G. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

H. Boiler Flue Venting:

1. Install venting kit and combustion-air intake.
2. Connect full size to boiler connections.[**Comply with requirements in Section 235100 "Breechings, Chimneys, and Stacks."**]

I. Connect breeching to full size of boiler outlet. Comply with requirements in Section 235100 "Breechings, Chimneys, and Stacks" for venting materials.

J. Install flue-gas recirculation duct from vent to burner. Comply with requirements in Section 235100 "Breechings, Chimneys, and Stacks" for recirculation duct materials.

K. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

L. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

a. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.

b. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and [**water temperature**] [**steam pressure**].
c. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Remove and replace malfunctioning units and retest as specified above.

D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

E. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment in order to comply.
3. Perform field performance tests to determine the capacity and efficiency of the boilers.

a. For dual-fuel boilers, perform tests for each fuel.
b. Test for full capacity.
c. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40 and 20 percent of full capacity. Determine efficiency at each test point.

4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
7. Notify Architect in advance of test dates.
8. Document test results in a report and submit to Architect.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain boilers. Video training sessions. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 235233

SECTION 235239 - FIRETUBE BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes packaged, factory-fabricated and -assembled boilers, trim, and accessories for generating steam with the following configurations and burners:

1. Horizontal, multi-pass scotch marine firetube boiler.
2. [**Gas**] [**Oil**] [**Combination gas and oil**] burner.

1.3 ACTION SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.

1. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.

a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.

2. Wiring Diagrams: Power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Source quality-control test reports.

C. Field quality-control test reports.

D. Warranty: Special warranty specified in this Section.

E. Other Informational Submittals:

1. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
2. Startup service reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For boilers, components, and accessories to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. UL Compliance: Test Boilers for compliance with [**UL 726, "Oil-Fired Boiler Assemblies."**] [**UL 726, "Oil-Fired Boiler Assemblies" and UL 795, "Commercial-Industrial Gas Heating Equipment."**] [**UL 795, "Commercial-Industrial Gas Heating Equipment."**] Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.8 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace front- and rear-door refractories and heat exchangers of boilers that fail in materials or workmanship within specified warranty period.

1. Horizontal, Firetube Boilers: Refractory in front and rear doors, 10 years from date of startup by factory-authorized personnel.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Atlas.
2. Babcock & Wilcox.
3. Cleaver-Brooks

2.2 MANUFACTURED UNITS

A. Description: Factory-fabricated, -assembled, and -tested, horizontal, firetube boilers with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket, flue-gas vent, water supply and return connections, and controls.

B. Pressure Vessel Design: Boiler shall be a multipass horizontal firetube updraft design utilizing, straight steel tubes, attached to front and rear tube sheets per ASME requirements. Design shall be optimzed for efficiency and longevity using computer fluid dynamic (CFD) modeling verifiable by manufacturer. Tube design shall utilize extended heating surface or dimple tube design to maximize efficiency and furnace size and reduce boiler foot print without the use of turbulator, swirlers, or other add-on appurtenances. [Primary fireside heating surface shall not exceed 359 sq.ft for “Ohio Special” design. Include the following accessories:

1. Handholes for water-side inspections.
2. Lifting lugs on top of boiler.
3. Front and rear blowdown and drain taps located at bottom centerline of boiler shell.

[Retain two subparagraphs below for hot-water boilers only.]

4. Tappings or flanges for supply- and return-water piping shall be located at top centerline of shell.
5. Built-in air separator with discharge tapping diptube.

6. Return tapping with internal flow nozzle.
   [Retain two subparagraphs below for steam boilers only.]
7. Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
8. Tappings for steam supply, makeup, level controls, and chemical treatment.

C. Front and Rear Doors:

1. [**Bolted**] [**Hinged**] [**Davited**], sealed with heat-resistant gaskets and fastened with lugs and cap screws.
2. Designed so tube sheets and flues are fully accessible for inspection or cleaning when doors are open.
3. Include observation ports in doors at both ends of boiler for inspection of flame conditions.
4. Door [**refractory**] [**insulation**] shall be accessible for inspection and maintenance.

D. Casing:

1. Insulation: Minimum 2-inch- (50-mm-) thick, mineral-fiber insulation surrounding the boiler shell.
2. Flue Connection: Flange at top of boiler.
3. Jacket: [**Galvanized sheet**] [**Sheet**] metal, with screw-fastened closures and powder-coated protective finish.
4. Mounting base to secure boiler to concrete base.

   a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment" when mounting base is anchored to building structure.

5. Control Compartment Enclosure: NEMA 250, Type [**1**] [**4**] [**4X**] [**12**].

E. Exhaust gas outlet shall be located in the front of the boiler shall include flue-gas thermometer having a minimum 3-1/2-inch- (89-mm-) diameter dial.

[Retain one of three "Burner" articles below.]

2.3 BURNER

[Retain this Article for forced-draft gas burners.]

A. Burner: The natural gas burner shall be factory installed, factory tested and warranted by the boiler manufacturer and shall be integral to the front head of the boiler. The burner shall be high radiant multiport with welded construction with multivane, stainless-steel, flame-retention diffuser for natural gas.[**Mounted burner shall be on hinged access door to permit access to combustion chamber.**]

B. Blower: A radial blade centrifugal fan integral to burner directly driven by motor shall pressurirze an air plenum feeding an internal rotary air damper assembly under pressure to control the air-fuel ratio. Blade dampers are not acceptable.

1. Motors: Comply with requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

C. Gas Train: Control devices and modulating control sequence shall comply with requirements in [**ASME CSD-1**] [**FMG**] [**IRI**] [**UL**].

D. Pilot: Intermittent-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

E. Flue-Gas Recirculation: [250 Hp and greater] Burner connections shall be equipped internal damper for recirculating flue gas into air plenum. [External FGR piping if required shall be furnished and installed by boiler manufacturer].

1. Maximum Oxides of Nitrogen Emissions: 30 ppm.

F. Fuel Air Ratio Control: The burner control shall provide cross limited parallel positioning control of fuel, combustion air, and [FGR] with individual control actuators without the use of a single jackshaft, cams, or linkages.

G. Turn Down Ratio: The burner shall be full modulation design with minimum turndown ratio and maximum excess air shall be
[100 to 225 Hp, Min. Turndown 4:1, Max. Excess Air 30%]
[250 to 300 Hp, Min. Turndown 10:1, Max Excess Air 15%]
[350 to 800 Hp, Min. Turndown 10:1, Max. Excess Air 15%]
[900 to 2,200 Hp, Min. Turndown 6:1, Max Excess Air 30%]

Maximum CO production shall not exceed 10 ppm on all fuels at all firing rates.

2.4 BURNER

[Retain this Article for No. 2 oil burners.]

A. Burner: The No.2 oil burner shall be factory installed, factory tested and warranted by the boiler manufacturer and shall be integral to the front head of the boiler. The burner shall be low air pressure atmomizing designwith retractable nozzle and multivane, stainless-steel, flame-retention diffuser for fuel oil. Pressure atomizing design is not acceptable.[**Mount burner on hinged access door to permit access to combustion chamber.**]

B. Blower: A radial blade centrifugal fan integral to burner, directly driven by motor shall pressurirze an air plenum feeding an internal rotary air damper assembly under pressure to control the air-fuel ratio. . Blade dampers are not acceptable.

C.

1. Motors: Comply with requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

   a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

D. Oil Supply: Control devices and modulating control sequence shall comply with requirements in [**ASME CSD-1**] [**FMG**] [**IRI**] [**UL**].

1. Oil Pump: Two-stage, direct drive gear-type oil pump [shipped loose for field installation] [rail mounted] shall be capable of producing discharge pressure required to operate the boiler under all conditions with a 10-inch Hg maximum vacuum suction pressure.
2. Oil Piping Specialties:

   a. Suction-line, manual, gate valve.
   b. Removable-mesh oil strainer.
   c. 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
   d. 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
   e. Nozzle-line, solenoid-safety-shutoff oil valve.

E. Pilot: [**Intermittent**] [**Interrupted**]-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with [**cadmium sulfide**] [**UV scanner**] flame-safety control.

F. Flue-Gas Recirculation: Flue Gas Recirculation shall not be utilized while firing oil..
1. Maximum Oxides of Nitrogen Emissions: Unregulated

G. Fuel Air Ratio Control: The burner control shall provide cross limited parallel positioning control of fuel, combustion air, and [FGR] with individual control actuators without the use of a single jackshaft, cams, or linkages.

H. Turn Down Ratio: The burner shall be full modulation design with minimum turndown ratio maximum excess air shall be
[100 to 225 Hp, Min. Turndown 4:1, Max. Excess Air 25%]
[250 to 300 Hp, Min. Turndown 7:1, Max Excess Air 25%]
[350 to 800 Hp, Min. Turndown 8:1, Max. Excess Air 25%]
[900 to 2,200 Hp, Min. Turndown 6:1, Max Excess Air 25%]

Maximum CO production shall not exceed 10 ppm on all fuels at all firing rates.

2.5 BURNER

[Retain this Article for combination gas and oil burners.]

A. Burner: The combination natural gas and No. 2 oil burner shall be installed, tested and warranted by the boiler manufacturer and shall be integral or mounted to the front head of the boiler. The burner shall combination natural gas and No. 2 oil design. The burner shall be high radiant multiport on gas and low air pressure atmomizing design with retractable nozzle on oil nozzle. The burner shall be able to be changed to either fuel by operator without the requirement of any tools. Includes a multivane, stainless-steel, flame-retention diffuser for fuel oil and natural gas.[**Mounted burner shall be on hinged access door to permit access to combustion chamber.**]

B. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.

1. Motors: Comply with requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

C. Oil Supply: Control devices and modulating control sequence shall comply with requirements in [**ASME CSD-1**] [**FMG**] [**IRI**] [**UL**].

1. Oil Pump: Two-stage, gear-type direct drive oil pump [shipped loose for field installation] [rail mounted] shall be capable of producing discharge pressure required to operate the boiler under all conditions with a 10-inch Hg maximum vacuum suction pressure.
2. Oil Piping Specialties:

a. Suction-line, manual, gate valve.
b. Removable-mesh oil strainer.
c. 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
d. 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
e. Nozzle-line, solenoid-safety-shutoff oil valve.

D. Gas Train: Control devices and modulating control sequence shall comply with requirements in [**ASME CSD-1**] [**FMG**] [**IRI**] [**UL**].

E. Gas Pilot: Intermittent-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.

F. Oil Pilot: Intermittent-electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with [**cadmium sulfide**] [**UV scanner**] flame-safety control.

G. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.

1. Maximum Oxides of Nitrogen Emissions: 30 ppm (Natural Gas) / Unregulated (Oil)

H. Fuel Air Ratio Control: The burner control shall provide cross limited parallel positioning control of fuel, combustion air, and [FGR] with individual control actuators without the use of a single jackshaft, cams, or linkages.

I. Turn Down Ratio: The burner shall be full modulation design with minimum turndown ratio without the introduction of excess air shall be

Firing on Natural Gas:
[100 to 225 Hp, Min. Turndown 4:1, Max. Excess Air 30%]
[250 to 300 Hp, Min. Turndown 10:1, Max Excess Air 15%]
[350 to 800 Hp, Min. Turndown 10:1, Max. Excess Air 15%]
[900 to 2,200 Hp, Min. Turndown 6:1, Max Excess Air 30%]

Firing on No. 2 Oil:
[100 to 225 Hp, Min. Turndown 4:1, Max. Excess Air 25%]
[250 to 300 Hp, Min. Turndown 7:1, Max Excess Air 25%]
[350 to 800 Hp, Min. Turndown 8:1, Max. Excess Air 25%]
[900 to 2,200 Hp, Min. Turndown 6:1, Max Excess Air 25%]

Maximum CO production shall not exceed 10 ppm on all fuels at all firing rates.

2.6 TRIM

[In paragraph below, retain first option if boiler operating pressure exceeds 15 psig (104 kPa).]

A. Include devices sized to comply with [**ANSI B31.1, "Power Piping**] [**ANSI B31.9, "Building Services Piping**]."

B. [Pressure] [Hot Water Temperature] Controller: Shall be controlled by boiler process controller for operating and firing rate. and a separate high limit controller with manaul reset.

C. Safety Relief Valve:

1. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
2. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.

    a. [Steam Boiler Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1 furnished and installed by contractor.]

D. Pressure Gage: Minimum diameter. Gage shall have normal operating pressure about 50 percent of full range.

E. [Hot Water Boiler- Low water cutoff with manual reset]

[Retain following paragraphs below if steam boiler]

F. Water Column: Water column/low water cutoff with reflex gauge glass and shut off cocks. Water level control system shall comprise of a mircoprocessor –based electronic control, a noncontact, non-wearing, continously reading absolute level sensor and pressure chamber providing the following function and control:
1. Continous Level Indication
2. Low Water Cutoff & Alarm
3. High Water Alarm
4. Low & High Water Warning
5. Full Modulation Control of Modulating Feedwater Control Valve
6. Continous Monitoring of Float Operation
7. Column Blowdown Detection and Reminder
8. Auto & Manual Reset
9. Real Time Clock
10. Alarm Annuciation
11. Alarm History Files with Time Stamp
12. Water Column Blowdown Record
13. Auxiliary Low Water Cut-off Check
14. RS 232 Interface

G. Valves:

[In first paragraph below, retain option if steam boiler operating pressure exceeds 15 psig (103 kPa).]

1. Valves shall be factory piped, hydrostatically tested, and ASME certified by boiler manufacturer including:
   a. Blowdown Valves: Factory-installed bottom blowdown piping from front and rear blowdown conections at full tapping size with two (2) quick opening and one (1) slow opening blowdown valves with rating as approved by ASME. Factory install stop valve on surface blowdown tapping of boiler.
   b. Feed Stop and Check Valves Feedwater piping to include globe pattern stop valve and swing check valve at full of size of feedwater inlet with rating as required by ASME. Factory install chemical feed stop valve on chemical tapping of boiler.
   c. Steam Valves: Factory install steam piping and valves, including ASME approved spool piece mounted on boiler outlet, stop-check valve sized for operating pressure and turndown of boiler, secondary spool piece with ¾" free-blow drain tapping and valve, and O.S.& Y stop valve

H. Modulating Feedwater Valve – Furnish globe style electric modulating feedwater valve designed for tight shut off with maximum differential pressure exceeding the safety valve setpoint and feedwater supply pressure.

2.1 BOILER FLAME SAFEGUARD CONTROLLER AND CONTROL PANEL

A. Flame Safeguard

1. Each boiler shall be factory equipped with flame safeguard controller providing technology and functions equal to the Cleaver-Brooks Model CB780E or Hon-

eywell RM7800L with display module.

2. Controller shall be computerized solid state having sequence and flame-on lights and digital "first out" fault code indications of flame safeguard trip functions. It shall include dynamic self-check logic. The controller shall have a fixed operating sequence incapable of being manually altered. The sequence shall include start, pre-purge, pilot and main fuel ignition run and post-purge cycles.

3. Controller shall be the non-recycle type for maximum safety that shall shutdown the burner and indicate as a minimum the following trip functions: pilot and main flame failure, high and low fire proving switch faults, running interlocks open, false flame signal and fuel valve open (when proof of closure switch is furnished).

4. The controller shall have a run/test switch. It shall allow interruptions to sequence just after pre-purge, during pilot ignition trial and run cycles for adjustments to firing rate motor, damper linkages and pilot flame for minimum turndown tests.

B. Control/Entrance Panel- A single common enclosure shall house the control panel and the entrance panel shall be factory mounted and wired on boiler. Enclosure shall be NEMA 4 rated and shall be mounted at the side of the boiler in a location convenient to the operator. Enclosure shall consist of upper and lower sections divided by a partition with a separate hinged door for each section. Upper section (low voltage) will house boiler controls including flame safeguard, water level system controller, and Integrated Boiler control system. Lower panel section (high voltage) will house entrance panel.

1. The panel shall contain the boiler flame safeguard controller, blower motor starter, indicating lights and selector switches. The panel shall have a removable sub-base for mounting the flame safeguard controller, blower motor starter, plug-in type fuel modules and terminal blocks. For combination gas-oil and heavy oil fired boilers the plug-in fuel module shall contain the fuel selector and/or oil heater selector switch.

2. The panel shall contain the following lights, switches and details:

a. Lights:
1) White - load demanded.
2) White - fuel valve open.
3) Red - low water.
4) Red - flame failure.

b. Control Switches
1) Burner On-Off.
2) Manual-Automatic.
3) Manual Firing Rate Control.

c. Oil, heat and moisture resistant wire shall be used and identified with circuit numbers corresponding to the electrical wiring diagram.
d. All electrical equipment and wiring shall be in conformance with Underwriters Laboratories requirements.
e. Boiler to be supplied with a control circuit transformer and fuse protection for the control circuit.
f. 4” Alarm Bell.
g. Terminals for Remote Emergency Shutoff.
h. Emergency Power Transfer Time Delay Circuit.

C. Integrated Control System -Each unit shall be factory equipped with a Boiler Control System providing technology and functions equal to the CB-HAWK ICS Advanced Boiler Control system.

1. ALTERNATE: Integrated Control System furnished, installed, and warranted by boiler manufacturer shall have design and function as specified below as manufactured by Preferred Instrument Model TS.

2. Each Boiler Control System shall be factory equipped with a pre-configured Programmable Controller and Human Machine Interface (HMI).

3. Major system components shall include:

a. Programmable Controller
b. 10” Color Touch Screen HMI
c. DeviceNet™ Communication Network
d. Various Controller Input/Output Modules
e. One Burner Management Controller and Wiring Sub-Base
f. One Flame Scanner: Infrared, Ultra-Violet, or UV Self-Check
g. One Flame Amplifier, to correspond with the selected Flame Scanner
h. Various Temperature and Pressure Sensors

4. Major functions that the Boiler Control System shall provide:

a. Automatic sequencing of the boiler through standby, pre-purge, pilot flame establishing period, main flame establishing period, run and post purge
b. Flame proving and lockout on flame failure during pilot flame proving, main flame proving, or run
c. Low fire damper/valve position for flame ignition trials
d. Full modulating control of fuel and combustion air
e. Utilize solid state controls and sensors to provide various control functions, such as:
   1) On/Off, and Modulating Control
   2) Modulating Control algorithm shall be Proportional-Integral-Derivative (PID) type
   3) Thermal Shock Protection based on water temperature and setpoint
   4) Various High and Low limit alarms and shutdowns

f. Touch Screen graphical operator interface and monitoring

1) Manual control of the boiler-firing rate utilizing control screens on the HMI to increment and decrement the firing rate
2) On screen indication of burner management controller status and diagnostics
3) On screen real-time display of all connected process parameters
4) On screen display of system alarms and faults
5) On screen history of alarms and faults
6) On screen recommendation for troubleshooting fault conditions
7) On screen water level indication (optional) and alarm(s)
8) Printing Alarm/Fault history

g. Building/Plant Automation System interface protocol translator through Master Panel
h. Ethernet communications
i. Tamper resistant control logic and password protection.
j. Night/Day Setback control
k. Stack Flue Gas, Combustion Air (optional), and Shell (water) temperatures
l. Boiler Efficiency calculation
m. Remote Modulation or Firing Rate Setpoint control
n. Assured Low Fire Cut-Off (ALFCO)
o. Assured Start Permissive Safety Interlocking

5. The Boiler Control System shall provide the following safety provisions for:

a. Integrated Burner Management
1) Examine all load terminals to assure it is capable of recognizing the true status of the external controls, limits and interlocks. If any input fails this test, the burner management system should lockout on safety shutdown.
2) Closed-loop logic test verifies integrity of safety critical loads (ignition, pilot, and main fuel valves) and must be able to lockout on safety.
3) Pre-ignition interlocks (fuel valve proof of closure, etc.) and flame signal checked during Standby and Pre-Purge.
4) Dynamic checking of the flame signal amplifier. The control flame signal amplifier must be able to recognize a no flame signal during this dynamic amplifier check.
5) Safe start check and expand check to include monitoring flame signal during standby.
6) High and Low fire switches checked for proper sequencing.
7) Tamper-proof Purge Timing and safety logic

b. Integrated Boiler Controls

1) Operating and Modulating Control
2) Primary Low Water Cut-Off
3) Variable Speed Drive (if used) fault shutdown
4) Password protection of Programmable Controller Logic
5) Password protection of Parallel Positioning Control (if used)

6. The Boiler Control System shall provide annunciation and diagnostics:

a. Active alarm annunciation
b. Provide historical alarm information for on screen display
c. Detects and isolates an alarm, and reports internal circuit faults
d. Printer output capable for logging alarms
e. Capability of printing alarm history of date, time, cycle of occurrence and date and time of acknowledgement up to the most recent 100 faults
f. English text description of the system fault and troubleshooting procedures
g. Water Level indication and low water Shutdown Alarm
h. Dynamic Self Checking
i. Natural Gas Flow and Totalization
j. Feedwater Flow and Totalization

7. The Boiler Control System shall be able to operate in these environmental conditions.

a. Supply Voltage: 120 VAC (+10%/-15%) 50 or 60 Hz
b. Maximum total connected load: 2000 VA
c. Operating temperature limits: 32 to 130°F
d. 85% RH continuous, non-condensing, humidity
e. 0.5G continuous vibration

8. All Boiler Control System wiring shall be in accordance with the National Electrical Codes and local electrical codes.

9. Boiler Control System component functions shall be as follows:

a. Burner Management Controller: Provides boiler sequencing logic to meet FM/IRI/UL/cUL approval body requirements.
b. Touch Screen Graphical Interface: Provides user interface to the control system, boiler overview screen with connected boiler parameter readouts, Burner Management Control status screen, alarm banners, diagnostic screens for fault troubleshooting, alarm history screen, system firing rate screen and system configuration screens.
c. DeviceNet™ Communication Network: Provides communication between the Programmable Controller and other peripheral devices.
d. Various Programmable Controller Input/Output modules: Provides interface for discrete powered and/or isolated relay signals, as well as for analog signals, from and/or to other input/output devices.
e. Stack Temperature Sensor: Measures and transmits a signal to the Pro-

grammable Controller in relation to boiler exit flue gas temperature. It is used for indication and in the calculation of boiler efficiency; it can also be used for high stack temperature alarm and shutdown.

f. Steam Pressure Transmitter (Steam Boiler): Provides an analog signal to the Programmable Controller for indication of boiler steam pressure; utilized for on/off and modulating control of the burner..

g. Water (shell) Temperature Sensor: Measures and transmits a signal to the Programmable Controller in relation to boiler water temperature; used for indication and thermal shock protection

D. Parallel Positioning Combustion Control- The integrated control system shall provide cross limited parallel positioning control of fuel, combustion air and flue gas recirculation (FGR). Individual actuators will be used to control each of above functions:

1. Air control - Firing rate control signal is compared with corrected fuel actuator position signal. Highest of the two values is a control signal for the combustion air actuator. Velocity limiter with adjustments in both directions (up and down) shall be provided. Control signal to the actuator is compared with feedback signal. If unacceptable error is detected for the preset amount of time, system will be shut down and fault will be annunciated.

2. Fuel control -Firing rate control signal is compared with air actuator position signal. Lowest of the two values is an input to the function generator. Output of the function generator is a control signal for the fuel actuator. Function generator has to have a minimum of 10 break points. The X-axis and Y-axis parameters must follow the relationship: X[1] < X[2] < X[3] <... < X[n], Y[1] < Y[2] < Y[3] < … < Y[n] Where n is the number of break points (20 maximum). Velocity limiter with adjustments in both directions (up and down) shall be provided. Control signal to the actuator is compared with feedback signal. If an unacceptable error is detected for the preset amount of time, system will be shut down and fault will be annunciated.

3. FGR control - Firing rate control signal is compared with air actuator position signal. Lowest of the two values is an input to the function generator. Output of the function generator is a control signal for the FGR actuator. Function generator has to have a minimum of 10 break points. The X-axis parameters must follow the relationship: X[1] < X[2] < X[3] <... < X[n], Where n is the number of break points (20 maximum). Velocity limiter with adjustments in both directions (up and down) shall be provided. Control signal to the actuator is compared with feedback signal. If unacceptable error is detected for the preset amount of time, system will be shut down and fault will be annunciated.

E. O_2 Trim Control – The integrated control system shall utilize a sensor in the stack outlet of the boiler to measure the oxygen concentration in the flue gas to adjust the fuel to air ratio of the combustion system to maintain maximum efficiency.

1. Oxygen Sensor – The oxygen sensor shall be a Zircona cell with temperature

held constant by a heater in an in-situ type stainless steel probe to provide fast response to changes in oxygen levels.

2. Air Trim - Interlinked with the Parallel Positioning system the integrated control shall continuously monitor oxygen concentration in boiler flue gas and trim the air flow actuator to maintain oxygen level at set point. Set point shall be dependent on boiler firing rate and fuel selection inputs to controller. Controller shall determine set point internally based on these inputs, through separate curves ("function generators") for each fuel. The rate-of-change of the firing rate input shall be limited to allow for the response time of the gases traveling through the boiler. Control to be direct acting. Proportional- plus-Integral (PI) with integral-only response to set point changes. Gain shall be varied based on firing rate, with faster response at high firing rates and slower response at low firing rates. Control to incorporate anti-reset windup capabilities when output reaches its limit. Since trim output must be able to add or subtract from fuel or air flow, the normal or "no trim" output shall be 50%.

3. Ambient Air Temperature - A thermocouple shall measure ambient air temperature to provide boiler efficiency calculation in conjunction with oxygen level and stack temperature and readout displayed on the HMI panel

F. Draft Control – The integrated control system shall utilize a modulating damper assembly on the boiler stack outlet to control the draft at the stack outlet. The integrated control system shall sense the pressure in the stack from a differential pressure transducer in the stack outlet and modulate the damper position to maintain a constant draft pressure. The control algorithm shall utilize feed forward control with outlet damper tracking in step with firing rate along a pre-programmed curve.

G. Variable Speed Combustion Air Control -The integrated control system shall provide a Variable Speed Drive controller for use on the burner's Combustion Air Fan blower motor for the purpose of providing Improved Boiler Efficiency and Reduced Electrical Energy consumption.

1. The Drive's voltage, frequency, and current ratings shall be rated in accordance with the electrical requirements as dictated by job site specifics, and for the properly rated motor horsepower.

2. The Variable Speed Drive must be capable of communicating over the Modbus protocol.

3. A Motor suitable for variable speed drive service must be supplied for use in conjunction with the Variable Speed Drive, and sized to match the motor requirements of the Combustion Air Fan Blower.

4. Variable Speed Drive shall be interlocked with boiler control to ensure safe operation.

H. The following additional sensors shall be included provided with the integrated control system and readout displayed on the HMI panel:

1. Economizer Feedwater Inlet Thermocouple

2. Economizer Feedwater Outlet Thermocouple

3. Economizer Stack Outlet Thermocouple

I. MASTER PANEL – A single NEMA 4 panel shall house separate process controller to interface to all boilers to facilitate Lead/Lag boiler function and building management communications. A 10" Color Touch Screen HMI shall be mounted in the panel door for display, setup, and diagnostics.

1. Lead / Lag Control – The integrated control system shall interface with the boilers with programming to automatically sequence up to six (7) boilers to maintain a steam header pressure.

a. Sequence of Operation - Unison Modulation. Steam pressure is compared with the setpoint and controller's processor executes PID algorithm. Lead boiler is commanded to come on-line first. Lag boiler #1 is commanded to come online when a firing rate signal for the lead boiler reaches lag boiler start point. Lag boiler #1 is commanded to stop when a firing rate signal for the lead boiler reaches lag boiler stop point. Lag boiler #2 is commanded to come on-line when a firing rate signal for the lag boiler #1 reaches lag boiler #2 start point. Lag boiler #2 is commanded to stop when a firing rate signal for the lag boiler #1 reaches lag boiler #2 stop point. Firing rates for all boilers are equal.

b. Hot Standby - System shall have a provision for keeping lag boilers in hot standby. Standby routine shall be based on a water temperature signal.

c. Firing Sequence Selection - Sequence in which boilers come on-line shall be selected via HMI. Adequate check shall be provided that does not allow improper sequence selection.

d. Automatic Rotation of the Boilers - System shall be provided with a sequence to automatically rotate sequence in which the boilers are fired. Rotation shall be based on the elapsed time.

e. Master panel shall include HMI for display and selection of the following parameters:

1) Display

- Available boilers
- Number of boilers required
- Selected sequence of firing
- Control output to each boiler
- Header steam pressure or water temperature on hot water Systems

- Setpoint
- Elapsed time from last rotation

2) Selection

- Number of boilers
- Sequence of firing
- Automatic or manual rotation
- Individual boiler start and stop points with timers
- Setpoint
- Proportional, integral and derivative gains for control algorithm

2. Building Management Communications – A protocol translator shall provide an interface to the Siemens Apogee Building Management System. The protocol translator shall be pre-programmed to provide data point reading from and non-safety related data point writing to each boiler and the lead/lag system through an Ethernet port to the Apogee system. A list of data points shall be provided to allow the building management system contractor to program interface to their system.

3. A 16-port industrial grade Ethernet Switch hub shall be provided to allow inter-face of all Ethernet device communications.

J. Combustion air control: motor operator with potentiometer controlling the combustion air damper and fuel metering valves to regulate the fire according to demand.

2.7 ELECTRICAL POWER

A. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in electrical Sections.

B. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.

1. House in NEMA 250, Type [**1**] [**4**] [**4X**] [**12**] enclosure.
2. Wiring shall be numbered and color-coded to match wiring diagram.
3. Install wiring outside of an enclosure in a [**metal**]raceway.
4. Field power interface shall be to fused disconnect switch.
5. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
6. Provide each motor with overcurrent protection.

2.8 CAPACITIES AND CHARACTERISTICS

A. Heating Medium: Steam.

B. Design Pressure Rating: [**30 psig (207 kPa)**] [**60 psig (420 kPa)**] [**100 psig (690 kPa)**] [**125 psig (860 kPa)**] [**140 psig (966 kPa)**] [**160 psig (1100 kPa)**].

C. Design Pressure Rating: [**15 psig (104 kPa)**] [**150 psig (1035 kPa)**] [**200 psig (1380 kPa)**] [**250 psig (1725 kPa)**] [**300 psig (2070 kPa)**] [**350 psig (2415 kPa)**].

D. Safety Relief Valve Setting: <**Insert psig (kPa).**>

E. Entering-Water Temperature: <**Insert deg F (deg C).**>

F. Leaving-Water Temperature: <**Insert deg F (deg C).**>

G. Design Water Flow Rate: <**Insert gpm (L/s).**>

H. Design Pressure Drop: <**Insert psig (kPa).**>

I. Steam Operating Pressure: <**Insert psig (kPa).**>

J. Steam Flow Rate: <**Insert lb/h (kg/s).**>

K. Minimum Efficiency AFUE: <**Insert number**> percent.

L. Minimum Thermal Efficiency: <**Insert number**> percent.

M. Minimum Combustion Efficiency: <**Insert number**> percent.

N. Maximum Excess Air Percentage: <**Insert number>** percent

O. AGA Input: <**Insert MBh (kW).**>

P. I=B=R Input: <**Insert MBh (kW).**>

Q. Gas Input: <**Insert cfh (mL/s).**>

R. Oil Input: <**Insert gph (mL/s).**>

S. AGA Output Capacity: <**Insert MBh (kW).**>

T. DOE Output Capacity: <**Insert MBh (kW).**>

U. Equivalent Direct Radiation: <**Insert EDR (W).**>

V. Burner Blower:

1. Motor Horsepower: <**Insert value.**>
2. RPM: <**Insert value.**>

W. Electrical Characteristics:

1. Volts: [**115**] [**208**] [**230**] [**460**] V.
2. Phase: [**Single**] [**Three**].
3. Hertz: [**50**] [**60**].
4. Full-Load Amperes: <**Insert value.**>
5. Minimum Circuit Ampacity: <**Insert value.**>
6. Maximum Overcurrent Protection: <**Insert amperage.**>

2.9 SOURCE QUALITY CONTROL

A. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

B. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

C. Allow Cleveland Clinic access to source quality-control testing of boilers. Notify Architect 14 days in advance of testing.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 BOILER INSTALLATION

A. Equipment Mounting: Install boilers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**]

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct bases to withstand, without damage to equipment, seismic force required by code.
3. Construct concrete bases [**4 inches (100 mm)**] [**6 inches (150 mm)**] [**8 inches (200 mm)**] high and extend base not less than 6 inches (150 mm) in all directions beyond the maximum dimensions of boiler unless otherwise indicated or unless required for seismic anchor support.

4. Minimum Compressive Strength: [**5000 psi (34.5 MPa)**] [**4500 psi (31 MPa)**] [**4000 psi (27.6 MPa)**] [**3500 psi (24.1 MPa)**] [**3000 psi (20.7 MPa)**] at 28 days.
5. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
6. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
7. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
8. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Equipment Mounting: Install boilers on cast-in-place concrete equipment base(s) using [**elastomeric pads**] [**elastomeric mounts**]. Comply with requirements for equipment bases specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**] Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1 inch (25 mm)**].
2. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.
7. Install on [**4-inch- (100-mm-)**] [**6-inch- (150-mm-)**] high concrete base[**designed to withstand, without damage to equipment, seismic force required by code**].

C. Equipment Mounting: Install boilers using [**elastomeric pads**] [**elastomeric mounts**]. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1 inch (25 mm)**].

D. Install gas-fired boilers according to NFPA 54.

E. Install oil-fired boilers according to NFPA 31.

F. Assemble and install boiler trim.

G. Install electrical devices furnished with boiler but not specified to be factory mounted.

H. Install control wiring to field-mounted electrical devices.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.

D. Connect oil piping full size to burner inlet with shutoff valve and union.

E. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tappings with shutoff valve and union or flange at each connection.

F. Install piping from safety relief valves to nearest floor drain.

G. Install piping from safety valves to drip-pan elbow and to nearest floor drain.

H. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

I. Connect breeching full size to boiler outlet. Comply with requirements in Section 235100 "Breechings, Chimneys, and Stacks" for venting materials.

J. Install flue-gas recirculation duct from vent to burner. Comply with requirements in Section 235100 "Breechings, Chimneys, and Stacks" for recirculation duct materials.

K. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

L. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

a. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.
b. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and [**water temperature**] [**steam pressure**].
c. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Remove and replace malfunctioning units and retest as specified above.

D. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

E. Performance Tests:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment in order to comply.
3. Perform field performance tests to determine the capacity and efficiency of boilers.

    a. For dual-fuel boilers, perform tests for each fuel.
    b. Test for full capacity.
    c. Test for boiler efficiency at low fire, 20, 40, 60, 80, 100, 80, 60, 40 and 20 percent of full capacity. Determine efficiency at each test point.

4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
7. Notify Architect in advance of test dates.
8. Document test results in a report and submit to Architect.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain boilers. Video training sessions. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 235239

SECTION 235313 - BOILER FEEDWATER PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Feedwater pumps and receivers.
2. Vacuum-type feedwater pumps and receivers.

1.3 DEFINITION

A. NPSH: Net-positive suction head.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacity, temperature and NPSH required, pump performance curves with selection points clearly indicated, and furnished specialties and accessories.

B. Shop Drawings: Include plans, elevations, sections, details, dimensions, weights, loadings, required clearances, method of field assembly, and attachments to other work.

1. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Manufacturer Seismic Qualification Certification: Submit certification that feedwater equipment, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of internal and external parts during a seismic event and the unit will be fully operational after the event."

2. Dimensioned Outline Drawings of Equipment: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For feedwater equipment to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Regulatory Requirements: Fabricate and test unit according to ASME PTC 12.1, "Closed Feedwater Heaters."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. ASME Compliance: [**ASME B31.1, "Power Piping," for systems more than 15 psig (104 kPa)**] [**ASME B31.9, "Building Services Piping," for systems equal to or less than 15 psig (104 kPa)**]. Safety valves and pressure vessels shall bear the appropriate ASME label.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Preparation for Shipping: Clean flanges and exposed-metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store units in dry location.

C. Retain protective flange covers and machined-surface protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with manufacturer's written rigging instructions.

1.9 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

PART 2 - PRODUCTS

2.1 FEEDWATER UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AESYS Technologies, LLC; Boiler Div.
2. Alyan Pump.
3. Aurora Pump; Pentair Pump Group.
4. BFS Industries, LLC.
5. Bryan Boilers; Bryan Steam, LLC.
6. Cleaver-Brooks; Div. of Aqua-Chem, Inc.
7. Deaerating Designs; a division of Precision Boilers, Inc.
8. Domestic Pump; a unit of ITT Fluid Technology.
9. Eastern Industrial Products, Inc.; Smith-Koch, Inc. Div.
10. Flotronics, Inc.
11. Gerow Equipment Co.; Pump & Hydraulic Division.
12. Hurst Boiler & Welding Company, Inc.
13. Industrial Steam.
14. Lattner Boiler Manufacturing.
15. Lockwood Products, Inc.; Sub. of John L. Underwood Co., Inc.
16. MEPCO (Marshall Engineered Products Co.).
17. Parker Boiler Co.
18. PVI Industries, LLC.
19. Roth Pump Company; a subsidiary of Roy E. Roth Co.
20. Sellers Engineering Co.
21. Shippensburg Pump Co., Inc.
22. Skidmore.
23. Stickle Steam Specialties Co., Inc.
24. Superior Boiler Works, Inc.
25. U.S. Deaerator Co.
26. US Filter.

B. Description: Factory-assembled and -tested unit consisting of a receiver, simplex feedwater pumps, controls, and the following features and accessories:

1. [**Liquid-filled industrial**][**Bimetal dial-type**] thermometer graduated in Fahrenheit.
2. Level gage glass, with stops at top and bottom.
3. Lifting eyes.
4. Companion flanges.
5. Pump, suction and discharge isolation valve, inlet strainer, discharge check valve, and liquid-filled pressure gage.
6. Makeup Water Assembly: Electric level controller and valve; with inlet strainer and three-valve bypass.
7. Feedwater Heater: Sparge tube, thermostat, and control valve.
8. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A 53/A 53M, Type S (seamless), Grade B; or ASTM A 106, Type S, Grade B, Schedule 80; with threaded joints and fittings.

a. Cast-Iron Threaded Fittings: ASME B16.4; Class 250.
b. Malleable-Iron Threaded Fittings: ASME B16.3, Class 300.
c. Forged-Steel Fittings: ASME B16.11, Class 3000.
d. Malleable-Iron Unions: ASME B16.39; Class 300.
e. Forged-Steel Unions: MSS SP-83, Class 3000.

9. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule 80; with welded joints and carbon-steel fittings and flanges.

a. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
b. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class [**150**] [**300**], including bolts, nuts, and gaskets.

C. Receiver:

1. Material: Welded carbon steel.
2. Additional corrosion protection:

a. [**0.07-inch (1.8-mm)**] [**0.13-inch (3.3-mm)**] [**0.19-inch (4.8-mm)**] thickness allowance.
b. Electrolytic corrosion-inhibitor anode.

3. Finish: [**Primer**] [**Primer under enamel topcoat**] [**Primer under epoxy topcoat**].
4. Factory-Applied Insulation and Jacket: Minimum thickness of **2 inches (50 mm)** for mineral-fiber pipe and tank insulation. Cover insulation with [**painted steel**] [**stucco-embossed aluminum**] jacket.
5. Mounting Arrangement: Floor mounted or above.
6. Mounting Frame: Structural-steel stand to support receiver and pumps.[**Fabricate stand with bracing adequate for seismic forces according to authorities having jurisdiction and to allow anchoring mounting frame to floor.**]

D. Vertical Feedwater Pump: Flange-mounted, close-coupled, single-stage, radially split-case-design centrifugal pump; rated for **175-psig (1205-kPa)** minimum working pressure and a continuous water temperature of at least **225 deg F (107 deg C)**; with the following features:

1. Impeller: Bronze.
2. Seals: Mechanical.
3. Motor: Totally enclosed fan-cooled enclosure. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

E. Horizontal Feedwater Pump: Base-mounted, single-stage, radially split-case-design centrifugal pump; rated for **175-psig (1205-kPa)** minimum working pressure and a continuous water temperature of at least **225 deg F (107 deg C)**; with the following features:

1. Impeller: Bronze.
2. Coupling: [**Close**] [**Flexible**].
3. Seals: Mechanical.
4. Motor: Totally enclosed fan-cooled enclosure. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

F. Control panel shall be unit mounted and factory wired and include the following:

1. NEMA 250, Type [**1**] [**4**] [**4X**] [**12**] enclosure.
2. Single-point field power interface to fused disconnect switch.

    a. Branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.

3. NEMA-rated motor controller for each motor, and include a hand-off-auto switch and overcurrent protection.

    a. Alternating controls for duplex units with intermittent operation as indicated by control sequence.

4. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
5. Wiring outside of an enclosure in a [**metal**]raceway. Make connections to motor with liquidtight conduit.
6. Removable control mounting plate.
7. Visual indication of status and alarm with momentary test push button.
8. Audible alarm and silence switch.
9. Visual indication of elapsed run time, graduated in hours.
10. Fused control-circuit transformer.
11. Microprocessor-based controller.

G. Feedwater Simplex-Pump Control Sequence:

1. Boiler water-level controller starts and stops pump to maintain boiler water-level set point.
2. Visual indication of pump on and off status.
3. Visual and audible alarm indication of pump failure.

H. Receiver Makeup Water Control Sequence:

1. Electric level controller operates electric control valve to maintain receiver water-level set point.
2. Mechanical float operates integral valve to maintain water-level set point.
3. Visual and audible alarm indication of low and high receiver-water level.

I. Building Management System Interface: Factory install hardware to enable building management system to monitor and display points.

1. Hardwired Monitoring Points: On/off status for each pump[**, failure alarm for each pump**] [**, receiver low-water-level alarm**] [**, receiver high-water-level alarm**] [**, feedwater temperature**].

J. Capacities and Characteristics:

1. Condensate Receiver:

    a. Volume: <**Insert gal. (L).**>
    b. Diameter: <**Insert inches (mm).**>

c. Length: <**Insert inches (mm).**>
d. Height to Condensate Inlet: <**Insert inches (mm).**>
e. Condensate Return Minimum Inlet Size: <**Insert NPS (DN).**>
f. Makeup Water Minimum Inlet Size: <**Insert NPS (DN).**>
g. Sparge-Tube Steam Supply: <**Insert lb/h (kW).**>

2. Feedwater Pumps:

a. No. of Pumps: [**Simplex**] [**Duplex**].
b. Flow Rate: <**Insert gpm (L/s).**>
c. NPSH Required: <**Insert psig (kPa).**>
d. Rated Operating Temperature: <**Insert deg F (deg C).**>
e. Head Pressure: <**Insert psig (kPa).**>
f. Horsepower: <**Insert horsepower.**>
g. Speed: <**Insert value**> RPM.
h. Volts: [**115**] [**208**] [**230**] [**460**] V.
i. Phase: [**Single**] [**Three**].
j. Hertz: 60.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before feedwater unit installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting feedwater unit performance, maintenance, and operations.

1. Final feedwater unit locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Equipment Mounting: Install feedwater unit on cast-in-place concrete equipment base. Comply with requirements for equipment bases specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**]

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct bases to withstand, without damage to equipment, seismic force required by code.
3. Construct concrete bases [**4 inches (100 mm)**] [**6 inches (150 mm)**] [**8 inches (200 mm)**] high and extend base not less than 6 inches (150 mm) in all directions beyond the maximum dimensions of feedwater unit unless otherwise indicated or unless required for seismic anchor support.
4. Minimum Compressive Strength: [**5000 psi (34.5 MPa)**] [**4500 psi (31 MPa)**] [**4000 psi (27.6 MPa)**] [**3500 psi (24.1 MPa)**] [**3000 psi (20.7 MPa)**] at 28 days.

5. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
6. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
7. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
8. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Equipment Mounting: Install feedwater unit on cast-in-place concrete equipment base using [**elastomeric pads**] [**elastomeric mounts**]. Comply with requirements for equipment bases specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**] Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1 inch (25 mm)**].
2. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.
7. Install on [**4-inch- (100-mm-)**] [**6-inch- (150-mm-)**] high concrete base[**designed to withstand, without damage to equipment, seismic force required by code**].

C. Equipment Mounting: Install feedwater unit using [**elastomeric pads**] [**elastomeric mounts**]. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1 inch (25 mm)**].

D. Install unit to permit access for maintenance.

E. Support piping independent of pumps.

F. Install base-mounted pumps on concrete bases with grouted base frames.

G. Install parts and accessories shipped loose.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect makeup water piping and cooling-water piping with reduced-pressure backflow preventers.

D. Install overflow drain piping to nearest floor drain.

E. Install vents and extend to outdoors; terminate with elbow turned down and an insect screen.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Tests and Inspections:

1. Inspect field-assembled components, equipment installation, and piping and electrical connections for compliance with manufacturer's written instructions.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Check bearing lubrication.
4. Verify proper motor rotation.
5. Start up service.
6. Report results in writing.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust boiler water-level controls to properly stage unit.

B. Set field-adjustable, makeup water and cooling-water controls.

3.6 CLEANING

A. Clean equipment internally; remove coatings applied for protection during shipping and storage, foreign material, and oily residue according to manufacturer's written instructions.

B. Clean strainers.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain feedwater units. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 235313

SECTION 235316 - DEAERATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes packaged, factory-assembled deaerators.

1.3 DEFINITIONS

A. Feedwater Pump: Pump that moves feedwater from the deaerator to the boiler.

B. Transfer Pump: Pump that moves feedwater from the surge tank to the deaerator.

C. NPSH: Net-positive suction head.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated makeup water, feedwater, and steam flow rates; working pressure; tank capacities; storage capacity in minutes; temperature and NPSH required; pump performance curves with selection points clearly indicated; furnished specialties; and accessories.

B. Shop Drawings: For deaerators, signed and sealed by a qualified professional engineer; include plans, elevations, sections, details, dimensions, weights, loadings, required clearances, and attachments to other work.

1. For installed products indicated to comply with design loads, include structural analysis data.
2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing deaerator bases.
3. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Manufacturer Seismic Qualification Certification: Submit certification that deaerators, accessories, and components will withstand seismic forces as indicated in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For deaerators to include in emergency, operation, and maintenance manuals.

1.7 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASME Compliance: ASME Section VIII Pressure Vessel Code. [**ASME B31.1, "Power Piping," for systems more than 15 psig (104 kPa)**] [**ASME B31.9, "Building Services Piping," for systems equal to or less than 15 psig (104 kPa)**]. Safety valves and pressure vessels shall bear the appropriate ASME label.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Protect flanges, pipe openings, nozzles, bearings, and couplings from damage during shipping and storage.

B. Comply with manufacturer's written rigging instructions.

C. Deliver deaerators as factory-assembled units with protective crating and covering.

1.9 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.10 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Gaskets: Furnish one replacement gasket(s) for each gasketed opening.
2. Gage Glass: Furnish one replacement glass(es) for each gage glass.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cleaver-Brooks; Div. of Aqua-Chem Inc.
   2. Cochrane, Inc.; a Crane Co. Company.
   3. Kansas City Deaerator Company.

2.2 MANUFACTURED UNITS

A. Horizontal, spray, single-compartment deaerator, and a separate packaged surge tank with transfer and feedwater pumps and controls to supply feedwater to deaerator.

B. Material for Wetted Components: Components in contact with water that has not been deaerated shall be made of Type [**304**] [**316**] stainless steel.

C. Adjustable Spray Valves: Type 316 stainless steel. Arrange spray valves for counterflow of steam and condensate and so corrosive gases being vented do not contact deaerator's head or shell.

D. Vent Condenser: Stainless steel, with automatic and manual vent valves.

E. Deaerator and Storage Tank:

   1. Material: Welded carbon steel.
   2. Additional Corrosion Protection:

      a. [**0.07-inch (1.8-mm)**] [**0.13-inch (3.3-mm)**] [**0.19-inch (4.8-mm)**] thickness allowance.
      b. Electrolytic corrosion-inhibitor anode.

   3. Access: Manhole in deaerator and storage tank for access to internal components for inspection and service.
   4. Factory-Applied Insulation and Jacket: Minimum thickness of **2 inches (50 mm)** for mineral-fiber pipe and tank insulation. Cover insulation with [**painted steel**] [**stucco-embossed aluminum**] [**stainless-steel**] jacket.
   5. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A 53/A 53M, Type S (seamless), Grade B; or ASTM A 106, Type S, Grade B, Schedule [**40**] [**80**]; with threaded joints and fittings.

      a. Cast-Iron Threaded Fittings: ASME B16.4, Class 250.
      b. Malleable-Iron Threaded Fittings: ASME B16.3, Class 300.
      c. Forged-Steel Fittings: ASME B16.11, Class 3000.

d. Malleable-Iron Unions: ASME B16.39, Class 300.
e. Forged-Steel Unions: MSS SP-83, Class 3000.

6. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule [**40**] [**80**]; with welded joints and carbon-steel fittings and flanges.

a. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
b. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class [**150**] [**300**], including bolts, nuts, and gaskets.

F. Accessories:

1. Lifting eyes.
2. Companion flanges.
3. Pump suction piping with vortex breaker, isolation valve, strainer, and flexible connector.
4. Pump discharge piping with check valve, isolation valve, and liquid-filled pressure gage graduated in pounds force per square inch.
5. Pump-discharge bypass [**relief valve**] [nipple **orifice**] [**relief valve with orifice plate**].
6. Makeup Water Assembly:
   a. Factory-mounted, electric, modulating valve with factory-mounted, magnetic flag type level indicator with 4-20ma water-level transmitter and controller.
   b. Factory-mounted, pneumatic modulating valve with factory-mounted water-level controller.
   c. Factory-mounted, three-valve bypass and inlet strainer.

7. Steam Pressure-Reducing Valve(s): [Steam pilot operated] **[electic actuated] [pneumatic actuated]** with three-valve bypass, and sized to reduce boiler outlet pressure to the deaerator operating pressure.
8. Tank Overflow Drain: Sized to relieve full capacity at operating pressure.
9. Safety Valve(s): ASME labeled and sized to relieve full capacity of pressure-reducing valve.
10. Vents: Manual and automatic vent valves.
11. Vacuum breaker.
12. Meters and Gages:

    a. Full-height, [high visability magnetic flag type] [water-level gage glass], and stop valve set.
    b. [**Liquid-filled industrial**] [**Bimetal dial-type**] thermometer graduated in Fahrenheit mounted to measure temperature in storage section of tank.
    c. Pressure gage graduated in pounds force per square inch mounted to measure pressure in steam section of tank.

13. Provision for chemical injection quill.
14. Chemical injection quill.
15. Sampling connection with valve.
16. Tank drain connection with valve.
17. Oxygen test kit.

G. Support Frame: Structural-steel frame for supporting tank and pumps. Weld or bolt to tank.

1. Fabricate support frame with bracing adequate for seismic forces according to authorities having jurisdiction and to allow installation by anchoring deaerators to floor only.

H. Feedwater Pump: Grundfos Multistage Vertical Centrifual Feedwater Pump with Low NPHR K option.

1. Seals: Mechanical, suitable for **250 deg F (121 deg C)**.
2. Pump Motor: **Vertical** totally enclosed fan-cooled enclosure, **close** coupled to pump. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

I. Deaerator Control and Feedwater Pump Control Panel: Factory mounted and wired and including the following:

1. NEMA 250, Type [**1**] [**4**] [**4X**] [**12**] enclosure.
2. Single-point, field power connection to fused disconnect switch.

   a. Branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.

3. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor.

   a. Alternating control as indicated by control sequence for each pump.

4. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
5. [**Metal raceway**] [**Raceway**] for factory-installed wiring outside of enclosures. Make connections to motor with liquidtight conduit.
6. Removable control mounting plate.
7. Visual indication of status and alarm with momentary test push button.
8. Audible alarm and silence switch.
9. Visual indication of elapsed run time, graduated in hours.
10. Fusible, control-circuit transformer.
11. Microprocessor-based controller.

J. Advanced Deaerator Control System (ADAC)

1. System shall be equipped with a pre-configured Programmable Controller and Human Machine Interface to provide control logic for the following funtions.
   a. 1-6 feed pumps and 1-3 transfer pumps
   b. Make up water level control for DA tank or DA and Surge
   c. Low Water, Hi Water, and Aux Low Water alarms
   d. Chemical feed control
2. Hardware Platform - Standard System
   a. Compact Logix L32E Processor or equivalent
   b. Power Supply
   c. Discrete Input Module
   d. Discrete Output Module
   e. Analog Input Module 4 Channel
   f. Analog Input Module 8 Channel
   g. Analog Output Module 2 Channel
   h. Analog Output Module 8 Channel

i. Right Termination End Cap
j. HMI Display, 7” Serial Color - Standard on single tank systems
k. HMI Display, 10” Serial Color Standard on two tank systems, optional on single tank systems
l. Optional Components
   1) 1. Veris Current Switch - sized for pump
   2) 2. Electric actuators for pump water recirculation bypass - sized for system
   3) 3. PowerFlex 70, 400, or 700 Variable Speed Drive or equivalent

3. Sensors and Transmitters
   a. Tank Level Indication
      1) Standard
         a) DA tank - GEMS Mini Sure Site with transmitter or equivalent
         b) Surge tank - GEMS Mini Sure Site with transmitter
      2) Optional
         a) DA tank - Differential pressure level transmitter
         b) Surge tank - Differential pressure level transmitter
   b. Tank Pressure and Temperature

DA tank pressure transmitter
DA pump discharge pressure transmitter
Surge tank transfer pump pressure transmitter
DA tank temperature transmitter
Surge tank temperature transmitter

   c. Pump flow proving sensors
      1) Pressure switch mounted after each pump or differential pressure switch across pump or Veris current switch on the high voltage pump motor leads.
      2) E&H or equivalent flow transmitters - sized per application

4. VALVES
   a. Make-up water valves - all sized per application
   b. DA tank glove styel make-up valve - Siemens SK electronic actuator or equivalent with 3 valve bypass and strainer
   c. DA tank emergency or glove style raw water make-up valve - Siemens SK electronic actuator or equivalent with 3 valve bypass and strainer
   d. Surge tank glove style make-up valve - Siemens SK electronic actuator or equivalent with 3 valve bypass and strainer

5. MAJOR FUNCTIONS:
   a. Feed water pump control
      1) System will be able to support up to 6 pumps, selected using the HMI (no PC or additional software required). Upon selection, graphics and control logic will be activated automatically.
      2) Pumps may be part of a common header or may feed individual boilers. If part of a common header pumps may be configured to operate in a lead/lag sequence based on system demand. If one pump per boiler hard piped, NO vsd option is available and there is not lead lag or alternation.
      3) Order of pump alternation can be automatically rotated to share running time and wear equally between pumps.
      4) For a common boiler feedwater pump discharge system, PLC monitors 4-20 mA pressure signal from boiler feedwater header to determine when to

command pumps to start/stop. In a VSD system the 4-20 mA pressure signal will determine VSD output.

5) If the pumps are feeding individual boilers, pumps will be turned on/off based on individual discrete 110 VAC signals from each boiler.

6) PLC/VSDs can only control pumps that are in AUTO mode. Pumps in manual will run continuously. The hard wired Aux Low Water pump cutoff will prevent pumps from running in any mode if water level drops below set point..

b. Transfer pump control

1) System will be able to support up to 3 pumps for transferring water from the Surge tank to the DA. Pumps are selected using the HMI; no PC or additional software required. Upon selection, graphics and control logic will be activated automatically.

2) Pumps may be configured to operate in a lead/lag sequence based on system demand. In addition, order of pump alternation can be automatically rotated to share running time and wear equally between pumps.

c. DA make-up water level control

1) The lead pump runs continuously. If DA tank level falls below set point, make up valve will modulate to add condensate. If condensate tank discharge pressure falls below set point, the PLC will command the lag transfer pump to start.

2) If surge tank discharge pressure continues tofall below set point, the PLC will sound an alarm. Operator must respond to the alarm condition and reset the alarm.

3) When level control is in manual mode, the make up valve can be opened or closed from the HMI screen, or optionally by a manual potentiometer. Either method will allow the operator to manually adjust the valve between fully open and fully closed to control the incoming flow of make up water

4) Surge tank MUV biasing mode.

a) A bias may be enabled (user defined) to force the primary MUV feeding the DA tank to close as level falls in the surge tank. The bias factor applied to the primary MUV position increases as the level in the surge tank gets lower.

b) This prevents the surge tank from pumping down to low water cutout so it can continue to run while condensate is returned to it.

c) You would then have the secondary valve plumbed to the DA from a separate source and add water to the DA to be heated, deaerated and sent to the boilers instead of adding cold water to the surge tank.

5) Pump Lead/Lag and Alternating Control

a) Selection of pumps and rotation schedule are configurable from the HMI. PLC will monitor all pumps and determine availability; pumps may be taken out of rotation for maintenance.

b) When system is in auto rotation, if a pump is not available the PLC will alternate to the next available one. If no pumps are available an alarm will sound, requiring manual reset. PLC will maintain equal run time between all pumps.

c) If Lead/Lag option is selected, pump start/stop set points are set from the HMI. Start point is based on percentage of set point achieved by previous pump in sequence. PLC internal timers will maintain minimum load fluctuations.

d) If Lead/Lag and VSD options are selected, VSD% to start/stop lag pump is set from the HMI. When lag function is activated, VSDs function in unison modulation until the speed reaches VSD stop point; then lag pump shuts off.

e) When pump alternation is selected, alternation schedule is configured from the HMI. When current pump run time is met, next pump will start and come up to speed; previous pump will then stop.

6) Chemical Feed Control

a) One set of dry contacts wired to terminal blocks will be provided to change state when any boiler feed pump is running, enabling customer chemical feed pump.

6. ADDITIONAL ADAC SYSTEM FUNCTIONS:

a. A pressure sensor mounted in steam space monitors Deaerator pressure.

b. A set of contacts on each pump's overload relay provides indication of pump failure. If VSDs or soft starters are used, a fault contact is monitored by the PLC to indicate pump failure.

c. A set of contacts on each pump starter indicates pump running. If VSDs or soft starters are used, a contact is monitored by the PLC to indicate run status.

d. A selector switch is mounted at each pump starter to allow Hand- Off-Auto switching. 'Hand' ignores all external signals except Aux Low Water Cutoff. 'Off ' ignores all signals and prevents pump from running, 'Auto' allows pump to run based on commands from the PLC.

7. ALARM FEATURES

a. DA Tank water level alarms

1) Low Water — If water level as indicated by the tank level device falls to a pre-set point, the PLC will sound an alarm, display a message on the HMI, log a message to the alarm history file, and turn on the appropriate stack light.

2) Low Low Water — If water level falls further to the pre-set Low Low Water point, the PLC will sound an alarm, display a message on the HMI, log a message to the alarm history file, and turn on the appropriate stack light and shut off all pumps.

3) Hi Water — If water level as indicated by the tank level device rises to a pre-set point, the PLC will sound an alarm, display a message on the HMI, log a message to the alarm history file, and turn on the appropriate stack light.

4) Aux Low Water — If water level falls to the pre-set Aux Low Water point, the hard wired Aux Low Water device will open, signalling the PLC and shutting down all pumps for that tank. The PLC will sound an alarm, display a message on the HMI, log a message to the alarm history file, and turn on the appropriate stack light.

b. Surge Tank water level alarms (same as above)

8. ADAC COMMUNICATION OPTIONS

a. Ethernet connectivity

1) PLC features an OPC compliant Ethernet/IP port for connection to a Building/Plant Automation System or Local Area Network.

2) Remote monitoring/data logging available using RSView software.

3) Connection to HAWK Master Panel (Note: Existing Master Panels would require a program upgrade and possibly a processor upgrade to use this option).

4) Compliance with IEEE 802.3 Physical and Data Link, TCP/IP protocol, and Control and Information Protocol (CIP) standards.

b. Other communication options

1) For Monitoring purposes only, communication to most major building management system interfaces such as Johnson Controls Metasys, ASHRAE Bacnet, LON, and Siemens will be available via a Cleaver-Brooks protocol translator bridge. Check with Cleaver-Brooks for specific information.

2) Data can be transferred by Ethernet through a CB Master Panel to a customer BAS. If a Master Panel is unavailable, the protocol translator can be configured to communicate directly between the ADAC and the customer BAS.

2.3 SURGE TANK

A. Description: Factory-assembled and -tested unit consisting of a condensate receiver, transfer pumps, and controls.

B. Accessories:

1. Liquid-filled industrial thermometer graduated in Fahrenheit.
2. [Magnetic Flag Type Level Indicator with stops at top and bottom.
3. Lifting eyes.
4. Companion flanges.
5. Pump suction piping with vortex breaker, isolation valve, strainer, and flexible connector.
6. Pump discharge piping with check valve, isolation valve, and liquid-filled pressure gage graduated in pounds force per square inch.
7. Pump-discharge bypass [**relief valve**] [**orifice plate**] [**relief valve with orifice plate**].

C. Factory-Installed Pipe, NPS 2-1/2 (DN 65) and Smaller: ASTM A 53/A 53M, Type S (seamless), Grade B; or ASTM A 106, Type S, Grade B, Schedule 80; with threaded joints and fittings.

1. Cast-Iron Threaded Fittings: ASME B16.4, Class 250.
2. Malleable-Iron Threaded Fittings: ASME B16.3, Class 300.
3. Forged-Steel Fittings: ASME B16.11, Class 3000.
4. Malleable-Iron Unions: ASME B16.39, Class 300.
5. Forged-Steel Unions: MSS SP-83, Class 3000.

D. Factory-Installed Pipe, NPS 3 (DN 80) and Larger: ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule 80; with welded joints and carbon-steel fittings and flanges.

1. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
2. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 300, including bolts, nuts, and gaskets.

E. Tank:

1. Material: Welded carbon steel.
2. Additional Corrosion Protection:
    a. [**0.07-inch (1.8-mm)**] [**0.13-inch (3.3-mm)**] [**0.19-inch (4.8-mm)**] thickness allowance.
    b. Electrolytic corrosion-inhibitor anode.
3. Access: Manhole in tank for access to internal components for inspection and service.
4. Factory-Applied Insulation and Jacket: Minimum thickness of [**2 inches (50 mm)**] for mineral-fiber pipe and tank insulation. Cover insulation with [**painted steel**] [**stucco-embossed aluminum**] [**stainless-steel**] jacket.

F. Support Frame: Structural-steel frame for supporting tank. Weld or bolt to tank.

1. Fabricate support frame with bracing adequate for seismic forces according to authorities having jurisdiction and to allow installation by anchoring deaerators to floor only.

G. Transfer Pump: Grundfos Vertical, flange-mounted, close-coupled, multistage centrifugal with K Low NPSH option

1. Impeller: Stainless Steel.
2. Seals: Mechanical.
3. Motor: Totally enclosed fan-cooled enclosure. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

H. Transfer Pump Control Panel: Factory mounted and wired and including the following:

1. NEMA 250, Type [**1**] [**4**] [**4X**] [**12**] enclosure.
2. Single-point, field power connection to fused disconnect switch.
    a. Branch power circuit to each motor and to controls with a disconnect switch or circuit breaker.
3. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor.
    a. Alternating control indicated by control sequence for each pump.
4. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
5. [**Metal raceway**] [**Raceway**] for factory-installed wiring outside of enclosures. Make connections to motor with liquidtight conduit.
6. Removable control mounting plate.
7. Visual indication of on/off status and pump failure alarm with momentary test push button.
8. Audible alarm and silence switch.
9. Visual indication of elapsed run time, graduated in hours.
10. Fusible, control-circuit transformer.
11. ADAC Microprocessor-based controller.

2.4 CAPACITIES AND CHARACTERISTICS

A. Feedwater Flow Rate: <**Insert gpm (L/s).**>

B. Steam Flow Rate: <**Insert lb/h (kg/h).**>

C. Makeup Water Flow Rate: <**Insert gpm (L/s).**>

D. Makeup Water Temperature: <**Insert deg F (deg C).**>

E. Capacity: Capable of raising temperature of condensate and makeup water to within **3 deg F (2 deg C)** of saturated steam temperature.

F. Minimum Working Pressure: **50 psig (345 kPa)**.

G. Operating Pressure Range: [**Atmospheric**] [**From 2 to 15 psig (14 to 104 kPa)**].

H. Resultant Oxygen Content: Not more than [**0.03**] [**0.005**] **cc/L** through an operating range between [**0**] [**3**] [**5**] and 100 percent of full load.

I. Storage Tank:

1. Tank Capacity to Overflow: <**Insert gal. (L).**>
2. Storage Time: 10 minutes.

J. Feedwater Pumps:

1. No. of Pumps: Duplex.
2. Flow Rate: <**Insert gpm (L/s).**>
3. NPSH Required: <**Insert psig (kPa).**>
4. Rated Operating Temperature: <**Insert deg F (deg C).**>
5. Head Pressure: <**Insert psig (kPa).**>
6. Horsepower: <**Insert hp (kW).**>
7. Speed: <**Insert rpm.**>
8. Volts: [**115**] [**208**] [**230**] [**460**] V.
9. Phase: [**Single**] [**Three**].
10. Hertz: 60.

K. Surge Tank:

1. Tank Capacity to Overflow: <**Insert gal. (L).**>
2. Storage Time: <**Insert number**> minutes.

L. Transfer Pumps:

1. No. of Pumps: Duplex.
2. Flow Rate: <**Insert gpm (L/s).**>
3. NPSH Required: <**Insert psig (kPa).**>
4. Rated Operating Temperature: <**Insert deg F (deg C).**>
5. Head Pressure: <**Insert psig (kPa).**>
6. Horsepower: <**Insert hp (kW).**>

7. Speed: <**Insert rpm.**>
8. Volts: [**115**] [**208**] [**230**] [**460**] V.
9. Phase: [**Single**] [**Three**].
10. Hertz: 60.

2.5 FACTORY FINISHES

A. Manufacturer's standard prime-coat finish ready for field painting.

B. Manufacturer's standard paint in standard colors, applied to factory-assembled and -tested unit before shipping.

C. Do not paint aluminum, galvanized-steel, and stainless-steel surfaces.

2.6 SOURCE QUALITY CONTROL

A. Fabricate and label deaerator tanks according to ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

B. Factory install and test piping that connects pumps to tanks according to [**ASME B31.1, "Power Piping**] [**ASME B31.9, "Building Services Piping**]."

C. Factory test performance and certify test results on packaged deaerator units, according to ASME PTC 12.3, before shipping to Project.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before deaerator installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance, maintenance, and operations.

1. Final deaerator locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Equipment Mounting: Install deaerators on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**]

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct bases to withstand, without damage to equipment, seismic force required by code.

3. Construct concrete bases [**4 inches (100 mm)**] [**6 inches (150 mm)**] [**8 inches (200 mm)**] high and extend base not less than 6 inches (150 mm) in all directions beyond the maximum dimensions of deaerator unless otherwise indicated or unless required for seismic anchor support.
4. Minimum Compressive Strength: [**5000 psi (34.5 MPa)**] [**4500 psi (31 MPa)**] [**4000 psi (27.6 MPa)**] [**3500 psi (24.1 MPa)**] [**3000 psi (20.7 MPa)**] at 28 days.
5. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
6. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
7. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
8. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Equipment Mounting: Install deaerators on cast-in-place concrete equipment base(s) using [**elastomeric pads**] [**elastomeric mounts**]. Comply with requirements for equipment bases specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**] Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1 inch (25 mm)**].
2. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.
7. Install on [**4-inch- (100-mm-)**] [**6-inch- (150-mm-)**] high concrete base[**designed to withstand, without damage to equipment, seismic force required by code**].

C. Equipment Mounting: Install deaerators using [**elastomeric pads**] [**elastomeric mounts**]. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1 inch (25 mm)**].

D. Install deaerators to permit access for service and maintenance.

E. Support piping independent of pumps.

F. Install base-mounted pumps on concrete base with grouted base frame.

G. Install all parts and materials not factory installed.

H. Extend overflow drains to floor drains.

I. Extend vent piping to outside and terminate with manufacturer-approved cap furnished with deaerator.

J. Install piping adjacent to machine to allow service and maintenance.

3.3 CONNECTIONS

A. Steam and condensate piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect steam and condensate piping to tank tappings with shutoff valves and unions or flanges at each connection.

C. Connect condensate drains, pump-discharge piping, vents, overflow drains, makeup water, steam supply, and cooling water piping.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Inspect field-assembled components and equipment installation, including piping and electrical connections, for compliance with requirements.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Verify bearing lubrication.
4. Verify proper motor rotation.
5. Test Reports: Prepare a written report to record the following:

   a. Test procedures used.
   b. Test results that comply with requirements.
   c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Remove and replace malfunctioning equipment and retest as specified above.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions and do the following:

1. Set deaerator makeup water-level controls.
2. Verify bearing lubrication.
3. Verify proper motor rotation.
4. Start pumps according to manufacturer's written instructions.

3.6 ADJUSTING AND CLEANING

A. Adjust initial temperature and pressure set points.

B. Set field-adjustable switches and circuit-breaker trip ranges.

C. Clean strainers.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain deaerators. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 235316

SECTION 235700 - HEAT EXCHANGERS FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes [**shell-and-tube**] [**and**] [**plate**] heat exchangers.

1.3 DEFINITIONS

A. TEMA: Tubular Exchanger Manufacturers Association.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, and furnished specialties and accessories.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Design Calculations: Calculate requirements for selecting seismic restraints and for designing bases.
2. Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.

C. Delegated-Design Submittal: Details and design calculations for seismic restraints for heat exchangers.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Equipment room, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Tube-removal space.
2. Structural members to which heat exchangers will be attached.

B. Seismic Qualification Certificates: For heat exchanger, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Heat Exchanger: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of heat exchanger anchorage devices on which certification is based and their installation requirements.

C. Product Certificates: For each type of shell-and-tube heat exchanger. Documentation that shell-and-tube heat exchangers comply with "TEMA Standards."

D. Source quality-control reports.

E. Field quality-control reports.

F. Sample Warranty: For manufacturer's warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For heat exchangers to include in emergency, operation, and maintenance manuals.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of domestic-water heat exchangers that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including heat exchanger, storage tank, and supports.
b. Faulty operation of controls.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.

a. Shell-and-Tube, Domestic-Water Heat Exchangers:

1) Tube Coil: One year(s).
2) Other Components: One year(s).

b. Plate, Domestic-Water Heat Exchangers:

1) Brazed-Plate Type: One year(s).
2) Plate-and-Frame Type: One year(s).

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design seismic restraints for heat exchangers.

B. Seismic Performance: Heat exchangers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Component Importance Factor is [**1.5**] [**1.0**].

2.2 SHELL-AND-TUBE HEAT EXCHANGERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. API Heat Transfer Inc.
2. Armstrong Pumps, Inc.
3. ITT Corporation; Bell & Gossett.
4. TACO Incorporated.
5. Thrush Company, Inc.

B. Description: Packaged assembly of tank, heat-exchanger coils, and specialties.

C. Construction:

1. Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.
2. Fabricate and label shell-and-tube heat exchangers to comply with "TEMA Standards."

D. Configuration: U-tube with removable bundle.

E. Shell Materials: Steel.

F. Head:

1. Materials: [**Cast iron**] [**Cast stainless steel**] [**Fabricated steel**] [**Fabricated steel with removable cover**] [**Fabricated stainless steel**] [**Fabricated stainless steel with removable cover**].
2. Flanged and bolted to shell.

G. Tube:

1. [**Seamless copper**] [**Stainless-steel**] tubes.
2. Tube diameter is determined by manufacturer based on service.

H. Tubesheet Materials: Steel.

I. Baffles: Steel.

J. Piping Connections: Factory fabricated of materials compatible with heat-exchanger shell. Attach tappings to shell before testing and labeling.

1. NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
2. NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

K. Support Saddles:

1. Fabricated of material similar to shell.
2. Fabricate foot mount with provision for anchoring to support.
3. Fabricate attachment of saddle supports to pressure vessel with reinforcement strong enough to resist heat-exchanger movement during seismic event when heat-exchanger saddles are anchored to building structure.

L. Capacities and Characteristics:

1. General:

a. Shell Diameter: <**Insert NPS (DN)**>.
b. Heat-Exchanger Length: <**Insert inches (mm)**>.
c. Heat-Exchanger Surface Area: <**Insert sq. ft. (sq. m)**>.
d. Number of Passes: <**Insert number**>.
e. Heat Exchanged: <**Insert Btu/h (kW)**>.
f. Operating Weight: <**Insert lb (kg)**>.

2. Shell Side:

a. Fluid: [**Water**] [**Steam**].
b. Working Pressure: <**Insert psig (kPa)**>.
c. Supply Pressure: <**Insert psig (kPa)**>.
d. Steam Flow Rate: <**Insert lb/h (kg/h)**>.
e. Water Flow Rate: <**Insert gpm (L/s)**>.
f. Pressure Drop: <**Insert psig (kPa)**>.
g. Inlet Temperature: <**Insert deg F (deg C)**>.
h. Outlet Temperature: <**Insert deg F (deg C)**>.
i. Fouling Factor: <**Insert value**>.
j. Inlet Size: <**Insert NPS (DN)**>.
k. Outlet Size: <**Insert NPS (DN)**>.

3. Tube Side:

a. Fluid: [**Water**] [**Steam**] <**Insert type**>.
b. Working Pressure: <**Insert psig (kPa)**>.
c. Supply Pressure: <**Insert psig (kPa)**>.
d. Steam Flow Rate: <**Insert lb/h (kg/h)**>.

e. Water Flow Rate: <**Insert gpm (L/s)**>.
f. Pressure Drop: <**Insert psig (kPa)**>.
g. Inlet Temperature: <**Insert deg F (deg C)**>.
h. Outlet Temperature: <**Insert deg F (deg C)**>.
i. Fouling Factor: <**Insert value**>.
j. Inlet Size: <**Insert NPS (DN)**>.
k. Outlet Size: <**Insert NPS (DN)**>.

2.3 GASKETED-PLATE HEAT EXCHANGERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Alfa Laval Inc.
2. API Heat Transfer Inc.
3. APV; a brand of SPX Corporation.
4. Armstrong Pumps, Inc.
5. Delta T Heat Exchangers.
6. ITT Corporation; Bell & Gossett.
7. Mueller, Paul, Company.
8. Polaris Plate Heat Exchangers.
9. SEC Heat Exchangers.
10. TACO Incorporated.
11. Thermo Dynamics Ltd.
12. Tranter, Inc.

B. Configuration: Freestanding assembly consisting of frame support, top and bottom carrying and guide bars, fixed and movable end plates, tie rods, individually removable plates, and one-piece gaskets.

C. Construction: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1.

D. Frame:

1. Capacity to accommodate 20 percent additional plates.
2. Painted carbon steel with provisions for anchoring to support.

E. Top and Bottom Carrying and Guide Bars: Painted carbon steel, aluminum, or stainless steel.

1. Fabricate attachment of heat-exchanger carrying and guide bars with reinforcement strong enough to resist heat-exchanger movement during seismic event when heat-exchanger carrying and guide bars are anchored to building structure.

F. End-Plate Material: Painted carbon steel.

G. Tie Rods and Nuts: Steel or stainless steel.

H. Plate Material: [**0.024 inch (0.6 mm)**] [**0.031 inch (0.8 mm)**] [**0.039 inch (1 mm)**] thick before stamping; [**Type 304**] [**Type 304L**] [**Type 316**] [**Type 316L**] stainless steel.

I. Gasket Materials: [**Nitrile rubber**] [**EPDM rubber**].

1. Glue: Chlorine free.

J. Piping Connections: Factory fabricated of materials compatible with heat-exchanger shell. Attach tappings to shell before testing and labeling.

1. NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
2. NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

K. Enclose plates in solid [**aluminum**] [**stainless-steel**] removable shroud.

L. Capacities and Characteristics:

1. General:

a. Heat-Exchanger Surface Area: <**Insert sq. ft. (sq. m)**>.
b. Number of Plates: <**Insert number**>.
c. Number of Passes: [**One**] <**Insert number**>.
d. Heat Exchanged: <**Insert Btu/h (kW)**>.
e. Operating Weight: <**Insert lb (kg)**>.

2. Hot Side:

a. Fluid: [**Water**] [**Steam**].
b. Working Pressure: <**Insert psig (kPa)**>.
c. Supply Pressure: <**Insert psig (kPa)**>.
d. Steam Flow Rate: <**Insert lb/h (kg/h)**>.
e. Water Flow Rate: <**Insert gpm (L/s)**>.
f. Pressure Drop: <**Insert psig (kPa)**>.
g. Inlet Temperature: <**Insert deg F (deg C)**>.
h. Outlet Temperature: <**Insert deg F (deg C)**>.
i. Fouling Factor: <**Insert value**>.
j. Inlet Size: <**Insert NPS (DN)**>.
k. Outlet Size: <**Insert NPS (DN)**>.

3. Cold Side:

a. Fluid: [**Water**] [**Steam**].
b. Working Pressure: <**Insert psig (kPa)**>.
c. Supply Pressure: <**Insert psig (kPa)**>.
d. Steam Flow Rate: <**Insert lb/h (kg/h)**>.
e. Water Flow Rate: <**Insert gpm (L/s)**>.
f. Pressure Drop: <**Insert psig (kPa)**>.
g. Inlet Temperature: <**Insert deg F (deg C)**>.
h. Outlet Temperature: <**Insert deg F (deg C)**>.
i. Fouling Factor: <**Insert value**>.
j. Inlet Size: <**Insert NPS (DN)**>.
k. Outlet Size: <**Insert NPS (DN)**>.

2.4 ACCESSORIES

A. Hangers and Supports:

1. Custom, steel [**supports**] [**cradles**] for mounting on [**floor**] [**wall**] [**structural steel**].

a. Minimum Number of Cradles: <**Insert number**>.

2. Factory-fabricated steel [**supports**] [**cradles**] to ensure both horizontal and vertical support of heat exchanger. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Shroud: [**Steel**] [**Stainless-steel**] [**Aluminum**] sheet.

C. Miscellaneous Components for High-Temperature Hot-Water Unit: Control valve, valves, and piping.[**Include components fitted for pneumatic control.**]

D. Miscellaneous Components for Steam Unit: Strainers, steam-control valve, steam trap, valves, pressure gage, thermometer, and piping.[**Include components fitted for pneumatic control.**]

E. Pressure Relief Valves: [**Bronze**] [**Brass**], <**Insert NPS (DN)**>, ASME rated and stamped.

1. Pressure relief valve setting: <**Insert psig (kPa)**>.

2.5 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect heat exchangers according to ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 1. Affix ASME label.

B. Hydrostatically test heat exchangers to minimum of one and one-half times pressure rating before shipment.

C. Heat exchangers will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas for compliance with requirements for installation tolerances and for structural rigidity, strength, anchors, and other conditions affecting performance of heat exchangers.

B. Examine roughing-in for heat-exchanger piping to verify actual locations of piping connections before equipment installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SHELL-AND-TUBE HEAT-EXCHANGER INSTALLATION

A. Equipment Mounting: Install heat exchangers on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**]

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct bases to withstand, without damage to equipment, seismic force required by code.
3. Construct concrete bases [**4 inches (100 mm)**] [**6 inches (150 mm)**] [**8 inches (200 mm)**] high and extend base not less than 6 inches (150 mm) in all directions beyond the maximum dimensions of heat exchangers unless otherwise indicated or unless required for seismic anchor support.
4. Minimum Compressive Strength: [**5000 psi (34.5 MPa)**] [**4500 psi (31 MPa)**] [**4000 psi (27.6 MPa)**] [**3500 psi (24.1 MPa)**] [**3000 psi (20.7 MPa)**] at 28 days.
5. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
6. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
7. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
8. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Equipment Mounting: Install heat exchangers with continuous-thread hanger rods and [**elastomeric hangers**] [**spring hangers**] [**spring hangers with vertical-limit stop**] of size required to support weight of heat exchangers filled with water.

1. Comply with requirements for seismic-restraint devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

C. Install heat exchangers on saddle supports.

D. Heat-Exchanger Supports: Use factory-fabricated steel cradles and supports specifically designed for each heat exchanger.

3.3 GASKETED-PLATE HEAT-EXCHANGER INSTALLATION

A. Install gasketed-plate heat exchanger on custom-designed wall supports anchored to structure as indicated on Drawings.

B. Install metal shroud over installed gasketed-plate heat exchanger according to manufacturer's written instructions.

3.4 BRAZED-PLATE HEAT-EXCHANGER INSTALLATION

A. Install brazed-plate heat exchanger on custom-designed wall supports anchored to structure as indicated on Drawings.

3.5 CONNECTIONS

A. Comply with requirements for piping specified in other Section 232113 "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Comply with requirements for steam and condensate piping specified in Section 232213 "Steam and Condensate Heating Piping."

C. Maintain manufacturer's recommended clearances for tube removal, service, and maintenance.

D. Install piping adjacent to heat exchangers to allow space for service and maintenance of heat exchangers. Arrange piping for easy removal of heat exchangers.

E. Install shutoff valves at heat-exchanger inlet and outlet connections.

F. Install relief valves on heat-exchanger heated-fluid connection and install pipe relief valves, full size of valve connection, to floor drain.

G. Install vacuum breaker at heat-exchanger steam inlet connection.

H. Install hose end valve to drain shell.

I. Install thermometer on heat-exchanger and inlet and outlet piping, and install thermometer on heating-fluid inlet and outlet piping. Comply with requirements for thermometers specified in Section 230519 "Meters and Gages for HVAC Piping."

J. Install pressure gages on heat-exchanger and heating-fluid piping. Comply with requirements for pressure gages specified in Section 230519 "Meters and Gages for HVAC Piping."

3.6 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Heat exchanger will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.7 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain heat exchangers.

END OF SECTION 235700

SECTION 236416 - CENTRIFUGAL WATER CHILLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Packaged, water-cooled, electric-motor-driven centrifugal chillers.
2. Packaged, portable refrigerant recovery units.
3. Heat-exchanger, brush-cleaning system.

B. Related Section:

1. Section 283500 "Refrigerant Detection and Alarm" for refrigerant monitors, alarms, supplemental breathing apparatus, and ventilation equipment interlocks.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.

C. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.

D. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and referenced to ARI standard rating conditions.

E. kW/Ton (kW/kW): The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons (kW) at any given set of rating conditions.

F. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and intended for operating conditions other than the ARI standard rating conditions.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Centrifugal chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

B. Condenser-Fluid Temperature Performance:

1. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of [**60 deg F** **(16 deg C)**] [**55 deg F** **(13 deg C)**] [**40 deg F** **(4 deg C)**] and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
2. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of [**65 deg F** **(18 deg C)**] [**60 deg F** **(16 deg C)**] [**55 deg F** **(13 deg C)**].
3. Make factory modifications to standard chiller design if necessary to comply with performance indicated.

C. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

D. Performance Tolerance: Comply with the following in lieu of ARI 550/590:

1. Allowable Capacity Tolerance: Zero percent.
2. Allowable IPLV/NPLV Performance Tolerance: Zero percent.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.

1. Performance at ARI standard conditions and at conditions indicated.
2. Performance at ARI standard unloading conditions.
3. Minimum evaporator flow rate.
4. Refrigerant capacity of chiller.
5. Oil capacity of chiller.
6. Fluid capacity of evaporator, condenser.
7. Characteristics of safety relief valves.
8. Minimum entering condenser-fluid temperature.
9. Performance at varying capacities with constant design condenser-fluid temperature. Repeat performance at varying capacities for different condenser-fluid temperatures from design to minimum in **5 deg F** **(3 deg C)** increments.

B. LEED Submittals:

1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Structural supports.
2. Piping roughing-in requirements.
3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

B. Certificates: For certification required in "Quality Assurance" Article.

C. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control reports.

E. Startup service reports.

F. Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

A. ARI Certification: Certify chiller according to ARI 550 certification program.

B. ARI Rating: Rate chiller performance according to requirements in ARI 550/590.

C. ASHRAE Compliance:

1. ASHRAE 15 for safety code for mechanical refrigeration.
2. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.

D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

E. ASME Compliance: Fabricate and label chillers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1[**, as applicable to chiller design**]. For chillers charged with R-134a refrigerant, include an ASME U-stamp and nameplate certifying compliance.

F. Comply with NFPA 70.

G. Comply with requirements of UL and UL Canada, and include label by a qualified testing agency showing compliance.

H. Green Seal Compliance: Signed by [**manufacturer**] [**Green Seal**] certifying compliance with GS-31.

1.9 DELIVERY, STORAGE, AND HANDLING

[Retain one of first two paragraphs below.]

A. Ship chillers from the factory fully charged with refrigerant.

B. Ship each chiller with a full charge of refrigerant. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.

C. Ship each oil-lubricated chiller with a full charge of oil.

1. Ship oil in containers separate from chiller.

D. Package chiller for export shipping in totally enclosed [**bagging**] [**crate**] [**crate with bagging**].

1.10 COORDINATION

[Retain first paragraph below for mounting chillers on concrete bases.]

A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

[Retain paragraph below for mounting chillers on a structural-steel support structure.]

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

1.11 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.

1. Extended warranties include, but are not limited to, the following:

    a. Complete chiller including refrigerant and oil charge.
    b. Complete compressor and drive assembly including refrigerant and oil charge.
    c. Refrigerant and oil charge.
    d. Parts and labor.
    e. Loss of refrigerant charge for any reason.

2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Daiken/McQuay.
2. Trane; a division of American Standard.
3. YORK International Corporation.

2.2 MANUFACTURED UNIT

A. Description: Factory-assembled and -tested chiller complete with compressor, compressor motor, compressor motor controller, lubrication system evaporator, condenser, controls, interconnecting unit piping and wiring, and indicated accessories.

1. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.
2. For chillers with dual compressors, provide each compressor with a dedicated motor and motor controller, and provide for continued operation when either compressor-drive assembly fails or is being serviced.

B. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.

2.3 COMPRESSOR-DRIVE ASSEMBLY

A. Description: Single-stage or multistage, variable-displacement, centrifugal-type compressor driven by an electric motor.

1. Where indicated, provide oil-free compressor technology using a permanent magnet synchronous motor, magnetic bearings, integral variable frequency controller, and digital electronic controls.

B. Compressor:

1. Casing: Cast iron, precision ground.
2. Impeller: High-strength cast aluminum or cast-aluminum alloy on carbon- or alloy-steel shaft.

C. Drive Direct- or gear-drive, open or hermetic design using an electric motor as the driver.

[Retain first subparagraph below for gear drives.]

1. Gear Drives: For chillers with gear drives, provide single- or double-helical gear design continuously coated with oil while chiller is operating. Gears shall comply with American Gear Manufacturer Association standards.

[Retain first subparagraph below for open drives.]

2. Drive Coupling: For chillers with open drives, provide flexible disc with all-metal construction and no wearing parts to ensure long life without the need for lubrication.
3. Seals: Seal drive assembly to prevent refrigerant leakage.

D. Compressor Motor:

1. Continuous-duty, squirrel-cage, induction-type, two-pole motor with energy efficiency required to suit chiller energy efficiency indicated.
2. Factory mounted, aligned, and balanced as part of compressor assembly before shipping.
3. Motor shall be of sufficient capacity to drive compressor throughout entire operating range without overload and with sufficient capacity to start and accelerate compressor without damage.
4. For chillers with open drives, provide motor with [**open-dripproof**] [**weather-protected, Type I**] [**weather-protected, Type II**] [**totally enclosed**] enclosure.
5. Provide motor with thermistor or RTD in each of three-phase motor windings to monitor temperature and report information to chiller control panel.
6. Provide motor with thermistor or RTD to monitor bearing temperature and report information to chiller control panel.
7. Provide open-drive motor with internal electric heater, internally powered from chiller power supply.

E. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.

1. Overspeed Test: 25 percent above design operating speed.

F. Service: Easily accessible for inspection and service.

1. Compressor's internal components shall be accessible without having to remove compressor-drive assembly from chiller.
2. Provide lifting lugs or eyebolts attached to casing.

G. Economizers: For multistage chillers, provide interstage economizers.

H. Capacity Control: Modulating, variable-inlet, guide-vane assembly combined with hot-gas bypass, if necessary, to achieve performance indicated.

1. Maintain stable operation that is free of surge, cavitation, and vibration throughout range of operation. Configure to achieve most energy-efficient operation possible.
2. Operating Range: From 100 to [**15**] [**10**] [**5**] [**zero**] percent of design capacity.
3. Condenser-Fluid Unloading Requirements over Operating Range: [**Constant-design entering condenser-fluid temperature**] [**Drop-in entering condenser-fluid temperature of 2.5 deg F (1.4 deg C) for each 10 percent in capacity reduction**].
4. Chillers with variable frequency controllers shall modulate compressor speed with variable-inlet, guide-vane control to achieve optimum energy efficiency.

I. Oil Lubrication System: Consisting of pump, filtration, [**heater,**]cooler, factory-wired power connection, and controls.

1. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, coastdown, and standby conditions including power failure.
2. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.
3. Dual oil filers, one redundant, shall be the easily replaceable cartridge type, minimum 0.5-micron efficiency, with means of positive isolation while servicing.
4. Refrigerant-cooled oil cooler.
5. Factory-installed and pressure-tested piping with isolation valves and accessories.
6. Oil compatible with refrigerant and chiller components.
7. Positive visual indication of oil level.

2.4 REFRIGERATION

A. Refrigerant:

1. Type: [**R-123; ASHRAE 34, Class B1**] [**or**] [**R-134a; ASHRAE 34, Class A1**].
2. Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.

B. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.

C. Pressure Relief Device:

1. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. For Chillers Using R-123: [**Rupture disc constructed of frangible carbon**] [**Spring-loaded, pressure relief valve; single- or multiple-reseating type**].
3. For Chillers Using R-134a: ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.

D. Refrigeration Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system. Comply with requirements in ASHRAE 15 and ASHRAE 147.

E. Refrigerant Isolation for Chillers Using R-134a: Factory install positive shutoff, manual isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell. In addition, provide isolation valve on suction side of compressor from evaporator to allow for isolation and storage of full refrigerant charge in the chiller evaporator shell.

F. Purge System:

1. For chillers operating at subatmospheric pressures (using R-123 refrigerant), factory install an automatic purge system for collection and return of refrigerant and lubricating oil and for removal of noncondensables including, but not limited to, water, water vapor, and noncondensable gases.
2. System shall be a thermal purge design, refrigerant or air cooled, equipped with a carbon filter that includes an automatic regeneration cycle.
3. Factory wire to chiller's main power supply and system complete with controls, piping, and refrigerant valves to isolate the purge system from the chiller.
4. Construct components of noncorrodible materials.
5. Controls shall interface with chiller control panel to indicate modes of operation, set points, data reports, diagnostics, and alarms.
6. Efficiency of not more than 0.02 lb of refrigerant per pound of air (9 g of refrigerant per gram of air) when rated according to ARI 580.
7. Operation independent of chiller per ASHRAE 147.

G. Positive-Pressure System:

1. For chillers operating at subatmospheric pressures (using R-123 refrigerant), factory install an automatic positive-pressure system.
2. During nonoperational periods, positive-pressure system shall automatically maintain a positive pressure for atmosphere in the refrigerant pressure vessel of not less than 0.5 psig (3 kPa) adjustable up to a pressure that remains within the vessel design pressure limits.
3. System shall be factory wired and include controller, electric heat, pressure transmitter, or switch.

2.5 EVAPORATOR

A. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from condenser.

B. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.

C. Designed to prevent liquid refrigerant carryover from entering compressor.

D. Provide evaporator with sight glass or other form of positive visual verification of liquid-refrigerant level.

E. Tubes:

1. Individually replaceable from either end and without damage to tube sheets and other tubes.
2. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
3. Material: Copper.
4. Nominal OD: [**Manufacturer's choice**] [**3/4 inch (19 mm)**] [**1 inch (25 mm)**] [**3/4 or 1 inch (19 or 25 mm)**].
5. Minimum Wall Thickness: [**Manufacturer's choice**] [**0.025 inch (0.6 mm)**] [**0.028 inch (0.7 mm)**] [**0.035 inch (0.9 mm)**].
6. External Finish: Manufacturer's standard.
7. Internal Finish: [**Enhanced**] [**Smooth**] [**Enhanced or smooth**].

F. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.

G. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.

H. Water Box:

1. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. Marine type for water box with piping connections. Standard type for water box without piping connections.
3. Provide water boxes [**and marine water-box covers**]with lifting lugs or eyebolts.
4. [**Hinged**] [**Davited**] [**Hinged or davited**] water boxes.
5. [**Hinged**] [**Davited**] [**Hinged or davited**] marine water-box covers.
6. Nozzle Pipe Connections: [**Welded, ASME B16.5, flat-face flange**] [**Welded, ASME B16.5, raised-face flange**] [**Grooved for mechanical-joint coupling**] [**Grooved with mechanical-joint coupling and flange adapter**].
7. Thermistor or RTD temperature sensor factory installed in each nozzle.
8. Fit each water box with [**3/4-inch (19-mm)**] [**1-inch (25-mm)**] [**3/4- or 1-inch (19- or 25-mm)**] drain connection at low point and vent connection at high point, each with threaded plug.

I. Additional Corrosion Protection:

1. Electrolytic corrosion-inhibitor anode.
2. Coat wetted surfaces with a corrosion-resistant finish.
3. Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

2.6 CONDENSER

A. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator.

B. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.

C. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.

D. Provide condenser with sight glass or other form of positive visual verification of refrigerant charge and condition.

E. Tubes:

1. Individually replaceable from either end and without damage to tube sheets and other tubes.
2. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
3. Material: Copper.
4. Nominal OD: [**Manufacturer's choice**] [**3/4 inch (19 mm)**] [**1 inch (25 mm)**] [**3/4 or 1 inch (19 or 25 mm)**].
5. Minimum Wall Thickness: [**Manufacturer's choice**] [**0.025 inch (0.6 mm)**] [**0.028 inch (0.7 mm)**] [**0.035 inch (0.9 mm)**].
6. External Finish: Manufacturer's standard.
7. Internal Finish: [**Enhanced**] [**Smooth**] [**Enhanced or smooth**].

F. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.

G. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.

H. Water Box:

1. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
2. Marine type for water box with piping connections. Standard type for water box without piping connections.
3. Provide water boxes [**and marine water-box covers**]with lifting lugs or eyebolts.
4. [**Hinged**] [**Davited**] [**Hinged or davited**] water boxes.
5. [**Hinged**] [**Davited**] [**Hinged or davited**] marine water-box covers.
6. Nozzle Pipe Connections: [**Welded, ASME B16.5, flat-face flange**] [**Welded, ASME B16.5, raised-face flange**] [**Grooved for mechanical-joint coupling**] [**Grooved with mechanical-joint coupling and flange adapter**].
7. Thermistor or RTD temperature sensor factory installed in each nozzle.
8. Fit each water box with [**3/4-inch (19-mm)**] [**1-inch (25-mm)**] [**3/4- or 1-inch (19- or 25-mm)**] drain connection at low point and vent connection at high point, each with threaded plug.

I. Additional Corrosion Protection:

1. Electrolytic corrosion-inhibitor anode.
2. Coat wetted surfaces with a corrosion-resistant finish.
3. Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

2.7 INSULATION

A. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.

1. Thickness: **1-1/2 inches (38 mm)**.

B. Adhesive: As recommended by insulation manufacturer.

C. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.

1. Apply adhesive to 100 percent of insulation contact surface.
2. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
3. Seal seams and joints to provide a vapor barrier.
4. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.

2.8 ELECTRICAL

A. Factory installed and wired, and functionally tested at factory before shipment.

B. Single-point, field-power connection to fused disconnect switch. Minimum withstand rating shall be as required by electrical power distribution system, but not less than [**42,000**] [**65,000**] A.

1. Branch power circuit to each motor, electric heater, dedicated electrical load, and controls with disconnect switch or circuit breaker.

   a. NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
   b. NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.

2. NEMA ICS 2-rated motor controller for auxiliary motors, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller for each variable-speed motor furnished.
3. Control-circuit transformer with primary and secondary side fuses.

C. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.

D. Factory-installed wiring outside of enclosures shall be in metal raceway except make terminal connections with not more than a 24-inch (610-mm) length of liquidtight conduit.

E. Factory install and wire capacitor bank for the purpose of power factor correction to 0.95 at all operating conditions.

1. If capacitors are mounted in a dedicated enclosure, use same NEMA enclosure type as motor controller. Provide enclosure with service entrance knockouts and bushings for conduit.
2. Capacitors shall be non-PCB dielectric fluid, metallized electrode design, low loss with low-temperature rise. The kVAr ratings shall be indicated and shall not exceed the maximum limitations set by NFPA 70. Provide individual cells as required.
3. Provide each cell with current-limiting replaceable fuses and carbon-film discharge resistors to reduce residual voltage to less than 50 V within one minute after de-energizing.
4. Provide a ground terminal and a terminal block or individual connectors for phase connection.

2.9 MOTOR CONTROLLER

A. Enclosure: [**Factory installed, unit mounted**] [**Factory furnished, field mounted**], [**NEMA 250**] [**NEMA ICS 6**], [**Type 1**] [**Type 4**] [**Type 4X**] [**Type 12**], with hinged full-front access door[**with lock and key or padlock and key**].

B. Control Circuit: Obtained from integral control power transformer with a control power [**transformer**] [**source**] of enough capacity to operate connected control devices.

C. Overload Relay: Shall be sized according to UL 1995 or shall be an integral component of chiller control microprocessor.

D. Across-the-Line Controller: NEMA ICS 2, Class A, full voltage, nonreversing; include isolation switch and current-limiting fuses.

E. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition.

F. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition; include isolation switch and current-limiting fuses.

G. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.

1. Surge suppressor in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
2. Visual indication of motor and control status, including the following conditions:

   a. Controller on.
   b. Overload trip.
   c. Loss of phase.
   d. Starter fault.

H. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.

1. Externally Operated, Door-Interlocked Disconnect: Fused disconnect switch. Minimum withstand rating shall be as required by electrical power distribution system, but not less than [**42,000**] [**65,000**] A.
2. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
3. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
4. Control Relays: Time-delay relays.
5. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
6. Number-of-Starts Counter: Numerical readout on face of enclosure.
7. Meters: Panel type, **4-1/4 inches** **(108 mm)** with 120-degree scale and 2 percent accuracy. Where indicated, provide transfer device with an off position. Meters shall indicate the following:

    a. Ammeter: Output current for each phase, with current sensors rated to suit application.
    b. Voltmeter: Output voltage for each phase.
    c. Frequency Meter: Output frequency.
    d. Real-time clock with current time and date.
    e. Total run time.

8. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

    a. Selectable, digital display of the following:

        1) Phase Currents, Each Phase: Plus or minus 1 percent.
        2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
        3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
        4) Three-Phase Real Power: Plus or minus 2 percent.
        5) Three-Phase Reactive Power: Plus or minus 2 percent.
        6) Power Factor: Plus or minus 2 percent.
        7) Frequency: Plus or minus 0.5 percent.
        8) Integrated Demand with Demand Interval Selectable from Five to 60 Minutes: Plus or minus 2 percent.
        9) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.

    b. Mounting: Display and control unit flush or semirecessed in instrument compartment door.

9. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
10. Power Protection: Chiller shall shut down within six cycles of power interruption.

2.10 VARIABLE FREQUENCY CONTROLLER

A. Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.

B. Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.

C. Enclosure: Unit mounted, NEMA 250, [**Type 1**] [**Type 4**] [**Type 4x**] [**Type 12**], with hinged full-front access door with lock and key.

D. Integral Disconnecting Means: [**Door-interlocked,**]NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than [**42,000**] [**65,000**] A.

E. Technology: Pulse width modulated (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.

F. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.

1. Rectifier section shall be a full-wave diode bridge that changes fixed-voltage, fixed-frequency, ac line power to a fixed dc voltage. Silicon controller rectifiers, current source inverters, and paralleling of devices are unacceptable. Rectifier shall be insensitive to phase rotation of the ac line.
2. Regulator shall provide full digital control of frequency and voltage.
3. Inverter section shall change fixed dc voltage to variable-frequency, variable ac voltage, for application to a squirrel-cage motor. Inverter shall produce a sine-coded, pulse width modulated (PWM) output wave form and shall conduct no radio-frequency interference back to the input power supply.

G. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.

H. Operating Requirements:

1. Input AC Voltage Tolerance: 460-V ac, plus 10 percent or 506 V maximum.
2. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
3. Capable of driving full load, without derating, under the following conditions:

   a. Ambient Temperature: 0 to 50 deg C.
   b. Relative Humidity: Up to [**90**] [**95**] percent (noncondensing).
   c. Altitude: [**3300 feet (1005 m)**] [**6600 feet (2010 m)**].

4. Minimum Efficiency: 96 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 95 percent without harmonic filter, 98 percent with harmonic filter.
6. Overload Capability: 1.05 times the full-load current for 7 seconds.
7. Starting Torque: As required by compressor-drive assembly.
8. Speed Regulation: Plus or minus 1 percent.
9. Isolated control interface to allow controller to follow control signal over a 10:1 speed range.
10. To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
11. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.

I. Internal Adjustability Capabilities:

1. Minimum Output Frequency: 6 Hz.
2. Maximum Output Frequency: 60 Hz.
3. Acceleration: 2 seconds to a minimum of 60 seconds.
4. Deceleration: 2 seconds to a minimum of 60 seconds.
5. Current Limit: 30 percent to a minimum of 100 percent of maximum rating.

J. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:

1. Overtemperature.
2. Short circuit at controller output.
3. Ground fault at controller output. Variable frequency controller shall be able to start a grounded motor.
4. Open circuit at controller output.
5. Input undervoltage.
6. Input overvoltage.
7. Loss of input phase.
8. Reverse phase.
9. AC line switching transients.
10. Instantaneous overload, line to line or line to ground.
11. Sustained overload exceeding 100 percent of controller rated current.
12. Starting a rotating motor.

K. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.

L. Automatic Reset and Restart: Capable of three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Controller shall be capable of automatic restart on phase-loss and overvoltage and undervoltage trips.

M. Visual Indication: On face of controller enclosure or chiller control enclosure; indicating the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.
7. Motor speed (percent).
8. Fault or alarm status (code).
9. DC-link voltage.
10. Motor output voltage.
11. Input kilovolt amperes.
12. Total power factor.
13. Input kilowatts.
14. Input kilowatt-hours.
15. Three-phase input voltage.

16. Three-phase output voltage.
17. Three-phase input current.
18. Three-phase output current.
19. Three-phase input voltage total harmonic distortion.
20. Three-phase input current total harmonic distortion.
21. Output frequency (Hertz).
22. Elapsed operating time (hours).
23. Diagnostic and service parameters.

N. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.

O. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and six programmable digital inputs.

P. Active Harmonic Distortion Filter: Factory mounted and wired to limit total voltage and current distortion to 5 percent.

Q. Input Line Conditioning: <**Insert requirements**>.

R. Cooling: Air cooled.

S. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.

1. Control Relays: Auxiliary and adjustable time-delay relays.

T. Chiller Capacity Control Interface: Equip chiller with adaptive control logic to automatically adjust the compressor motor speed and the compressor pre-rotation inlet vane position independently to achieve maximum part-load efficiency in response to sensor inputs that are integral to the chiller controls.

2.11 CONTROLS

A. Control: Standalone and microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.

B. Enclosure: Unit mounted, NEMA 250, [**Type 1**] [**Type 4**] [**Type 4x**] [**Type 12**], hinged or lockable; factory wired with a single-point, field-power connection and a separate control circuit.

C. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units selectable through the interface, display the following information:

1. Date and time.
2. Operating or alarm status.

3. Fault history with not less than last 10 faults displayed.
4. Set points of controllable parameters.
5. Trend data.
6. Operating hours.
7. Number of chiller starts.
8. Outdoor-air temperature or space temperature if required for chilled-water reset.
9. Entering- and leaving-fluid temperatures of evaporator and condenser.
10. Difference in fluid temperatures of evaporator and condenser.
11. Fluid flow of evaporator and condenser.
12. Fluid pressure drop of evaporator and condenser.
13. Refrigerant pressures in evaporator and condenser.
14. Refrigerant saturation temperature in evaporator and condenser shell.
15. Compressor refrigerant suction and discharge temperature.
16. Compressor bearing temperature.
17. Motor bearing temperature.
18. Motor winding temperature.
19. Oil temperature.
20. Oil discharge pressure.
21. Phase current.
22. Percent of motor rated load amperage.
23. Phase voltage.
24. Demand power (kilowatts).
25. Energy use (kilowatt-hours).
26. Power factor.
27. For chillers equipped with variable frequency controllers and harmonic filters, include the following:

    a. Output voltage and frequency.
    b. Voltage total harmonic distortion for each phase.
    c. Supply current total demand distortion for each phase.
    d. Inlet vane position.
    e. Controller internal ambient temperature.
    f. Heatsink temperature.

28. Purge suction temperature if purge system is provided.
29. Purge elapsed time if purge system is provided.

D. Control Functions:

1. Manual or automatic startup and shutdown time schedule.
2. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Evaporator fluid temperature shall be reset based on [**return-water**] [**outdoor-air**] [**space**] temperature.
3. Current limit and demand limit.
4. Condenser-fluid temperature.
5. External chiller emergency stop.
6. Variable evaporator flow.
7. Thermal storage.

E. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:

1. Low evaporator pressure or temperature; high condenser pressure.
2. Low evaporator fluid temperature.
3. Low oil differential pressure.
4. High or low oil pressure.
5. High oil temperature.
6. High compressor-discharge temperature.
7. Loss of condenser-fluid flow.
8. Loss of evaporator fluid flow.
9. Motor overcurrent.
10. Motor overvoltage.
11. Motor undervoltage.
12. Motor phase reversal.
13. Motor phase failure.
14. Sensor- or detection-circuit fault.
15. Processor communication loss.
16. Motor controller fault.
17. Extended compressor surge.
18. Excessive air-leakage detection for chillers using R-123 refrigerant.

F. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.

G. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.

H. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.

I. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a modbus connection.

J. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.

1. Hardwired Points:

   a. Monitoring: On-off status, [**common trouble alarm**] [**electrical power demand (kilowatts)**] [**electrical power consumption (kilowatt-hours)**] [**power factor**].
   b. Control: On-off operation, [**chilled-water, discharge temperature set-point adjustment**] [**electrical power demand limit**].

2. ASHRAE 135 (BACnet) [**LonTalk**] [**Modbus**] [**Industry-accepted, open-protocol**] communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.

2.12 FINISH

A. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:

1. Provide at least one coat of primer with a total dry film thickness of at least 2 mils (0.05 mm).
2. Provide at least two coats of [**alkyd-modified, vinyl enamel**] [**epoxy**] [**polyurethane**] finish with a total dry film thickness of at least 4 mils (0.10 mm).
3. Paint surfaces that are to be insulated before applying the insulation.
4. Paint installed insulation to match adjacent uninsulated surfaces.
5. Color of finish coat to be [**manufacturer's standard**] [**custom color selected by Architect**].

B. Provide the Cleveland Clinic with quart container of paint used in application of topcoat to use in touchup applications after Project Closeout.

2.13 ACCESSORIES

A. Flow Switches:

1. Chiller manufacturer shall furnish a switch for each evaporator and condenser and verify field-mounting location before installation.
2. Paddle Flow Switches:

a. Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
b. Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
c. Pressure rating equal to pressure rating of heat exchanger.
d. Construct body and wetted parts of Type 316 stainless steel.
e. House switch in a NEMA 250, Type 4 enclosure constructed of die-cast aluminum.
f. Vane length to suit installation.

3. Pressure Differential Switches:

a. Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
b. Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
c. Set Point: Screw type, field adjustable.
d. Electrical Connections: Internally mounted screw-type terminal blocks.
e. Switch Enclosure: NEMA 250, Type 4.
f. Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.

B. Vibration Isolation:

1. Chiller manufacturer shall furnish vibration isolation for each chiller.

2. Neoprene Pad:

   a. Two layers of 0.375-inch- (10-mm-) thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gage, stainless-steel plate.
   b. Fabricate pads from 40- to 50-durometer neoprene.
   c. Provide stainless-steel square bearing plate to load the pad uniformly between 20 and 40 psig (138 and 276 kPa) with a 0.12- to 0.16-inch (3- to 4-mm) deflection.

3. Spring Isolator:

   a. Stable in operation and designed for not less than 30 percent reserve deflection beyond actual operating conditions. Isolators shall be designed so that the Kx/Ky ratio shall be 1.0 or more for stability.
   b. Provide PVC or neoprene-coated springs and hot-dip, galvanized-steel components. Aluminum components shall be etched and painted. Nuts, bolts, and washers shall be zinc electroplated.
   c. Isolators shall be adjustable and with an open spring, having one or more coil springs attached to a top compression plate and a baseplate. An elastomeric pad with a minimum thickness of 0.25 inch (6 mm) shall be bonded to the baseplate.
   d. Spring assembly shall be removable and shall fit within a welded steel enclosure consisting of a top plate and rigid lower housing, which serves as a blocking device during installation. Isolated restraining bolts shall not be engaged during normal operation and shall connect the top plate and lower housing to prevent the isolated equipment from rising when drained of fluid.
   e. Isolators shall be selected for a nominal [**1-inch (25-mm)**] [**2-inch (50-mm)**] deflection.

C. Sound Barrier:

1. Furnish removable and reusable sound-barrier covers over the compressor housing, hermetic motor, compressor suction and discharge piping, and condenser shell.
2. Provide for repeated installation and removal without use of tape or calk.
3. Inner and outer cover shall consist of a PTFE-impregnated fiberglass cloth enclosing heavy-density, needled fiberglass insulation material with a mass-loaded vinyl acoustic barrier.
4. Covers shall be double sewn and lock stitched with edges folded and sewn so no raw cut edges are exposed.
5. Form covers around control devices, gages, conduit, piping, and supports without degrading sound-barrier performance.
6. Continuously lap all exposed seams at least 2 inches (50 mm) for better sound containment.
7. Permanently label each section of cover to indicate its location, description, size, and number sequence.
8. Randomly place stainless-steel quilting pins to prevent covers from shifting and sagging.

D. Tool Kit: Chiller manufacturer shall assemble a tool kit specially designed for use in serving the chiller(s) furnished. Include special tools required to service chiller components not readily available to Cleveland Clinic service personnel in performing routine maintenance. Place tools in a lockable case with hinged cover. Provide a list of each tool furnished and attach the list to underside of case cover.

2.14 CAPACITIES AND CHARACTERISTICS

A. Capacity: <**Insert tons (kW)**>.

B. Full-Load Efficiency:

1. COP: <**Insert value**>.
2. EER: <**Insert value**>.
3. Power Input/Cooling Output: <**Insert kW/ton (kW/kW)**>.
4. Comply with GS-31.
5. Comply with FEMP.

C. Part-Load Efficiency:

1. IPLV: <**Insert value**>.
2. NPLV: <**Insert value**>.
3. Comply with GS-31.
4. Comply with FEMP.

D. Evaporator:

1. Pressure Rating: <**Insert psig (kPa)**>.
2. Number of Passes: [**One**] [**Two**] [**Three**].
3. Fluid Type: Water.
4. Design Fluid Flow Rate: <**Insert gpm (L/s)**>.
5. Minimum Fluid Flow Rate: <**Insert gpm (L/s)**>.
6. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
7. Leaving-Fluid Temperature: <**Insert deg F (deg C)**>.
8. Fluid Pressure Drop: <**Insert feet of head (kPa)**>.
9. Fluid Velocity: <**Insert fps (m/s)**>.
10. Fouling Factor: [**0.0001 sq. ft. x h x deg F/Btu (0.000018 sq. m x deg C/W)**] [**0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)**] [**0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)**].

E. Condenser:

1. Pressure Rating: <**Insert psig (kPa)**>.
2. Number of Passes: [**One**] [**Two**] [**Three**].
3. Fluid Type: Water.
4. Design Fluid Flow Rate: <**Insert gpm (L/s)**>.
5. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
6. Leaving-Fluid Temperature: <**Insert deg F (deg C)**>.
7. Fluid Pressure Drop: <**Insert feet of head (kPa)**>.
8. Fluid Velocity: <**Insert fps (m/s)**>.
9. Fouling Factor: [**0.00025 sq. ft. x h x deg F/Btu (0.000044 sq. m x deg C/W)**] [**0.0005 sq. ft. x h x deg F/Btu (0.00011 sq. m x deg C/W)**] [**0.001 sq. ft. x h x deg F/Btu (0.00022 sq. m x deg C/W)**].

F. Compressor:

1. Number of Compressors: [**One**] [**Two**].

2. [**First**]Compressor Rated Load Amperes: <**Insert value**>.
3. [**First**]Compressor Locked-Rotor Amperes: <**Insert value**>.
4. Second Compressor Rated Load Amperes: <**Insert value**>.
5. Second Compressor Locked-Rotor Amperes: <**Insert value**>.

G. Chiller Control Electrical Requirements:

1. Power Connections: [**Integral**] [**Field**].
2. Power Input: <**Insert kilowatts**>.
3. Minimum Circuit Ampacity: <**Insert value**>.
4. Maximum Overcurrent Protection Device: <**Insert amperage**>.
5. Volts: 120-V ac.
6. Phase: [**Single**] [**Three**].
7. Hertz: 60.

H. Chiller Electrical Requirements:

1. Power Input: <**Insert kilowatts**>.
2. Power Factor: [**0.90**] [**0.95**].
3. Minimum Circuit Ampacity: <**Insert value**>.
4. Maximum Overcurrent Protection Device: <**Insert amperage**>.
5. Volts: [**208**] [**240**] [**480**] [**600**] [**2300**] [**4160**]-V ac.
6. Phase: Three.
7. Hertz: 60.

I. Noise Rating: 85 sound power level when measured according to ARI 575. Provide factory-installed sound treatment if necessary to achieve the performance indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine chillers before installation. Reject chillers that are damaged.

B. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.

1. Final chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 CHILLER INSTALLATION

A. Install chillers on support structure indicated.

B. Equipment Mounting: Install chiller on concrete bases using [**elastomeric pads**] [**restrained spring isolators**]. Comply with requirements for concrete bases specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**] Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1/2 inch (13 mm)**] [**1 inch (25 mm)**] [**2 inches (50 mm)**].
2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
5. Install anchor bolts to elevations required for proper attachment to supported equipment.

C. Equipment Mounting: Install chiller using [**elastomeric pads**] [**restrained spring isolators**]. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1/2 inch (13 mm)**] [**1 inch (25 mm)**] [**2 inches (50 mm)**].

D. Equipment Mounting: Install chiller on concrete bases. Comply with requirements for concrete bases specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**]

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to supported equipment.

E. Maintain manufacturer's recommended clearances for service and maintenance.

F. Charge chiller with refrigerant and fill with oil if not factory installed.

G. Install separate devices furnished by manufacturer and not factory installed.

3.3 HEAT-EXCHANGER, BRUSH-CLEANING SYSTEM INSTALLATION

A. Install brush-cleaning system control panel adjacent to chiller control panel.

B. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.

C. Provide field electric power, as required, to each system control panel and electric actuated valve.

D. Provide pneumatic piping with pressure regulator and isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.

E. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.

F. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and control panel, with chiller in operation.

3.4 CONNECTIONS

A. Comply with requirements for piping specified in Section 232113 "Hydronic Piping" and Section 232300 "Refrigerant Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to chiller to allow service and maintenance.

C. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.

D. Condenser-Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.

E. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend separate vent piping for each chiller to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.

F. For chillers equipped with a purge system, extend separate purge vent piping for each chiller to the outdoors. Comply with ASHRAE 15 and ASHRAE 147.

G. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
3. Verify that pumps are installed and functional.
4. Verify that thermometers and gages are installed.
5. Operate chiller for run-in period.
6. Check bearing lubrication and oil levels.
7. Verify that refrigerant pressure relief device is vented outside.
8. Verify proper motor rotation.
9. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
10. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
11. Verify and record performance of chiller protection devices.
12. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.

C. Prepare test and inspection startup reports.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain chillers. Video record the training sessions.

END OF SECTION 236416

SECTION 236500 - COOLING TOWERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Open-circuit, induced-draft, counterflow cooling towers.
2. Open-circuit, induced-draft, crossflow cooling towers.

1.3 DEFINITIONS

A. BMS: Building management system.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design cooling tower support structure[**and seismic restraints**] [**and wind restraints**], including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Structural Performance: Cooling tower support structure shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to SEI/ASCE 7.

1. Dead Loads: <**Insert loads**>.
2. Live Loads: <**Insert loads**>.
3. Roof Loads: <**Insert loads**>.
4. Snow Loads: <**Insert loads**>.
5. Seismic Loads: <**Insert loads**>.
6. Wind Loads: <**Insert loads**>.
7. Deflection Limits: Design system to withstand design loads without deflections greater than the following:

C. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, pressure drop, fan performance data, rating curves with selected points indicated, furnished specialties, and accessories.

1. Maximum flow rate.
2. Minimum flow rate.
3. Drift loss as percent of design flow rate.
4. Volume of water in suspension for purposes of sizing a remote storage tank.
5. Sound power levels in eight octave bands for operation with fans off, fans at minimum, and design speed.
6. Performance curves for the following:

   a. Varying entering-water temperatures from design to minimum.
   b. Varying ambient wet-bulb temperatures from design to minimum.
   c. Varying water flow rates from design to minimum.
   d. Varying fan operation (off, minimum, and design speed).

7. Fan airflow, brake horsepower, and drive losses.
8. Pump flow rate, head, brake horsepower, and efficiency.
9. Motor amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
10. Electrical power requirements for each cooling tower component requiring power.

B. Shop Drawings: Complete set of manufacturer's prints of cooling tower assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Sizes and locations of piping and wiring connections.
5. Wiring Diagrams: For power, signal, and control wiring.

C. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail fabrication and assembly of support structure.
2. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
3. Design Calculations: Calculate requirements for selecting vibration isolators[**and seismic restraints**] [**and wind restraints**] and for designing vibration isolation bases.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:

1. Structural supports.
2. Piping roughing-in requirements.
3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

B. Certificates: For certification required in "Quality Assurance" Article.

C. Seismic Qualification Certificates: For cooling towers, accessories, and components, from manufacturers.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control reports.

E. Field quality-control reports.

F. Startup service reports.

G. Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each cooling tower to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: [**Certified by CTI**] [**An NRTL**].

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. ASME Compliance: Fabricate and label heat-exchanger coils to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

E. CTI Certification: Cooling tower thermal performance according to CTI STD 201, "Certification Standard for Commercial Water-Cooling Towers Thermal Performance."

F. FMG approval and listing in the latest edition of FMG's "Approval Guide."

1.9 COORDINATION

[Retain first paragraph below for mounting towers on concrete bases.]

A. Coordinate sizes and locations of concrete bases with actual equipment provided.

[Retain first paragraph below for mounting towers on a structural-steel support structure.]

B. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.

[Retain paragraph below for mounting tower on the roof.]

C. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period:

1. Fan assembly including fan, drive, and motor.
2. All components of cooling tower.
3. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 OPEN-CIRCUIT, INDUCED-DRAFT, COUNTERFLOW COOLING TOWERS

A. Products: Subject to compliance with requirements, provide one of the following:

1. Baltimore Aircoil Company.
2. Marley Cooling Technologies, an SPX Corporation.

B. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.

C. Cooling tower designed to resist wind load of **30 lbf/sq. ft. (1.44 kPa)**.

D. Casing and Frame:

1. Casing[**and Frame**] Material: [**Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Stainless steel**].
2. Frame Material: [**Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating**] [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Stainless steel**].
3. Fasteners: [**Galvanized**] [**Stainless**] steel.
4. Joints and Seams: Sealed watertight.

5. Welded Connections: Continuous and watertight.

E. Collection Basin:

1. Material: **Stainless steel**.
2. Strainer: Removable[**stainless-steel**] strainer with openings smaller than nozzle orifices.
3. Overflow and drain connections.
4. Makeup water connection.
5. Outlet Connection: ASME B16.5, Class 150 flange.
6. Removable equalization flume plate between adjacent cells of multiple-cell towers.
7. Equalizer connection for field-installed equalizer piping.
8. Basin Sweeper Distribution Piping and Nozzles:

    a. Pipe Material: PVC.
    b. Nozzle Material: Plastic.
    c. Configure piping and nozzles to minimize sediment from collecting in the collection basin.

F. Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**].
2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide [**control of water makeup valve**] [**control of water makeup valve and low-level alarm**] [**control of water makeup valve and low- and high-level alarms**] [**control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level**].
3. Electrode Probes: Stainless steel.
4. Water Stilling Chamber: [**Corrosion-resistant material**] [**Galvanized steel**] [**PVC pipe**] [**Stainless steel**].
5. Solenoid Valve: Slow closing[**with stainless-steel body**]; controlled and powered through level controller in response to water-level set point.
6. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

G. Electric Basin Heater:

1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
2. Heater Control Panel: Mounted on the side of each cooling tower cell.
3. Enclosure: NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**].
4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
5. Control-circuit transformer with primary and secondary side fuses.
6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
7. Single-point, field-power connection to a [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**] and heater branch circuiting complying with NFPA 70.
8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

H. Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

I. Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

J. Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.

K. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.

1. Pipe Material: [**Fiberglass**] [**PVC**] [**Galvanized steel**].
2. Spray Nozzle Material: [**Plastic**] [**Polypropylene**] [**PVC**].
3. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.

L. Fill:

1. Materials: [**CPVC**] [**PVC**], resistant to rot, decay, and biological attack; with maximum flame-spread index of [**5**] [**25**] according to ASTM E 84.
2. Minimum Thickness: [**15 mils (0.4 mm)**] [**20 mils (0.5 mm)**] before forming.
3. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
4. Fill Material Operating Temperature: Suitable for entering-water temperatures up through **120 deg F (49 deg C)**.

M. [**Removable**]Drift Eliminator:

1. Material: PVC; resistant to rot, decay, and biological attack; with maximum flame-spread index of [**5**] [**25**] according to ASTM E 84.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.

N. Air-Intake Louvers:

1. Material: [**PVC**] [**Matching casing**].
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.

O. [**Removable**]Air-Intake Screens: [**Galvanized**] [**Polymer-coated, galvanized**] [**Stainless**]-steel wire mesh.

P. Axial Fan: Balanced at the factory after assembly.

1. Blade Material: [**Aluminum**] [**Galvanized steel**].
2. Hub Material: [**Aluminum**] [**Galvanized steel**].
3. Blade Pitch: Field adjustable.
4. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens, complying with OSHA regulations.

5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of [**40,000**] [**50,000**] hours.
6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

Q. Belt Drive:

1. Service Factor: 1.5 based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.

   a. Belt: Multiple V-belt design with a matched set of[**cogged**] belts.
   b. Belt: One-piece, multigrooved, solid-back belt.
   c. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
   d. Belt-Drive Guard: Comply with OSHA regulations.

R. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.

S. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.

1. Gear Drive and Coupling Service Factor: 2.0 based on motor nameplate horsepower.
2. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
3. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
4. Operation: Able to operate both forward and in reverse.
5. Drive-to-Motor Connection: [**Close coupled to motor using a flexible coupling**] [**Connected to motor located outside of cooling tower casing by a full-floating drive shaft**].
6. Drive Shaft Material: [**Corrosion resistant**] [**Stainless steel**], and fitted with flexible couplings on both ends. Provide exposed shaft and couplings with guards according to OSHA regulations.
7. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel piping. Provide installation with oil-level sight glass.

T. Fan Motor:

1. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment" and not indicated below.
2. Motor Enclosure: [**Totally enclosed**] [**Totally enclosed air over (TEAO)**] [**Totally enclosed fan cooled (TEFC)**] [**with epoxy or polyurethane finish**].
3. Energy Efficiency: [**Comply with ASHRAE/IESNA 90.1**] [**NEMA Premium Efficient**].
4. Service Factor: 1.15.
5. Insulation: [**Class F**] [**Class H**].

6. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
7. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
8. Severe-duty rating with the following features:
   a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
   b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C.)
   c. Internal heater automatically energized when motor is de-energized.
9. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.

U. Fan Discharge Stack: Material shall match casing, [**manufacturer's standard**] [**velocity recovery**] design.

1. Stack Extension: Fabricated to extend above fan deck <**Insert distance**> unless otherwise indicated.
2. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.

V. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**].
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Provide switch[**with manual-reset button**] for [**field connection to a BMS and**]hardwired connection to fan motor electrical circuit.
4. Switch shall, on sensing excessive vibration,[**signal an alarm through the BMS and**] shut down the fan.

W. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch[**for connection to a BMS**].

1. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm[**through the BMS**].

X. Controls: Comply with requirements in Section 230900 "Instrumentation and Control for HVAC."

Y. Control Package: Factory installed and wired, and functionally tested at factory before shipment.

1. NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**] enclosure with removable internally mount backplate.
2. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.

4. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
5. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
6. Collection basin level controller complying with requirements in [**"Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve"**] [**"Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve"**] Paragraph.
7. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
8. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
9. Oil-level switch for each fan with a gear drive, complying with requirement in "Gear-Drive, Oil-Level Switch" Paragraph.
10. Single-point, field-power connection to a [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**] [**for each cooling tower cell**].

    a. Branch power circuit to each motor and electric basin heater and to controls[**with a disconnect switch or circuit breaker**].
    b. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.

11. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
12. Visual indication of status and alarm[**with momentary test push button**] for each motor.
13. Audible alarm and silence switch.
14. Visual indication of elapsed run time, graduated in hours for each motor.
15. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:

    a. Operational status of each motor.
    b. Position of dampers.
    c. Cooling tower leaving-fluid temperature.
    d. Fan vibration alarm.
    e. Oil-level alarm.
    f. Collection basin [**high**] [**low**] [**high- and low**]-water-level alarms.

Z. Personnel Access Components:

1. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
2. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
3. External Platforms with Handrails: Aluminum, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
4. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
5. Internal Platforms: Aluminum, or galvanized-steel bar grating.

a. Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
b. Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

AA. Capacities and Characteristics:

1. Number of Cells: <**Insert quantity**>.
2. Air-Inlet Arrangement: All sides.
3. Maximum Drift Loss: [**0.005**] percent of design water flow.
4. Water Flow/Cell: <**Insert gpm (L/s)**>.
5. Minimum Water Flow/Cell: <**Insert gpm (L/s)**>.
6. Water Pressure Drop: <**Insert psig (kPa)**>.
7. Entering-Water Temperature: <**Insert deg F (deg C)**>.
8. Leaving-Water Temperature: <**Insert deg F (deg C)**>.
9. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.
10. Economizer Mode:

    a. Water Flow/Cell: <**Insert gpm (L/s)**>.
    b. Entering-Water Temperature: <**Insert deg F (deg C)**>.
    c. Leaving-Water Temperature: <**Insert deg F (deg C)**>.
    d. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.

11. Fan Drive: Belt, direct, or gear.
12. Fan Motor:

    a. Type: [**Single speed**] [**Two speed, single winding**] [**Two speed, two winding**] [**Variable speed**].
    b. Horsepower/Cell: <**Insert horsepower**>.
    c. Full-Load Ampacity: <**Insert value**>.
    d. Minimum Circuit Ampacity: <**Insert value**>.
    e. Maximum Overcurrent Protection Device: <**Insert amperage**>.
    f. Electrical Characteristics: [**208**] [**240**] [**480**] -V ac, 3 phase, 60 Hz.

13. Sound Pressure Level: <**Insert dBA**> at <**Insert distance in feet (m)**> [**when measured according to CTI ATC 128**].
14. Basin Heater:

    a. Basin Water Temperature: **40 deg F (5 deg C)**.
    b. Outdoor Ambient Temperature: [**0 deg F (minus 18 deg C)**] [**Minus 20 deg F (Minus 29 deg C)**].
    [Retain first five subparagraphs below for projects with electric basin heaters.]
    c. Capacity/Cell: <**Insert kilowatts**>.
    d. Full-Load Ampacity: <**Insert value**>.
    e. Minimum Circuit Ampacity: <**Insert value**>.
    f. Maximum Overcurrent Protection Device: <**Insert amperage**>.
    g. Electrical Characteristics: [**208**] [**240**] [**480**] -V ac, 3 phase, 60 Hz.
    [Retain first four subparagraphs below for projects with hot-water-coil basin heaters.]
    h. Capacity/Cell: <**Insert MBtu/h (kW)**>.

i. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
j. Fluid Flow Rate: <**Insert gpm (L/s)**>.
k. Fluid Pressure Drop: <**Insert psig (kPa)**>.

[Retain three subparagraphs below for projects with steam-coil or -injection basin heaters.]

l. Capacity/Cell: <**Insert MBtu/h (kW)**>.
m. Steam Flow: <**Insert lb/h (L/s)**>.
n. Steam Pressure: <**Insert psig (kPa)**>.

2.2 OPEN-CIRCUIT, INDUCED-DRAFT, CROSSFLOW COOLING TOWERS

A. Products: Subject to compliance with requirements, provide one of the following:

1. Baltimore Aircoil Company; Series 1500 and 3000.
2. Marley Cooling Technologies, an SPX Corporation; Models Aquatower, AV series, NC Class, Primus.

B. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.

C. Cooling tower designed to resist wind load of **30 lbf/sq. ft. (1.44 kPa)**.

D. Casing and Frame:

1. Casing[**and Frame**] Material: [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
2. Frame Material: [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
3. Fasteners: [**Galvanized**] [**Stainless**] steel.
4. Joints and Seams: Sealed watertight.
5. Welded Connections: Continuous and watertight.

E. Collection Basin:

1. Material: [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
2. Removable[**stainless-steel**] strainer with openings smaller than nozzle orifices.
3. Overflow and drain connections.
4. Makeup water connection.
5. Outlet Connection: ASME B16.5, Class 150 flange.
6. Removable equalization flume plate between adjacent cells of multiple-cell towers.
7. Equalizer connection for field-installed equalizer piping.
8. Basin Sweeper Distribution Piping and Nozzles:

a. Pipe Material: PVC.
b. Nozzle Material: Plastic.
c. Configure piping and nozzles to minimize sediment from collecting in the collection basin.

F. Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:

1. Enclosures: NEMA 250, [**Type 4**] [**Type 4X**].
2. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide [**control of water makeup valve**] [**control of water makeup valve and low-level alarm**] [**control of water makeup valve and low- and high-level alarms**] [**control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level**].
3. Electrode Probes: Stainless steel.
4. Water Stilling Chamber: [**Corrosion-resistant material**] [**Galvanized steel**] [**PVC pipe**] [**Stainless steel**].
5. Solenoid Valve: Slow closing[**with stainless-steel body**], controlled and powered through level controller in response to water-level set point.
6. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

G. Electric Basin Heater:

1. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
2. Heater Control Panel: Mounted on the side of each cooling tower cell.
3. Enclosure: NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**].
4. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
5. Control-circuit transformer with primary and secondary side fuses.
6. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
7. Single-point, field-power connection to a [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**] and heater branch circuiting complying with NFPA 70.
8. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

H. Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

I. Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

J. Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.

K. Gravity Water Distribution Basin: Nonpressurized design with head of water level in basin adequate to overcome spray nozzle losses and designed to evenly distribute water over fill throughout the flow range indicated.

1. Material: [**Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating**] [**Polymer-coated galvanized steel**] [**Stainless steel**].
2. Location: Over each bank of fill with easily replaceable [**plastic**] spray nozzles mounted in bottom of basin.
3. Inlet Connection: ASME B16.5, Class 150 flange.
4. Joints and Seams: Sealed watertight.
5. Partitioning Dams: Same material as basin to distribute water over the fill to minimize icing while operating throughout the flow range indicated.
6. Removable Panels: Same material as basin to completely cover top of basin. Secure panels to basin with removable [**corrosion-resistant**] [**stainless-steel**] hardware.

7. Valves: Manufacturer's standard valve installed at each inlet connection and arranged to balance or shut off flow to each gravity distribution basin.
8. Single-Inlet, Field Pipe Connection: [**Galvanized-steel**] [**PVC**] pipe arranged to provide balancing of flow within cooling tower cell without the need for additional balancing valves. Pipe each cooling tower cell internally to a single, field connection suitable for mating to ASME B16.5, Class 150 flange and located on the [**bottom**] [**side**] unless otherwise indicated.

L. Fill:

1. Materials: PVC, with maximum flame-spread index of [**5**] [**25**] according to ASTM E 84.
2. Minimum Thickness: [**15 mils (0.4 mm)**] [**20 mils (0.5 mm)**], before forming.
3. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
4. Fill Material Operating Temperature: Suitable for entering-water temperatures up through **120 deg F (49 deg C)**.

M. Drift Eliminator:

1. Material: PVC; with maximum flame-spread index of [**5**] [**25**] according to ASTM E 84.
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
4. Location: [**Integral to**] [**Separate and removable from**] fill.

N. Air-Intake Louvers:

1. Material: [**PVC**] [**Matching casing**].
2. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
3. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.
4. Location: [**Integral to**] [**Separate from**] fill.

O. [**Removable**]Air-Intake Screens: [**Galvanized**] [**Polymer-coated, galvanized**] [**Stainless**]-steel wire mesh.

P. Axial Fan: Balanced at the factory after assembly.

1. Blade Material: [**Aluminum**] [**Galvanized steel**].
2. Hub Material: [**Aluminum**] [**Galvanized steel**].
3. Blade Pitch: Field adjustable.
4. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
5. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of [**40,000**] [**50,000**] hours.
6. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

Q. Belt Drive:

1. Service Factor: 1.5 based on motor nameplate horsepower.
2. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
3. Belt: One-piece, multigrooved, solid-back belt.
4. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
5. Belt-Drive Guard: Comply with OSHA regulations.
6. Two-Motor, Single-Fan Drive:

   a. Two single-speed motors per fan, one sized for full speed and load and the other sized for 67 percent of full-load speed.
   b. Each motor with belt drive and configured for operation when other motor fails.
   c. Controls and wiring same as two-speed, two-winding motor.

R. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.

1. Gear Drive and Coupling Service Factor: 2.0 based on motor nameplate horsepower.
2. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
3. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
4. Operation: Able to operate both forward and in reverse.
5. Drive-to-Motor Connection: [**Close coupled to motor using a flexible coupling**] [**Connected to motor located outside of cooling tower casing by a full-floating drive shaft**].
6. Drive Shaft Material: [**Corrosion resistant**] [**Stainless steel**], and fitted with flexible couplings on both ends. Provide exposed shaft and couplings with guards according to OSHA regulations.
7. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel piping. Provide installation with oil-level sight glass.

S. Fan Motor:

1. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Section 230513 "Common Motor Requirements for HVAC Equipment" and not indicated below.
2. Motor Enclosure: [**Totally enclosed**] [**Totally enclosed air over (TEAO)**] [**Totally enclosed fan cooled (TEFC)**] [**with epoxy or polyurethane finish**].
3. Energy Efficiency: [**Comply with ASHRAE/IESNA 90.1**] [**NEMA Premium Efficient**].
4. Service Factor: 1.15.
5. Insulation: [**Class F**] [**Class H**].
6. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
7. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.

8. Severe-duty rating with the following features:

    a. Rotor and stator protected with corrosion-inhibiting epoxy resin.
    b. Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C.)
    c. Internal heater automatically energized when motor is de-energized.

9. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.

T. Fan Discharge Stack: Material shall match casing, [**manufacturer's standard**] [**velocity recovery**] design.

1. Stack Extension: Fabricated to extend above fan deck <**Insert distance**> unless otherwise indicated.
2. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.

U. Vibration Switch: For each fan drive.

1. Enclosure: NEMA 250, [**Type 4**] [**Type 4X**].
2. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
3. Provide switch[**with manual-reset button**] for [**field connection to a BMS and**]hardwired connection to fan motor electrical circuit.
4. Switch shall, on sensing excessive vibration,[**signal an alarm through the BMS and**] shut down the fan.

V. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch[**for connection to a BMS**].

1. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm[**through the BMS**].

W. Capacity-Control Dampers: [**Galvanized-steel**] [**Stainless-steel**] dampers, with linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.

X. Controls: Comply with requirements in Section 230900 "Instrumentation and Control for HVAC."

Y. Control Package: Factory installed and wired, and functionally tested at factory before shipment.

1. NEMA 250, [**Type 3R**] [**Type 4**] [**Type 4X**] enclosure with removable internally mount backplate.
2. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.

5. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
6. Collection basin level controller complying with requirements in [**"Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve"**] [**"Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve"**] Paragraph.
7. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
8. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
9. Oil-level switch for each fan with a gear drive, complying with requirement in "Gear-Drive, Oil-Level Switch" Paragraph.
10. Single-point, field-power connection to a [**fused disconnect switch**] [**nonfused disconnect switch**] [**circuit breaker**] [**for each cooling tower cell**].

    a. Branch power circuit to each motor and electric basin heater and to controls[**with a disconnect switch or circuit breaker**].
    b. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.

11. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
12. Visual indication of status and alarm[**with momentary test push button**] for each motor.
13. Audible alarm and silence switch.
14. Visual indication of elapsed run time, graduated in hours for each motor.
15. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:

    a. Operational status of each motor.
    b. Position of dampers.
    c. Cooling tower leaving-fluid temperature.
    d. Fan vibration alarm.
    e. Oil-level alarm.
    f. Collection basin [**high**] [**low**] [**high- and low**]-water-level alarms.

Z. Personnel Access Components:

1. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
2. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
3. External Platforms with Handrails: Aluminum, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
4. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
5. Internal Platforms: Aluminum, or galvanized-steel bar grating.

a. Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
b. Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

AA. Capacities and Characteristics:

1. Number of Cells: <**Insert quantity**>.
2. Air-Inlet Arrangement: [**Single side**] [**Two sides**].
3. Maximum Drift Loss: [**0.005**] percent of design water flow.
4. Water Flow/Cell: <**Insert gpm (L/s)**>.
5. Minimum Water Flow/Cell: <**Insert gpm (L/s)**>.
6. Water Pressure Drop: <**Insert psig (kPa)**>.
7. Entering-Water Temperature: <**Insert deg F (deg C)**>.
8. Leaving-Water Temperature: <**Insert deg F (deg C)**>.
9. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.
10. Economizer Mode:

    a. Water Flow/Cell: <**Insert gpm (L/s)**>.
    b. Entering-Water Temperature: <**Insert deg F (deg C)**>.
    c. Leaving-Water Temperature: <**Insert deg F (deg C)**>.
    d. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.

11. Fan Drive: Belt or gear.
12. Fan Motor:

    a. Type: [**Single speed**] [**Two speed, single winding**] [**Two speed, two winding**] [**Variable speed**].
    b. Horsepower/Cell: <**Insert horsepower**>.
    c. Full-Load Ampacity: <**Insert value**>.
    d. Minimum Circuit Ampacity: <**Insert value**>.
    e. Maximum Overcurrent Protection Device: <**Insert amperage**>.
    f. Electrical Characteristics: [**208**] [**240**] [**480**] -V ac, 3 phase, 60 Hz.

13. Sound Pressure Level: <**Insert dBA**> at <**Insert distance in feet (m)**> [**when measured according to CTI ATC 128**].
14. Basin Heater:

    a. Basin Water Temperature: **40 deg F (5 deg C)**.
    b. Outdoor Ambient Temperature: [**0 deg F (minus 18 deg C)**] [**Minus 20 deg F (Minus 29 deg C)**].
    [Retain first five subparagraphs below for projects with electric basin heaters.]
    c. Capacity/Cell: <**Insert kilowatts**> .
    d. Full-Load Ampacity: <**Insert value**>.
    e. Minimum Circuit Ampacity: <**Insert value**>.
    f. Maximum Overcurrent Protection Device: <**Insert amperage**>.
    g. Electrical Characteristics: [**208**] [**240**] [**480**] -V ac, 3 phase, 60 Hz.
    [Retain first four subparagraphs below for projects with hot-water-coil basin heaters.]
    h. Capacity/Cell: <**Insert MBtu/h (kW)**>.

i. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
j. Fluid Flow Rate: <**Insert gpm (L/s)**>.
k. Fluid Pressure Drop: <**Insert psig (kPa)**>.

[Retain three subparagraphs below for projects with steam-coil or -injection basin heaters.]

l. Capacity/Cell: <**Insert MBtu/h (kW)**>.
m. Steam Flow: <**Insert lb/h (L/s)**>.
n. Steam Pressure: <**Insert psig (kPa)**>.

2.3 SOURCE QUALITY CONTROL

A. Verification of Performance: Test and certify cooling tower performance according to CTI STD 201, "Certification Standard for Commercial Water-Cooling Towers Thermal Performance."

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before cooling tower installation, examine roughing-in for tower support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting tower performance, maintenance, and operation.

1. Cooling tower locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install cooling towers on support structure indicated.

[Retain first paragraph below for equipment supported on concrete base and vibration isolation devices.]

B. Equipment Mounting: Install cooling tower on concrete bases using [**elastomeric pads**] [**elastomeric mounts**] [**restrained spring isolators**]. Comply with requirements in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**] Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/2 inch (13 mm)**] [**1 inch (25 mm)**] [**2 inches (50 mm)**] [**3 inches (75 mm)**].
2. Provide [**galvanized**] [**stainless**]-steel plate to equally distribute weight over elastomeric pad.
3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.

4. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

[Retain first paragraph below for equipment supported on vibration isolation devices without a concrete base.]

C. Equipment Mounting: Install cooling tower using [**elastomeric pads**] [**elastomeric mounts**] [**restrained spring isolators**]. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/2 inch (13 mm)**] [**1 inch (25 mm)**] [**2 inches (50 mm)**] [**3 inches (75 mm)**].
2. Provide [**galvanized**] [**stainless**]-steel plate to equally distribute weight over elastomeric pad.

[Retain first paragraph below for equipment to be installed on concrete bases without vibration isolation devices.]

D. Equipment Mounting: Install cooling tower on concrete bases. Comply with requirements in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**]

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

E. Install anchor bolts to elevations required for proper attachment to supported equipment.

F. Maintain manufacturer's recommended clearances for service and maintenance.

G. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to cooling towers to allow service and maintenance.

C. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.

D. Provide drain piping with valve at cooling tower drain connections and at low points in piping.

E. Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.

F. Domestic Water Piping: Comply with applicable requirements in Section 221116 "Domestic Water Piping." Connect to water-level control with shutoff valve and union, flange, or mechanical coupling at each connection.

G. Supply and Return Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping." Connect to entering cooling tower connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gage,[**flow meter,**] and drain connection with valve. Connect to leaving cooling tower connection with shutoff valve. Make connections to cooling tower with a [**union**] [**flange**] [**mechanical coupling**] [**union, flange, or mechanical coupling**].

H. Equalizer Piping: Piping requirements to match supply and return piping. Connect an equalizer pipe, full size of cooling tower connection, between tower cells. Connect to cooling tower with shutoff valve.

[Retain first paragraph below if hot-water basin heater is installed.]

I. Hot-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping." Connect to supply and return basin heater with shutoff valve, strainer, control valve, and union or flange on supply connection and union or flange and balancing valve on return connection. Provide supply and return piping with pressure gage and thermometer.

[Retain paragraph below if steam basin heater is installed.]

J. Steam and Condensate Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping." Connect steam supply to basin heater with shutoff valve, strainer, control valve, and union or flange and condensate piping with union or flange, shutoff valve, strainer, and an appropriate steam trap.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Cleveland Clinic will engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections: Comply with [**ASME PTC 23, "ASME Performance Test Codes - Code on Atmospheric Water Cooling Equipment**] [**CTI ATC 105, "Acceptance Test Code for Water Cooling Towers**]."

C. Cooling towers will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Obtain performance data from manufacturer.

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

a. Clean entire unit including basins.
b. Verify that accessories are properly installed.
c. Verify clearances for airflow and for cooling tower servicing.
d. Check for vibration isolation and structural support.
e. Lubricate bearings.
f. Verify fan rotation for correct direction and for vibration or binding and correct problems.
g. Adjust belts to proper alignment and tension.
h. Verify proper oil level in gear-drive housing. Fill with oil to proper level.
i. Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
j. Check vibration switch setting. Verify operation.
k. Verify water level in tower basin. Fill to proper startup level. Check makeup water-level control and valve.
l. Verify operation of basin heater and control.
m. Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
n. Replace defective and malfunctioning units.

D. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.

E. Prepare a written startup report that records the results of tests and inspections.

3.6 ADJUSTING

A. Set and balance water flow to each tower inlet.

B. Adjust water-level control for proper operating level.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain cooling towers.

END OF SECTION 236500

SECTION 237313 - MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provision of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.02 RELATED DOCUMENTS

A. Section Includes:

1. Air handling units and components as scheduled and shown on drawings.

1.03 REFERENCES

A. AMCA 99 – Standard Handbook

B. AMCA 210 – Laboratory Methods of Testing Fans for Rating Purposes

C. AMCA 500 – Test Methods for Louvers, Dampers, and Shutters

D. AMCA 611-95 – Methods of Testing Airflow Measurement Stations for Rating

E. ANSI/AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings

F. ANSI/UL 900 – Test Performance of Air Filter Units

G. ARI 260 – Sound Rating of Ducted Air Moving and Conditioning Equipment

H. ARI 410 – Forced-Circulation Air Cooling and Air Heating Coils

I. ARI 430 – Testing and Rating of Central-Station Air Handling Units

J. ASHRAE 52.1/52.2 – Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size

K. ASHRAE 62 – Ventilation for Acceptable Indoor Air Quality

L. ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings

M. ASTM-C 1338 – Standard Test Method for Determining Fungi Resistance of Insulation Material and Facings.

N. NFPA 70 – National Electric Code (conductors, equipment and raceways)

O. NFPA 90A – Installation of Air Conditioning and Ventilation Systems

P. SMACNA – HVAC Duct Construction Standards

Q. UL-181 – Mold Growth and Humidity Test

R. UL-1995 – Standard for Safety for Heating and Cooling Equipment

S. ISO/PWD 13261-3 – Sound Power Rating of air-conditioning and air-source heat pump equipment: Part 3, Ducted Equipment.

T. ISO 9614 – Determination of sound power levels of noise sources using sound intensity: Part 1, Measurement at discrete points; Part 2, Measurement by scanning, and Part 3, Precision method for measurement by scanning.

1.04 QUALITY ASSURANCE

A. Manufacturer shall have a minimum of 25 years of experience in designing, manufacturing, and servicing air-handling units.

B. The design indicated on the schedules and shown on the drawings is based upon the products of the named manufacturer. Alternate equipment manufacturers are acceptable if equipment meets scheduled performance requirements and dimensional requirements.

C. If equipment is supplied by a manufacturer other than the one named, coordinate with the General Contractor and affected subcontractors to ensure the specified performance is met. This coordination shall include (but is not limited to) the following:
1. Structural supports for units.
2. Size and location of concrete bases/housekeeping pads
3. Ductwork sizes and connection locations
4. Piping size and connection/header locations
5. Interference with existing or planned ductwork, piping and wiring
6. Electrical power requirements and wire/conduit and over current protection sizes.
7. Trap height requirements

D. The Mechanical Contractor shall be responsible for costs incurred by the General Contractor, Subcontractors, and Consulting Engineers to accommodate units furnished by a manufacturer other than manufacturer named as basis of design.

1.05 RATINGS AND CERTIFICATIONS

A. Air Handling Unit safety: ETL or UL 1995

B. Air Handling Unit energy use: ASHRAE 90.1

C. Fans: AMCA 210

D. Air Coils: ARI 410

E. Air Handling Unit certification program: ARI 430

F. Filter media: ANSI/UL 900 listed Class I or Class II

G. Control wiring: NEC codes & ETL requirements

H. Motors: Federally mandated Energy Policy Act (EPACT).

I. Airflow Monitoring Stations: AMCA 611-95

1.06 SUBMITTAL DOCUMENTATION REQUIRED

A. Furnish fan performance ratings and fan curves with specified operating point clearly plotted.

B. Furnish drawings indicating unit dimensions, required clearances, field connection locations, and shipping drawings.

C. Furnish performance report showing fan, motor, coil, and component performance details. Performance report shall detail unit casing performance and include materials, gauges, and finishes.

D. Furnish operation and maintenance data, including instructions for lubrication, filter replacement, motor and drive replacement, and condensate pan cleaning; and spare parts lists.

E. Adjust and report performance ratings for the proper altitude of operation.

F. Report air-handling unit performance ratings in accordance with ARI-430 (static pressure, airflow, fan speed, and fan brake horsepower).

G. Report static pressure profiles by component section.

H. Report coil ratings in accordance with ARI-410 (capacities and pressure drops).

I. Report and rate sound power levels in accordance with ARI-260 (ducted discharge, ducted inlet, free inlet sound).

J. Airflow measuring device performance shall be certified and rated in accordance with AMCA-611. Report data in accordance with AMCA-611. Provide AMCA Certified Rating Seal for Airflow Measurement Performance.

K. Report panel deflection at +/-8” w.g., stated in terms of ‘L/X’ where ‘L’ is the casing panel length and ‘X’ is a constant provided by the AHU manufacturer.

L. Report casing leakage rate at +/-8” w.g., specified in terms of percentage of design airflow. Report weight loads and distributions by component section.

M. Report product data for filter media, filter performance data, filter assembly, and filter frames.

N. Report electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.

O. Report motor electrical characteristics.

1.07 DELIVERY, STORAGE AND HANDLING

A. Comply with ASHRAE 62, Section 5 (mold and corrosion resistant casings, filters upstream of wetted surfaces, and drain pan design).

B. Comply with ASHRAE 62, Section 7 (practices to be followed during construction and startup). Protect equipment from moisture by appropriate in-transit and on-site procedures.

C. Follow manufacturer's recommendations for handling, unloading and storage.

D. Protect, pack, and secure loose-shipped items within the air-handling units. Include detailed packing list of loose-shipped items, including illustrations and instructions for application.

E. Protect, pack and secure controls devices, motor control devices and other electronic equipment. Do not store electronic equipment in wet or damp areas even when they are sealed and secured.

F. Enclose and protect control panels, electronic or pneumatic devices, and variable frequency drives. Do not store equipment in wet or damp areas even when they are sealed and secured.

G. Seal openings to protect against damage during shipping, handling and storage.

H. Wrap indoor units with a tight sealing membrane. Wrapping membrane shall cover entire AHU during shipping and storage. Cover equipment, regardless of size or shape. Alternatively AHU must be tarped for shipment and storage.

I. Wrap equipment, including electrical components, for protection against rain, snow, wind, dirt, sun fading, road salt/chemicals, rust and corrosion. Keep equipment clean and dry.

J. Clearly mark AHU sections with unit tag number, segment sequence number, and direction of airflow. Securely affix safety-warning labels.

1.08 EXTRA MATERIALS

A. Provide one set of filters for balancing, and one additional set for final turnover to owner.

B. Provide one extra set of belts, in addition to the factory-installed set.

1.09 WARRANTY

A. Provide parts warranty for 18 months from date of shipment. Warranty shall cover manufacturer defects. Warranty work shall be performed by manufacturer's factory-trained and factory-employed technician. Service technician must be based within 50 miles of job site.

B. Include factory-provided controls in the parts warranties.

C. Parts associated with routine maintenance, such as belts and air filters shall be excluded.

1.10 SYSTEM STARTUP

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

B. Comply with manufacturer's start-up requirements to ensure safe and correct operation and integrity of warranty.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. YORK Solution

B. Approved Equal (Prior written approval by engineer of record is required)

2.02 GENERAL DESCRIPTION

A. Air Handling Unit (AHU) consists of a structural steel base, insulated casing, access doors, fans, motors, coils, filters, dampers, components, and accessories; as shown on drawings, schedules, and specifications.

B. Provide AHU to meet the specified levels of performance for scheduled items including airflow, static pressure, cooling capacity, heating capacity, electrical characteristics, sound, casing leakage, panel deflection and casing thermal performance.

C. AHU shall maintain structural integrity when wall panels are removed.

D. Provide internal components and accessories as specified and scheduled. Components and accessories shall be installed by the AHU manufacturer in an ISO-9002 certified facility.

E. Ship units in one piece. Split units only where necessary for shipping and installation.

F. Manufacturer shall provide detailed, step-by-step instructions for disassembly and reassembly.

G. For AHU segments that must be broken down for rigging and installation: segment shall be disassembled and reassembled by manufacturer's factory-trained service personnel.

H. Manufacturer shall perform a field leakage test to confirm 1% leakage per section 2.19.

I. Manufacturer shall provide a written statement confirming that the unit is built to the manufacturer's factory standards and that the unit will carry the full warranty.

2.03 STANDARDS COMPLIANCE

A. Comply with ratings and certifications referenced in this specification.

B. Manufacturers who do not comply with ARI-430 shall factory test EACH unit to verify brake horsepower rating, airflow performance and total static pressure performance. See specification Section 2.23 (VERIFICATION OF PERFORMANCE) for testing requirements.

C. Manufacturers who do not conform to requirements of ARI 260 for ducted discharge and return air sound shall submit EACH unit to an independent sound test laboratory for ARI 260 testing. The test laboratory shall conform to ARI 260, Section 4.4, Test Equipment and Facilities.

2.04 BASE RAIL

A. Provide a structural steel base rail under the full perimeter of the unit.

B. Provide base rail and lifting lug system that does not require additional support for rigging. Include base rail lifting lugs.

2.05 CASING

A. Provide double wall AHU casing. Exposed insulation is not acceptable.

B. Panel assembly shall meet UL standard 1995 for fire safety. Panel insulation shall comply with the requirements of NFPA 90A.

C. Provide an insulation system that is resistant to mold growth in accordance with a standardized test method such as UL 181 or ASTM C 1338.

D. Encapsulate insulation with sheet metal so that air does not contact insulation. Solid lined panels insulated with fiberglass shall be hermetically sealed at each corner and around their entire perimeter, to eliminate airflow through the panel and to eliminate microbial growth potential within the casing wall.

E. Provide casing with minimum thermal resistance (R-value) of 13 hr-ft^2-°F/BTU.

F. Roof, wall, floor, and access door panels shall be galvanized or stainless steel.

G. Provide an additional .125” aluminum diamond tread plate floor liner in access areas.

H. Provide panels with optional perforated liner in the fan section and other sections as shown on the drawings. Interior liner will be perforated galvanized. Minimum perforated panel thermal resistance (R-Value) will be R11 hr-ft^2-°F/BTU.

I. Provide a unit frame of galvanized steel that provides the overall structure of the unit and does not rely on the casing panels for structural integrity. Insulate frame in the same manner as panels, roof, and floors.

J. Provide AHU casing that leaks no more than 1% of design airflow at +/-8” w.g.

K. Provide wall panels and access doors that deflect no more than L/240 when subjected to +/-8” w.g. ‘L’ is the panel-span length and ‘L/240’ is the deflection at panel midpoint.

L. Provide floors and roofs that deflect no more than L/240 when subjected to a 300 lb load at mid-span. ‘L’ is the panel-span length and ‘L/240’ is the deflection at panel midpoint.

2.06 PRIMARY DRAIN PANS

A. Panel assembly shall meet UL standard 1995 for fire safety. Panel insulation shall comply with the requirements of NFPA 90A.

B. Provide an insulation system that is resistant to mold growth in accordance with a standardized test method such as UL 181 or ASTM C 1338.

C. Encapsulate insulation with sheet metal so that air does not contact insulation. Solid lined panels insulated with fiberglass shall be hermetically sealed at each corner and around their entire perimeter, to eliminate airflow through the panel and to eliminate microbial growth potential within the casing wall.

D. Provide floors that deflect no more than L/240 when subjected to a 300 lb load at mid-span. 'L' is the panel-span length and 'L/240' is the deflection at panel midpoint

E. Comply with the stated intent of ASHRAE Standard 62.

F. Provide a drain pan under each cooling coil and humidifier. Drain pans for cooling coils and humidifiers shall meet the requirements of ASHRAE 62.

G. Provide drain connection made of same material as drain pan. Do not use dissimilar metals because of the risk of galvanic corrosion. Weld connection to the drain pan.

H. Drain pan shall be double wall insulated with an insulation R-value of 6.25 hr-ft^2-°F/(BTU-in).

I. Provide drain pan under the complete width and length of cooling coil and humidifier sections. Drain pan shall be full width, and extend a minimum of 6" downstream of cooling coil.

J. Drain pan shall allow visual inspection and physical cleaning on 100% of the pan surface without removal of the coil or humidifier.

K. Provide a minimum of 1" clearance between the drain pan and any coil casing, coil support or any other obstruction.

L. Provide drain pan that allows the design rate of condensate drainage regardless of fan status.

M. Provide drain pan sloped in at least two planes by at least 1/8" per foot toward a single drain. Locate drain connection at the lowest point of the pan. Pan shall have no horizontal surfaces.

2.07 ACCESS DOORS

A. Provide access door(s) that meet requirements for the AHU casing.

B. Provide industrial style stainless steel hinges that permit 180 degrees of door swing.

C. Provide latches with roller cam mechanisms that ensure a tight seal. Rotating knife-edge or "paw" latches are not acceptable.

D. Provide each door with a single handle linked to multiple latching points or a separate handle for each latching point. Doors serving access segments shall have an interior latch handle.

E. Provide access doors with a locking hasp to accommodate a lockout device.

F. Provide double-pane viewing windows. Windows shall be a non-condensing type consisting of a desiccant dehumidification layer. Minimum dimension shall be 3” x 8”.

2.08 FANS

A. Provide single width single inlet (SWSI) plenum fans as shown on equipment schedule and drawings.

B. Airfoil fans shall comply with AMCA standard 99-2408-69 and 99-2401-82. Provide an AMCA Seal on airfoil fans. Airfoil fan performance shall be based on tests made in accordance with AMCA standards 210 and comply with the requirements of the AMCA certified ratings program for air performance.

C. Provide fans with true airfoil blades unless otherwise scheduled.

D. Provide fans with the following accessories:
1. Fan inlet screens in the inlets of fan housing (REQUIRED on SWSI plenum fans)
2. Access door inlet screen (on AHU casing)
3. OSHA-compliant belt guard enclosing the fan motor and drive

E. Provide airfoil fans with blades formed of extruded aluminum, as scheduled. Bent sheet metal blades are not acceptable.

F. Provide fans with polished steel shafts with first critical shaft speed at least 125% of the maximum operating speed for the fan pressure class. Shaft shall have an anti-corrosion coating.

G. Provide fan motor on an adjustable base to allow adjustable and consistent belt tension. Fan and motor shall be mounted on a structural steel fan isolation base.

H. Mount the fan and motor assembly on a common adjustable base. This common base shall attach to vibration isolators, which mount to structural support channels. These channels shall span the AHU floor and mount directly to the AHU frame. Manufacturers not complying with this requirement must submit detailed structural and weight data to a licensed structural engineer for review and stamped certification. The mechanical engineer shall review these engineers’ final reports prior to submittal approval.

I. Provide vibration isolation springs with 1” or 2” static deflection, as scheduled.

J. Provide horizontal thrust restraints between AHU casing and fan housings with end discharge. This requirement applies to the following cases:
1. SWSI fans operating at greater than 3” of total static pressure

2.09 BEARINGS AND DRIVES

A. Provide bearings complying with ANSI/AFBMA 9 for fatigue life ratings.

B. Provide fan bearings with an average life L50 of at least 200,000 hours.

C. Provide fan bearings with an average life L10 of at least 200,000 hours, as scheduled.

D. On other fans, provide re-greaseable bearings with hydraulic grease fittings and lube lines extended to the motor side of the fan or to the exterior of the unit (primary access side).

E. Provide plenum fans with direct-drive transmissions.

F. Provide drives selected with a 1.5 service factor. Sheaves shall be machined from a close grain cast iron and statically balanced by the manufacturer. Provide a fixed pitch sheave on the motor.

G. Provide fixed pitch sheaves on both the fan and motor. Fans with motors rated at 15 hp or less may be field balanced using variable pitch sheaves. Provide fixed pitch sheaves when final balance is complete. Air balancer shall select and provide final set of sheaves.

H. Provide multiple belt drives on belt driven fans with motors 10 hp or greater. Belts shall be V-type, precision molded, raw edge construction, anti-static, oil-resistant and heat-resistant.

2.10 ELECTRICAL MOTORS

A. Provide fan motors built in accordance with the latest standards of the NEMA and IEEE.

B. Provide AHU and fan motors in compliance with ASHRAE 90.1.

C. Provide fan motors with the following characteristics:
1. 60 hertz, 1750 rpm operation
2. Service factor of 1.15
3. Premium efficiency, or as required to meet ASHRAE 90.1
4. NEMA design ball bearing type
5. Rated for continuous duty at full load in a 104°F (40°C) ambient
6. Open drip proof (ODP) or totally enclosed, fan cooled (TEFC) as scheduled.
7. Suitable for use in variable frequency application, per NEMA MG-1 Part 30
8. Premium Efficiency Inverter ready per NEMA STD MG1 PART 31.4.4.2

D. Provide direct drive plenum fans coupled to premium efficiency motors with matching speed, as scheduled.

2.11 FACTORY INSTALLED ELECTRICAL ACCESSORIES

A. In addition to motor power terminals, provide an independent power terminal for convenience receptacles and lights. Provide switches as shown on drawings.

B. Provide incandescent or fluorescent lights in segments as scheduled or shown on drawings. Provide light switches as scheduled or shown on drawings.

C. Provide a 1-hour timer on external light switches.

D. Provide a 120v convenience receptacle on supply fan segment.

2.12 HEATING AND COOLING COMPONENTS

A. Provide coils manufactured by AHU manufacturer, except where noted in contract documents.

B. Coils shall meet or exceed performance scheduled on drawings.
   1. When applicable, provide coils with performance certified in accordance with ARI Standard 410 for coil capacity and pressure drop. Circuit coils such that the fluid velocity is within the range of certified rating conditions at design flow.

C. Provide cooling coils with a maximum face velocity as scheduled. Face velocity calculations shall be based on the finned area of the coil.

D. Provide cooling coil drain pan that is sufficient to contain coil condensate. Drain pan shall extend a minimum of 6” or 10” or 14” downstream of the face of the coil.

E. Provide coil segment casing to accommodate full-face or reduced-face coils as scheduled. Provide face and bypass coil segments with factory installed bypass damper.

F. Provide at least 18” or 24” or 30” of access between coils. Provide an easily operable access panel or door, as shown on drawings.

G. Provide coil segment casing that meets or exceeds casing performance of the unit.

H. Provide panels that are easily removable with no special tools.

I. Locate access doors to provide clearance for pipe insulation, connectors, and accessories. Space shall allow a minimum of 90 degrees of door swing.

J. Provide coils built in their own full perimeter frame. Tube sheets on each end shall have fully drawn collars to support and protect tubes. Horizontal coil casing and support members shall allow moisture to drain. Casing and support members shall not block finned area.

K. Individual coils shall be removable from the side of the AHU.

L. Provide an intermediate drain pan on stacked cooling coils. Intermediate drain pan shall slope in a minimum of two planes toward a single drain connection.

M. Provide a single intermediate vertical coil support on coils with a finned length greater than 62.” Provide two vertical supports on coils with a finned length greater than 100,” and three vertical supports on coils with a finned length greater than 141.”

N. Provide a 1/4" FPT plugged vent/drain tap on each connection. Circuiting shall allow draining and venting when installed. Extend coil connections through AHU casing. Extend vent, drain, and coil connections through AHU casing.

O. Staggered Coil bank shall be provided. Provide a 1/4" FPT plugged vent/drain tap on each connection. Circuiting shall allow draining and venting when installed. Vent, drain, and coil connections shall be supplied within 10” of the header. Extend vent, drain, and coil connections through AHU casing.

P. Insulate gap between coil stub out connection and AHU casing with a spool-shaped sleeve grommet. Adhesive rings applied to the casing walls are not acceptable.

Q. Water and glycol coils shall be operable at 250 psig working pressure and up to 300° F. Factory test water and glycol coils with 325 psig compressed air under water.

R. Direct expansion (DX) coils shall conform to ANSI B9.1 (Safety Code for Mechanical Refrigeration) when operating with a maximum refrigerant pressure of 250 psig. Factory test DX coils with 325 psig compressed air under water.

S. Steam distributing coils shall be operable at 50 psig pressure and a corresponding saturated steam temperature of 298° F. Factory test steam coils with 315 psig compressed air under water. Dehydrate and seal coils prior to shipping.

T. Provide steam-distributing coils with a tube outer diameter (OD) of 1" and an inner distribution tube of 5/8" O.D. Circuit coils for gravity drain of condensate without trapping. Steam shall discharge in the direction of condensate flow to ensure even heat transfer across each tube.

U. Provide water, glycol and DX coils with a tube OD of 5/8” or 1/2”. Mechanically expand tubes to form fin bond and provide burnished, work-hardened interior surface. Tubes shall have a minimum tube wall thickness of 0.020" or 0.025" or 0.035” or 0.049” for 5/8” tubes, and 0.016" or 0.020” or 0.032" for 1/2” tubes.

V. Provide coils with copper tube return bends with the following final minimum thicknesses:
1. 0.035” for 5/8” diameter tubes
2. 0.032” for 1/2” diameter tubes with 0.020” or 0.032” tube wall thicknesses
3. 0.020” for 1/2” diameter tubes with 0.016” tube wall thickness.

W. Provide water, glycol and steam coil headers made of seamless copper or brass tubing. Pipe connections shall be steel or red brass. Header connections (tubes and piping connections) shall be silver-brazed or TIG welded.

X. Provide DX coils with brass distributor and solder-type connections. Suction and discharge connections shall be on the same end regardless of coil depth. Mount refrigerant specialties outside of unit. Provide DX coils with a hot gas bypass port on distributor.

Y. Provide coils with die-formed, continuous aluminum or copper fins. Fins shall have fully drawn collars to accurately space fins and protect tubes. Fins shall be 0.006" or 0.008 or 0.01" thick.

Z. Provide coil coatings as scheduled or indicated on drawings.

2.13 FILTERS

A. Provide filter segments with filters and frames as scheduled.

B. Provide side or front loading filters for filter segments located upstream of coil segment(s) with an access door on the drive side through which filters can be easily loaded.

C. Provide face loading filters for segments located downstream of coil segment(s). Provide an 18” (minimum) access plenum and access door on the drive side through which face loading filters can be easily loaded.

D. Provide Class 2 or Class 1 filter media per U.L. 900 and as required by local codes.

E. Filter types, efficiencies, and nominal depths shall be as follows:
   1. Flat filters – 2” throwaway, 2” permanent cleanable, 2” 30% pleated, or 4” 30% pleated filters, as scheduled.
   2. Angled filters – 2” throwaway, 2” permanent cleanable, or 2” 30% pleated filters, as scheduled.
   3. Rigid filters – 4” mini pleated, 12” rigid, or 22” bag filters with efficiencies of 60-65% (MERV 11), 80-85% (MERV 13), 90-95% (MERV 14), or 90-95% (MERV 15), respectively; as scheduled.
      a. Provide a pre-filter rack in rigid filter segments. Pre-filters shall have 2” throwaway, 2” permanent cleanable, 2” 30% pleated, or 4” 30% pleated filters as scheduled.
   4. Carbon filters – 2” deep rechargeable, incinerable, or disposable panels filled with 60% activity carbon, as scheduled.
      a. Carbon filtration system shall be designed for a minimum contact efficiency of 99% with a residence time of at least 0.08 seconds.
      b. Provide post-filter and/or pre-filter rack in carbon filter segments with 2” throwaway, 2” permanent cleanable, 2” 30% pleated, or 4” 30% pleated filters, as scheduled.
   5. HEPA filters – 12” 99.97%, or 99.99% efficient media, as scheduled.
      a. Performance of installed filtration system shall be certified via a DOP test and classified as UL Class 1 when tested in accordance with UL Standard 586.
      b. Filter frame shall be specifically developed for HEPA filters, with appropriate quantities of filter clamps.

F. Provide a flush mounted, factory installed differential pressure gage on the drive side of unit to measure pressure drop across filters. Manufacturer shall provide fully functional gauges, complete with tubing.

2.14 DAMPERS

A. Provide dampers tested in accordance with AMCA 500.

B. Provide factory-installed dampers, as shown on drawings.

C. Dampers shall have airfoil blades, extruded vinyl edge seals, and flexible metal compressible jamb seals.

D. Dampers shall have a maximum leakage rate of 4 CFM/square foot at 1" w.g., and shall comply with ASHRAE 90.1.

E. Damper blades shall be parallel acting unless otherwise indicated.

F. Damper blades shall be galvanized steel or aluminum, as scheduled.

2.15 AIRFLOW MONITORING STATIONS

A. Provide airflow monitoring stations, as scheduled or shown on drawings.

B. Provide airflow monitoring stations tested in accordance with AMCA Standard 611 in an AMCA registered laboratory. Airflow monitoring stations shall bear the AMCA Ratings Seal for Airflow Measurement Performance.

C. If airflow station incorporates a control damper, control damper shall comply with leakage rates per ASHRAE 90.1 and with specification section 2.14 DAMPERS.

2.16 APPURTENANCES

A. Provide safety grates over bottom openings, as shown on drawings.
   1. Safety grates shall be capable of supporting a 300 lb. center load.

2.17 FINISHES

A. Manufacturer shall clean the exterior surfaces of units prior to finishing, painting, or shipment.

B. Manufacturer shall paint indoor units, as scheduled or shown on drawings.
   1. Manufacturer shall apply a primer prior to painting units.
   2. Manufacturer shall apply a finish coat of acrylic polyurethane paint.
   3. Finished unit shall exceed 500-hour salt spray solution (5%) test without any sign of red rust when tested in accordance with ASTM B-117.

2.18 TESTS AND INSPECTIONS

A. Manufacturer shall dynamically balance fan/motor/base assembly.
   1. Balance constant volume fan assemblies at design RPM.
   2. Balance variable volume fan assemblies from 10% to 100% of design RPM.
   3. Take filter-in measurements in the horizontal and vertical axes on the drive and opposite-drive sides of fan shafts.
   ~~4.~~ Constant speed fan vibration limits: filter-in measurements shall not exceed 4 mils.
   5. Variable speed fan vibration limits: filter -in measurements shall not exceed 7 mils.

2.19 VERIFICATION OF PERFORMANCE

A. Factory test one out of every five AHUs (or a minimum of one unit) to verify compliance with airflow, static pressure, casing leakage, and panel deflection requirements. Owner and engineer reserve the right to select units to be tested. Manufacturer shall pay food, lodging, and travel expenses for up to two witnesses.
   1. Alternatively, field test units to verify compliance with airflow, static pressure, casing leakage, and panel deflection requirements. Follow testing procedures outlined in this specification. Manufacturer shall hire mechanical engineer of record to supervise testing.

B. One representative from both the owner and the engineer shall witness test. Manufacturer shall pay food, lodging and transportation expenses for two witnesses.

C. Perform test on a fully assembled unit with sections joined per manufacturer's installation instructions. Use of additional material (tape, sealant, caulk) is not acceptable.

D. Perform tests to verify the following performance criteria:
   1. Casing leaks no more than 1% of design CFM at +/-8" w.g.
   2. Casing panels deflect no more than L/240 at +/-8" w.g. 'L' is defined as the panel span length and 'L/X' is the deflection at panel midpoint.

E. Manufacturer shall provide condensate analysis for unit design conditions.

F. Should a unit fail a test, treat unit with a permanent remedy at manufacturer's expense until test is successfully passed.

2.20 FACTORY TEST SETUP AND METHODS

A. AHU Preparation
   1. Assemble and seal AHU sections per manufacturer's installation manual.
   2. Close and latch access doors. No additional sealing is permitted.
   3. Seal duct, damper and louver openings.
   4. Blank off and seal supply fan opening(s).
   5. Blank off and seal supply fan bulkhead, to isolate positive and negative pressure sections.

B. Pressurization procedure
   1. Pressurize positive pressure side to specified static pressures using a pressure blower.
   2. Pressurize negative pressure side to specified static pressures using a pressure blower.
   3. Measure and monitor differential pressure exerted on the cabinet with a pressure gage.

C. Deflection test procedure
   1. Measure panel deflections at the centers (length and width) of four panels chosen by owner and engineer.
   2. Measure pressure drop through an ASME long radius nozzle that is mounted in the test module.
   3. Monitor leakage at the same time panel deflection is measured.

D. While under pressure, inspect units failing to meet specified leakage and deflection. Treat failing areas with a permanent remedy. Repeat test and inspection. Re-treat unit as necessary to pass both tests.

E. Provide test data and results in a complete report to the owner.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment per industry standards, applicable codes, and manufacturer's instructions.

B. Do not use AHUs for temporary heating, cooling or ventilation prior to complete inspection and startup performed per this specification.

C. Install AHUs on a concrete pad, or structural steel base, as shown on drawings.

D. Install AHUs with manufacturer’s recommended clearances for access, coil pull, and fan removal.

E. Provide one complete set of filters for testing, balancing, and commissioning. Provide second complete set of filters at time of transfer to owner.

F. Install AHU plumb and level. Connect piping and ductwork according to manufacturer’s instructions.

G. Install seismic restraints and anchors per applicable local building codes. Refer to specification Section 230548 (15240 / 15070) for product and installation requirements.

H. Insulate plumbing associated with drain pan drains and connections.

I. Install insulation on all staggered coil piping connections, both internal and external to the unit.

3.02 FIELD QUALITY CONTROL

A. Store per AHU manufacturer’s written recommendations. Store AHUs indoors in a warm, clean, dry place where units will be protected from weather, construction traffic, dirt, dust, water and moisture. If units will be stored for more than 6 months, follow manufacturer’s instruction for long-term storage.

B. Rig and lift units according manufacturer’s instructions.

3.03 AHU INSPECTION

A. Hire manufacturer’s factory-trained and factory-employed service technician to perform an inspection of unit and installation prior to startup. Technician shall inspect and verify the following as a minimum:
   1. Damage of any kind
   2. Level installation of unit
   3. Proper reassembly and sealing of unit segments at shipping splits.
   4. Installation of shipped-loose parts, including filters.
   5. Completion and tightness of electrical, ductwork and piping connections
   6. Tight seals around wiring, conduit and piping penetrations through AHU casing.
   7. Supply of electricity from the building’s permanent source
   8. Integrity of condensate trap for positive or negative pressure operation
   9. Condensate traps charged with water
   10. Removal of shipping bolts and shipping restraints
   11. Tightness and full motion range of damper linkages (operate manually)
   12. Complete installation of control system including end devices and wiring
   13. Cleanliness of AHU interior and connecting ductwork
   14. Proper service and access clearances
   15. Proper installation of filters

16. Filter gauge set to zero

B. Resolve any non-compliant items prior to proceeding with the inspection of the fan assembly.

3.04 INSPECTION AND ADJUSTMENT: AHU FAN ASSEMBLY

A. Hire the manufacturer's factory-trained and factory-employed service technician perform an inspection of the AHU fan assembly subsequent to general AHU inspection and prior to startup. Technician shall inspect and verify the following as a minimum:
   1. Fan isolation base and thrust restraint alignment
   2. Tight set screws on pulleys, bearings and fan
   3. Tight fan bearing bolts
   4. Tight fan and motor sheaves
   5. Tight motor base and mounting bolts
   6. Blower wheel tight and aligned to fan shaft
   7. Sheave alignment and belt tension
   8. Fan discharge alignment with discharge opening
   9. Fan bearing lubrication
   10. Free rotation of moving components (rotate manually)

B. Manufacturer shall perform service to bring fan performance within factory specifications.

3.05 STARTUP SERVICE AND OWNER TRAINING

A. Manufacturer's factory-trained and factory-employed service technician shall startup AHUs. Technician shall perform the following steps as a minimum:
   1. Energize the unit disconnect switch
   2. Verify correct voltage, phases and cycles
   3. Energize fan motor briefly ("bump") and verify correct direction of rotation.
   4. Re-check damper operation; verify that unit cannot and will not operate with all dampers in the closed position.
   5. Energize fan motors and verify that motor FLA is within manufacturer's tolerance of nameplate FLA for each phase.

B. Provide a minimum of 4 hours of training for owner's personnel by manufacturer's factory-trained and factory-employed service technician..

C. Training shall include startup and shutdown procedures as well as regular operation and maintenance requirements.

D. If AHU is provided with a factory-mounted variable frequency drive (VFD), hire the VFD manufacturer's factory-trained and factory-employed service technician to inspect, test, adjust, program and start the VFD. Ensure that critical resonant frequencies are programmed as 'skip frequencies' in the VFD controller.

E. Submit a startup report summarizing any problems found and remedies performed.

3.06 FIELD PERFORMANCE VERIFICATION

A. Leakage: Pressurize casing to +/-8” w.g. and measure leakage. If leakage exceeds 1% of design airflow, seal leakage points with a permanent solution. Repeat test. If the AHU still does not pass, contact the manufacturer to seal unit.

B. Submit a field test report with testing data recorded. Include description of corrective actions taken.

3.07 CLEANING

A. Clean unit interior prior to operating. Remove tools, debris, dust and dirt.

B. Clean exterior prior to transfer to owner.

3.08 DOCUMENTATION

A. Provide Installation Instruction Manual, & Startup checklist in the supply fan section of each unit.

B. Provide six copies of Spare Parts Manual for owner’s project system manual.

END OF SECTION

SECTION 237323 - CUSTOM CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 DESCRIPTION:

A. This section of the work includes the design, fabrication, testing, cleaning and packaging, shipment, final assembly and installation of custom built-up air handling units by the unit manufacturer in complete accordance with the following specification.

B. The details outlined and component manufacturers named in this specification may not be deviated from in the air handling unit manufacturer's preparation of the bid, even where techniques are required which are not considered standard by the manufacturer. The construction as described in this specification is considered essential, and any deviation from this specification must be specifically identified and bid as a Voluntary Alternate (add or deduct), but only after complying with the specification defined as the Base Bid.

1.3 QUALITY ASSURANCE:

A. All equipment or components of this specification section shall meet or exceed the requirements and quality of the items herein specified or as denoted on the drawings and schedule.

B. Equipment furnished under this specification shall be in accordance with the following industry, association and government codes and standards, as applicable to their design, fabrication, assembly and testing.

1. AMCA 99 Standards
2. ARI 430 Central Station Air Handling Units
3. NFPA 70 National Electric Code
4. NFPA 90A Standard for the Installation of Air Conditioning and Ventilating System

C. Fans shall be rated in accordance with AMCA Standard 210 for performance and AMCA Standard 301 for sound and shall bear the AMCA seal. Motor shall meet requirements of NEMA, IEEE, ANSI, and NEC standard. Coils shall be rated in accordance with ARI Standard 410 and bear the ARI seal.

D. Equipment within unit shall be UL listed where applicable.

1.4 SUBMITTALS:

A. WITH THE QUOTATION: Provide the following detailed information on the equipment proposed Unit manufacturer shall itemize all deviations from the specified requirements. If not so indicated, unit manufacturer will be required to furnish at no cost to the owner:

1. Information requested in the RFQ, including equipment data sheets, schedules and sketches.
2. Equipment drawings showing dimensions, weights (shipping & operating), configuration, major component locations, access door locations, duct connection sizes and locations, and shipping split locations.
3. Materials of construction for housing and major components.

B. AFTER PURCHASE: Make submittals in accordance with requirements of conditions of purchase. Submittals shall show Buyer’s purchase order number, equipment number and project number. Information shall include, as applicable, but not be limited to the following:

1. Information submitted with quotation, revised and expanded as required; including airborne and transmitted sound power levels by octave band for unit.
2. Fan manufacturer and performance curves with the operating points clearly indicated. Motor sizes and types.
3. Coil selections with sizes rows, fin spacing, face velocity, air & fluid temperatures, flow rates, air & fluid pressure drops, and connection sizes.
4. Proposed filters indicating size, efficiency, and pressure drop.
5. (If applicable) Electrical data, wiring diagrams, and accessory panel layouts. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
6. (If applicable) Factory testing procedures for review and acceptance.

C. AFTER RECEIPT OF APPROVED DRAWINGS: Submit manuals with detailed description of installation, operation, and maintenance, including the following:

1. All approved “Certified for Construction” drawings.
2. Written recommendations for field storage, both indoors and outdoors.
3. Installation requirements including assembly instructions, lifting requirements and adjustments.
4. Manufacturer’s literature describing each piece of equipment including operation instructions with step by step preparation of starting, shutdown, and draining and maintenance instructions including lubrication.

1.5 PRODUCT CLEANING, DELIVERY, STORAGE, AND HANDLING:

A. Thoroughly clean equipment, components and subassemblies of water, dirt, debris, weld splatter, grease, oil and other foreign matter prior to shipment.

B. Unit to be prepped and completely sealed for protection during shipment.

1. Seal all openings in unit casings with gasketed, thin gauge sheet metal closure sheets.
2. Seal closures, caps and plugs dust-tight and moisture-tight.
3. Protect pipe flanges with plywood coverings; protect pipe threads with plastic end caps or plugs.
4. Protect machined surfaces with suitable, easily removable rust preventive.
5. Provide full charge of proper lubricant for grease lubricated bearings.
6. Provide desiccant bags or vapor phase inhibitors where required to keep components dry.

C. Ship all air handlers with complete protection from rain and dirt. Air handlers shipped on open trailers shall be protected with a minimum of two (2) layers of heavy mill shrink wrap plastic. Covering units with tarpaulins will not be acceptable since tarpaulins may damage the unit surface.

D. Units delivered with scratched, dented, or dirty surfaces or damage of any type shall be restored to “as new” condition as directed by the Architect/Engineer/Owner at no cost to Owner.

E. If equipment is to be stored before use, shipping protection provided by the unit manufacturer shall remain on the unit until the unit is installed. Manufacturer shall submit written recommendations for field storage.

F. Provide non-corrosive nameplate permanently attached to the equipment containing the following information:

1. Manufacturer’s project/serial number
2. Plant name and location
3. Customer equipment number
4. Date of manufacture

1.6 WARRANTY:

A. All equipment, materials, and workmanship shall be warranted for (12) months from startup or (18) months from shipment, whichever period expires first. During the warranty period, the manufacturer shall repair or replace, at no additional cost to the Owner, any equipment, material, or workmanship in which defects may develop.

B. Warranty is for parts only; labor to remove or reinstall parts is the responsibility of others.

C. Unit casing and structural base shall be warranted against corrosion or failure under normal operating conditions for a period of forty (40) years from the date of unit delivery.

D. The manufacturer to provide full one year parts and labor warranty after owner acceptance. The warranty labor to be performed by a factory authorized technician; technician shall be capable of responding in a 2 hour period, 24 hours a day, 7 days per week. Warranty work may be required after hours to accommodate owner requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Provide air handling units as manufactured by: Air Enterprises, Enivronmental Air Systems, Inc.

B. Alternate pricing based on pre-approved manufacturers will be considered if the following performance requirements and construction techniques are adhered to in all respects. Any substitutions shall be approved by the Architect/Engineer/Owner in writing ten (10) days prior to bid.

C. The unit manufacturer shall have been manufacturing custom built-up air handling units for a minimum of 10 years.

2.2 CUSTOM BUILT-UP AIR HANDLING UNITS:

A. Custom built-up units shall be of the configuration, capacity and style as indicated on the drawings and Equipment Schedule and as specified herein. Through properly designed access; ease of maintenance, removability of components, and unit serviceability shall be assured.

B. The units shall be constructed for (select) indoor / outdoor installation. (If outdoor chosen) Outdoor units to be provided with weatherproofing (roofing, guttering, etc.) as defined herein.

C. The units shall consist of: (develop appropriate listing) intake sections for return and outside air, mixing section with dampers for outside air, return air and exhaust air, pre-filter section, final filter section, heating coil section, cooling coil section, humidifier section, supply and return fan sections, diffuser section, and discharge section.

D. (optional) Units shall be provided with a complete lighting system with switches and receptacles, damper operators furnished and installed on all dampers, and motor wiring to safety disconnect switches.

E. Unit shall employ aluminum material (panels, bases, supports, safing, etc.) to reduce overall unit weight and minimize facility maintenance requirements. (I do not like blanket statements requiring only aluminum, what about replacing aluminum with "….metal materials" (panels,…) while attempting to reduce…

F. Provide safing between internal components and unit casing to prevent air bypass. Safing material shall match unit interior. All seams or voids between safing, components and unit casing shall be caulked and sealed airtight.

G. Provide hygienic unit design with interior suitable for washing down. The use of support members framed within the unit casing which will allow for trapping of debris between the supports and casing will not be allowed. Unit insulation must be completely encapsulated.

H. The unit is to be shipped factory assembled in one complete section, when possible. If necessary to ship the unit in sections, due to rigging or shipping constraints, the unit is to be designed to minimize the number of sections. (optional) The unit manufacturer shall field erect the units in place at the jobsite.

I. The unit sizes shown on drawings are established based on unit performance, structural, and access requirements and are not to be altered. (optional) Maximum allowable section size to be h'-h" H x w'-w" W x d'-d" L & xx,xxx lbs.

2.3 UNIT BASE:

A. The unit shall be constructed on an all-aluminum or stainless steel structural base. The base shall be designed to distribute loads properly to a suitable mounting surface and be braced to support internal components without sagging, pulsating or oil canning.

B. The unit base shall be provided with sloped sumps in areas as indicated on the drawings. Sumps to be welded and guaranteed waterproof to serve as a drain pan to prevent building water damage from the unit. Sump to be double-sloped (min. ¼" per foot) towards units drains to positively remove condensate from the unit.

C. The base floor shall be minimum 3/16” thick aluminum plate welded at all joints and to structural members. Floor material shall have (select) smooth / safety-tread surface. The base floor shall be designed for a minimum live load of 100 pounds per square foot throughout the unit. The base floor is to be supported with adequate stiffening members to prevent oil canning. Caulking, gaskets and mechanical fasteners to guarantee seals and water tightness of joints will not be acceptable.

D. The perimeter support members shall be a minimum of 6” structural member properly sized to support all major components and the housing during rigging, handling and operation of the unit.

E. The underneath side of the base pan and base perimeter shall be insulated with minimum 2” thick 1.5-pcf high density polyisocyanurate foam insulation to form a vapor barrier. (optional – outdoor units) Vapor barrier is then protected by a 0.040” thick aluminum sheet attached to the bottom of the base.

F. Each section of the unit base shall contain a minimum 1” NPT drain to facilitate system washdown, maintenance and condensate removal. Areas in the base where potential standing water cannot be removed through drains or weep holes are not acceptable. Clean out drains shall be provided with removable caps of non-corrosive material.

G. All equipment within air handling unit shall be provided with a minimum 2" high base to raise equipment off unit floor for housekeeping. Equipment mounted directly on unit floor is unacceptable.

H. Supply air openings to be framed with 2” high water dam continuously welded to the pan to allow proper duct connections and to prevent moisture from entering the openings. Framed openings shall be provided with removable aluminum or 304 stainless steel grating designed and fabricated for a live load of 100 pounds per square foot. Galvanized or painted steel grating will not be accepted.

I. All unit base service openings shall be framed with a minimum 2” high water dam continuously welded to the floor. All pipe and electric conduit chases with openings to building or elements shall be covered with thin gage aluminum or 304 stainless steel. Penetrations by contractors shall be sealed by the respective contractor.

J. Fastening to floor plate or joining of unit sections to be accomplished by bolting through gasketed joints above the floor line or continuously welding. Fasteners which penetrate base floor plate are not acceptable.

K. Unit to be provided with properly located permanent lifting plates or removable lifting lugs for each section to adequately allow rigging of the unit sections in place.

L. (optional – as applicable) Base plates shall be provided for attachment to the perimeter members for securing the unit to the floor to prevent movement created by seismic conditions. Base plates and bolt patterns shall be provided in such a manner that the forces are evenly distributed over the base of the unit.

2.4 UNIT CASING

A. Air handling unit casing shall be built up from the unit base with panels. The unit manufacturer shall be the manufacturer of the panel system. Panels shall be load bearing and capable of forming the enclosure without additional structural members. Panels shall be joined together with independent joining member and fastened with closed end aluminum rivets or stainless steel fasteners. Plated fasteners will not be accepted.

B. (optional) Panel joints and seams shall be sealed with FDA approved sealant. Other sealing methods or materials must be approved by the Architect/Engineer/Owner in writing before application.

C. All panels shall be double wall all-aluminum construction with minimum 0.040” exterior and interior skin thicknesses. Interior finish to be smooth, mill finish; exterior finish to be a low-reflective textured mill finish. Each panel shall contain an integral frame or be properly supported by a structural framing system. Panel shall have continuous tight seal at the interior and exterior skins completely encapsulating the insulation.

D. The minimum panel thickness shall be 2-1/2” thick with 3-pcf high density (select) fiber with a R value shall be a minimum of 12 or greater / polyisocyanurate foam with a R value shall be a minimum of 17 or greater insulation.

E. Thickness of the panel skin, core density, rib structural frame spacing shall be regulated to eliminate panel pulsation and restrict the maximum deflection to 1/200 of any span at design load of 1-1/2 times the design positive or negative pressure plus snow and wind loading.

F. Casing system shall be guaranteed to assure the owner that system capacity, performance, and cleanliness standards specified are not compromised. Leakage to be guaranteed at no more than 1/2% of the design volume at 1-1/2 times the design operating pressure or 30 CFM, whichever is greater.

G. All casing walls shall be of panel construction, including but not limited to the fan discharge walls, mixing section walls and divider wall to the access corridor.

H. (optional) Panel system shall incorporate an integral thermal break system downstream of cooling coil such that there is no through metal path between the interior and exterior surface of the unit casing at all locations. The thermal break shall consist of a minimum 1/2" structural epoxy bridge. ~~Adhesive tapes or gaskets do not constitute an acceptable thermal break.~~ Criteria to evaluate requirement for thermal break system shall be based upon scheduled unit performance and ambient conditions anticipated around the units.

I. Any equipment flashing, internal partitions or other attachments to the casing shall be made in such a way as to ensure a permanent leak-tight connection. Attachments that are bolted, screwed, or welded to or through the casing creating air bypass, air leakage or rust propagation areas are not acceptable.

J. All ductwork penetrations through unit enclosure shall be provided with framed openings of size and arrangement as indicated on drawing. (optional) Openings to be provided with flanged duct connections of same material as casing interior extending a minimum of 4” from surface of unit casing.

K. Pipe and conduit penetrations through the unit casings shall be provided by the unit manufacturer and be properly sealed prior to leaving the factory. Penetrations sealed by simply caulking around extension are not acceptable.

L. Provide minimum 24" wide access doors for access to all internal components. Access doors shall be installed to open against the greatest pressure relative to air pressure on each side of access door.

1. Access doors shall be of the same construction as panels described above.
2. The access doors shall incorporate two continuous separate gasket seals around the entire periphery of the door. Gasket material shall be UV-resistant, closed cell neoprene; gaskets shall be attached by adhesive and not mechanically held in place. Single gasket seals will not be accepted.
3. Each access door shall contain a thermopane safety glass window (min. 10" square).
4. (optional) Provide 1" dia. test ports with screwed caps on casing upstream and downstream of all coils and filters for pressure and temperature measurement.
5. Each access door shall be mounted with a corrosion-resistant continuous piano hinge and shall have a least two (2) non-corrosive handles operable from either side.

M. Removable access panels shall be provided as indicated on the drawings for service and maintenance. Access panels shall be of the same construction as panels described above. Removable access panels shall be designed and constructed such that removal and replacement may be accomplished without disturbing adjacent panels. Airtight integrity must be maintained.

2.5 ROOF SYSTEM (use for outdoor units)

A. Unit roofs for outdoor units are to be sloped a minimum of 1/4" per foot to assure positive run-off. Roof to (select) peak in center and drain off to both sides / on door side and drain away from door side.

B. The entire roofing system shall be a polymer membrane permanently bonded to the unit roof. Membrane to be minimum 0.045" thick. Standing seam roofing system will not be acceptable.

C. Unit shall be provided with a non-corrosive rain gutter system with downspouts to guide unit roof water run-off to the building roof. Units incorporating roof systems without controlled water run-off accommodations are not acceptable.

2.6 OUTSIDE AIR SECTION

A. Outside air shall be admitted and exhaust air shall be discharged through storm-proof, extruded aluminum or stainless steel louvers, minimum 3-1/2" deep with aluminum or stainless steel bird-screen and aluminum or stainless steel weather hoods. Weatherhood exterior to match the finish of the unit casing.

(optional) Outside air shall be admitted through drainable blade stationary fog-type louver. Louver shall be certified storm-proof, extruded aluminum, with aluminum birdscreen. Louver to be Cesco Products, Type ASL6. Or equivalent by Greenheck, Air Balance, or Pottorff.

B. Louver shall have AMCA certified air performance and water penetration ratings.

C. (optional) Louver to be provided with a low-leakage outside air damper. Dampers shall be as specified below and shall be furnished and installed by the unit manufacturer.

D. Outside air intake shall be sized for a maximum of 450 fpm. Exhaust air discharge shall be sized for a maximum of 750 fpm.

2.7 MIXING SECTION

A. Complete with framed openings with low-leakage outside and return air dampers. Dampers shall be as specified below and shall be furnished and installed by the unit manufacturer.

B. Mixing section shall be designed for controlled mixing in that the proximity, relation, and air velocity for each respective damper shall be such that volume swings and stratification will be eliminated.

C. Outside air damper banks incorporating minimum outside air to be provided with an independent damper with independent control for minimum outside air. Minimum outside air provided by controlling outside air damper bank to a minimum position will not be acceptable.

2.8 DAMPERS

A. Dampers shall be low leakage, opposed blade design capable of withstanding 8” wg differential pressure at 2,000 fpm approach velocity. Leakage rate not to exceed 6 CFM per ft.^{2} at 4” wg differential pressure and 2,000 fpm approach velocity.

B. Damper frames shall be made of extruded aluminum. Damper blades shall be extruded aluminum airfoil shape to withstand high velocities and static pressures. Dampers shall be provided with stainless steel blade end seals and flexible synthetic blade edge seals.

C. (optional) Damper actuators to be mounted by unit manufacturer. Damper actuator to be Johnson Controls - model D3153 or equal. Actuators for dampers with modulating control to be provided with pilot positioners.

D. Acceptable dampers: Arrow ‘AFD-20’, Ruskin ‘CD-50’, TAMCO 1500, Greenheck.

2.9 SUPPLY & RETURN FAN SECTIONS:

A. Provide fans, motors and drives of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications.

B. (housed fans) Fan sections shall be complete with DWDI, arrangement 3, centrifugal fans as per the following:

1. Fan housing shall be heavy gauge construction with spun inlet cones. Housings shall be suitably braced to prevent vibration or pulsation. Scroll housing shall be connected to sideplates with a high quality air tight seal; seam shall be continuously welded as required for application. Bearing supports shall be rigid and shall provide a firm foundation for the shaft and bearings. Bearings supported from the fan housing will not be acceptable.

2. Fan wheels shall be non-overloading, airfoil type. Impellers shall be statically and dynamically balanced to a level of G6.3 (per ANSI 2-19) or better. Hubs shall be straight bored, keyed and set screwed to the shaft. Shafts are to be solid steel sized for first critical speed of at least 1.25 times the maximum speed for the class for class I and II fans and 1.42 times the maximum speed for class for class III and IV fans.

3. Bearings are to be heavy duty, grease lubricated, anti-friction, self-aligning, pillow block type and selected for minimum average bearing life (AFBMA L-50) in excess of 200,000 hours at the maximum class RPM. All bearings shall be equipped with regreasable Zerk fittings and lubrication lines extended to accessible location on fan housing for easy access for lubrication.

4. Fan shall be provided with heavy gauge wire inlet screens, housing access door, and scroll drain as required. In the event inlet vanes are provided, fan will not require inlet screens.

5. Fan shall be cleaned, prime coated and provided with two coats of enamel final coat.

6. Each fan shall be test run at their operating speed or at the maximum RPM for the particular fan's construction class prior to shipment. The fans are to be balanced and records maintained of the readings in the axial, vertical, and horizontal direction on each of the fan's bearings. Final peak velocity measurements shall not exceed 0.1 in/sec.

7. Acceptable fan manufacturers: Twin City Fan, Greenheck, Cook, New York Blower

C. (plenum fans) Fan sections shall be complete with SWSI, arrangement, (select) 3 (belt-drive) / 4 (direct-drive), plenum fans as per the following:

1. Fan unit shall be formed by welding heavy gauge steel inlet plate with spun inlet cones to steel angle frame. (Arr. 3 only) Bearing supports shall be rigid and shall provide a firm foundation for the shaft and bearings. Bearings supported from the fan housing will not be acceptable. A square formed lip shall surround the unit, suitable for attachment of flex connector.

2. Fan wheels shall be non-overloading, airfoil (I would not restrict to airfoil type only, I would say centrifugal type) type. Impellers shall be statically and dynamically balanced to a level of G6.3 (per ANSI 2-19) or better. Hubs shall be straight bored, keyed and set screwed to the shaft. Shafts are to be solid steel sized for first critical speed of at least 1.25 times the maximum speed for the class for class I and II fans and 1.42 times the maximum speed for class for class III and IV fans.

3. Bearings are to be heavy duty, grease lubricated, anti-friction, self-aligning, pillow block type and selected for minimum average bearing life (AFBMA L-50) in excess of 200,000 hours at the maximum class RPM. All bearings shall be equipped with regreasable Zerk fittings and lubrication lines extended to accessible location on fan housing for easy access for lubrication.

4. Fan shall be provided with wire mesh protective wheel enclosure and heavy gauge wire inlet screen. In the event inlet vanes are provided, fan will not require inlet screens.

5. Fan shall be cleaned, prime coated and provided with two coats of enamel final coat.

6. Each fan shall be test run at their operating speed or at the maximum RPM for the particular fan's construction class prior to shipment. The fans are to be balanced and records maintained of the readings in the axial, vertical, and horizontal direction on each of the fan's bearings. Final peak velocity measurements shall not exceed 0.1 in/sec.

7. Acceptable fan manufacturers: Twin City Fan, Greenheck, Cook, New York Blower

D. Motors shall be 1750 RPM, 460V/3ph/60Hz as per the following:

1. Motor shall be premium efficient, (select) ODP / TEFC enclosure.

2. Motor shall be of HP as listed on schedule and be selected for a minimum of 10% over calculated BHP. The motor service factor shall be a minimum of 1.15. (Substitute for arr. 4 direct-drive) Motor shall be of HP listed on schedule; selected to provide adequate torque

throughout entire range of fan operation and not exceed nameplate HP when fan operates at synchronous motor speed.

3. Motor shall be designed for continuous duty operation, NEMA Design B with class F insulation.
4. The motor shall be suitable for operating with variable frequency drives without undue noise, vibration or deterioration of reliability and life.
5. Motors shall be "Inverter Duty Rated" per NEMA Std. MG1 part 31.4.4.2 and labeled as such.
6. Variable frequency PWM driven motors shall include a circumferential, conductive micro fiber shaft grounding ring or equivalent shall be installed on the AC motor to discharge shaft currents to ground.
7. Provide stainless steel nameplate indicating the following:
   a) NEMA efficiency index nominal efficient (MB1-12.53BO).
   b) AFBMA bearing numbers.
   c) Lubrication instructions.
8. Acceptable motor manufactures: Baldor, Marathon Electric, TECO - Westinghouse

E. The entire fan assembly shall be provided with a minimum of 18" clearance on all unattached sides for proper service access. Fan inlets to be provided with a minimum clearance distance equal to 75% of the wheel diameter.

F. The unit manufacturer shall provide flexible connection between fan and fan wall. Fan assembly shall be provided with thrust arrestors as required to prevent damage to the flex connection. Flex connection material shall be flame retardant fabric suitable for intended use meeting the requirements of NFPA 90A.

G. The fan and motor shall be factory-mounted on a (select) spring / inertia type vibration base. The base shall be mounted on (select) stable free standing spring / adjustable, seismically restrained (seismic zone 4) isolators with 3" maximum deflection rating. Spring efficiency to be not less than 98%. (optional when using inertia base) The inertia base shall have additional mass equal to two times the fan weight. Mass to be provided by concrete installed by the general contractor during unit installation at the jobsite.

H. (Arr. 3 fans only) Motor shall be mounted on an adjustable motor base affixed to the fan vibration base. The motor base shall control belt tension in order to minimize belt servicing and extend belt life. The motor base shall be permanently aligned type so belts can be changed without having to realign the motor and V-belt drive. The motor base shall be mounted parallel to belt pull for maximum bearing life.

I. (Arr. 3 fans only) The V-belt drive shall be the constant speed type provided with a minimum of two (2) drive belts. Drives with two (2) belts shall have a minimum service factor of 2.0; all other drives shall have a service factor of 1.5. (optional) The unit manufacturer shall provide one (1) set of additional sheaves as required to balance the unit for the system. Installation of any additional sheaves shall be the responsibility of the balancing contractor.

J. (Arr. 3 fans only) V-belt drive shall be enclosed in a perforated metal belt guard. The belt guard is to be a two-piece design split along shaft centerlines; fastened with two quick disconnect clasps so that access to the belts can be made without the use of any tools. Designs resulting in loose hardware will not be accepted. Beltguard shall have framed holes at the fan & motor shaft with cover plates to allow for tachometer measurements.

K. (Optional) Fan section to be provided with structural I-beam assembly posted from the unit floor for mounting trolley to assist in motor removal; trolley assembly by others. Beam assembly to be steel construction; cleaned, prime coated and provided with two coats of enamel final coat.

L. (Optional - dual fan arrangements) Each fan shall have an isolation damper to isolate one of the fans off-line for servicing while the second fan continues to operate. Damper shall be per the following:

1. Dampers to be installed with the damper blades positioned vertically. Dampers shall be low leakage, opposed blade design capable of with standing 8” wg differential pressure at 2,000 fpm approach velocity. Leakage rate not to exceed 6 CFM per ft.^{2} at 4” wg differential pressure and 2,000 fpm approach.

2. Damper frames shall be made of extruded aluminum. Damper blades shall be extruded aluminum airfoil shape to withstand high velocities and static pressures. Dampers shall be provided with stainless steel blade end seals and extruded silicone blade edge seals.

3. Dampers shall be provided with two sets of linkage; one set concealed in the side frame of the damper and one set mounted from the blades on the face of the damper. Dampers are to be driven from an extended drive rod.

4. (optional) Damper actuators to be mounted by unit manufacturer. Damper actuator to be Johnson Controls – D-3240 series or equal.

5. Acceptable dampers: Arrow ‘AFD-20’, Ruskin ‘CD-50’, TAMCO 1500.

M. All features, as outlined above shall be provided in order to reduce fan system maintenance downtime and minimize equipment service.

2.10 (optional) AIR FLOW MEASUREMENT

A. Provide as indicated on the accompanying plans, airflow measurement provision (optional) and transmitters for the purpose of continuously monitoring unit airflow volume.

B. The airflow measurement system shall consist of a piezometric flow ring incorporated into the inlet of the fans. Ring shall consist of a minimum of four orifice ports strategically located in the throat of the fan inlet; orifice taps to be piped with tubing in a continuous ring. Tubing to be extended to accessible location for connection to flow transmitter.

C. Piezometric ring to be provided integral with the fan construction.

2.11 (optional) (select) DIFFUSING SCREEN / EVASE DIFFUSER SECTIONS

DIFFUSING SCREEN

A. Provide air diffusing screen downstream of supply fan to disperse air evenly across the downstream components. Free area of total diffusing screen area shall be equal to twice the area of the fan discharge.

B. Diffusing screen shall be minimum 1/8” thick aluminum material, 1/2” holes on 11/16” centers, mounted on aluminum vertical angles extending the full height of the unit section. Screen shall be rigidly bolted into place to prevent undue vibration and noise.

C. Diffusing screen shall be located not less than 12” from the fan discharge wall. Minimum clearance of 24” is required downstream of screen to adequately service final filters.

Or EVASE

A. Provide air diffusing evase downstream of supply fan to disperse air evenly across the downstream components and provide regain of velocity pressure at fan discharge.

B. Evase sides to provide total expansion angle at 15 °; top and bottom of evase expansion angle to be total 30 °. Evase length shall not be less than 75% of the fan wheel diameter for optimum regain.

C. Evase shall be minimum 16 ga galvanized steel material with edges sealed for maximum strength and minimum leakage. Evase shall be rigidly braced to prevent undue vibration and noise.

D. Evase to be mounted with leaving edge fixed to the fan discharge wall. Flexible connection to be provided between the fan and the evase.

2.12 FILTER SECTIONS:

A. Provide all prefilters and final filters of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications. Filters to be selected for a maximum face velocity of 500 fpm.

B. Filters shall have nominal rating of 500 fpm. Each cell shall be 24" x 24", or 12” x 24”. Initial pressure drop shall not exceed that indicated. Media shall be approved and listed as Underwriters Laboratories Class 2 when tested according to UL Standard 900 and as described below:

1. Prefilters: 2" thick MERV 7 efficiency (per ASHRAE Test Standard 52.2-2007), and MERV 12 (per ASHRAE Test Standard 52.2-2007), rigid disposable filters.
2. Final Filters: 12” rigid type, MERV 15 (per ASHRAE Test Standard 52.2-2007), rigid disposable filters.
3. HEPA Filters: 99.97% (when tested with 0.3 micron thermally generated particulates) high capacity HEPA filters tested and certified.

C. Filters shall be upstream removable. Side access is not acceptable. Pre-filter sections shall be complete with holding frames capable of holding prefilters with high efficiency filters. Prefilters shall be capable of being removed and installed without affecting seal of the high efficiency filter.

D. Filter frames upstream of cooling coils or humidifiers shall be galvanized steel construction; stainless steel or aluminum construction required for locations downstream of cooling coils or humidifiers. Frames to be provided with closed cell neoprene gasketing and all associated clips required to hold filter cells.

E. Filter holding frames shall be installed and individually sealed to prevent leakage around frames. Filter banks shall be reinforced with vertical stiffeners to assure rigidity. Unit manufacturer shall provide flashing between filter banks and unit casings to prevent air leakage or bypass around the frames. Installation techniques, sealing methods, and structural reinforcement eliminate unfiltered air bypass and assure system cleanliness based on filter efficiencies specified.

F. Unit manufacturer shall provide and install a Dwyer series 2000 magnehelic gauge complete with stainless steel static pressure tips and accessories for indicating the operating pressure drop of each filter bank. Indicating range of gauge shall be selected at two times the final resistance of the filter bank.

G. Unit manufacturer shall provide xxx (x) sets of prefilter media and xxx (x) sets of final filter media, (optional) and one (1) set of HEPA filter media with the unit for installation by others.

H. Acceptable filter frame and filter manufacturers: American Air Filter, Farr

2.13 COOLING COIL SECTION (CHILLED WATER):

A. Provide chilled water cooling coils of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications. Coils to be selected with maximum face velocity of 500 fpm; maximum head pressure loss of 20 ft.

B. Chilled water coils shall have minimum 0.025" thick, 5/8" diameter, copper tubes, 0.0075" (select) aluminum / copper fins, nonferrous headers with min. 1/2” dia. MPT drain and vent connections. Coil casings shall be minimum 16 gauge 304 stainless steel. Coil fin spacing shall not exceed 10 fpi.

C. Coils shall be circuited to provide the required performance; the use of internal restrictive devices, or turbulators, to obtain turbulent flow will not be acceptable.

D. Coils shall be tested to 250 psig under water and shall be guaranteed for 200 psig working pressure.

E. Coils shall be individually supported by a stainless steel rack system. This rack shall allow any one (1) coil to be removed though the unit casing, normal to the direction of air flow, without disturbing any other coil. Coils stacked one on top of the other will not be accepted.

F. Each coil shall include a sloped, positive-draining stainless steel condensate pan assembly. Drain pan to be constructed from minimum 16 gauge 304 stainless steel material. Coils shall set above the condensate pan for ease of removal. Intermediate condensate drain pan shall be minimum 1-1/2” deep; extending at least 3" upstream and at least 12" downstream of the coil face. Each drain pan shall be individually piped down to the bottom pan; lower drain pan to be provided with a drain connection of sufficient size to remove condensate extended to the unit exterior for connection by others.

G. Where necessary to prevent moisture carryover, each coil shall have aluminum or stainless steel moisture eliminators provided on the downstream side. Cooling coils condensate pans shall be designed and manufactured to incorporate future eliminators without any field modification.

H. Supply and return connections are to be extended and sealed through the casing wall; drain and vent connections shall be terminated internally. (optional) piped with ball valves and hose bibs for the drain.

I. Provide removable access panels in the unit casing on each side of the unit for ease of coil removal.

J. Acceptable coil manufacturers: Coilmaster, Heatcraft, Aerofin, Greenheck

2.14 HEATING COIL SECTION (HOT WATER):

A. Provide hot water heating coils of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications. Coils to be selected with maximum face velocity of 550 fpm; maximum head pressure loss of 15 ft.

B. Coils shall have minimum 0.020" thick, 5/8" diameter, copper tubes, 0.0075" (select) aluminum / copper fins, nonferrous headers with min. 1/2” dia. MPT drain and vent connections, and aluminum coil casing. Coil casings shall be minimum 16 gauge galvanized steel; aluminum or stainless steel casings required for coils located downstream of cooling coils or humidifiers. Coil fin spacing shall not exceed 10 fpi.

C. Coils shall be circuited to provide the required performance; the use of internal restrictive devices, or turbulators, to obtain turbulent flow will not be acceptable.

D. Coils shall be tested to 250 psig under water and shall be guaranteed for 200 psig working pressure.

E. Coils shall be individually supported by an all-aluminum rack system. This rack shall allow any one (1) coil to be removed though the unit casing without disturbing any other coil.

F. Supply and return connections are to be extended and sealed through the casing wall; drain and vent connections shall be terminated internally. (optional) piped with ball valves and hose bibs for the drain.

G. Acceptable coil manufacturers: Coilmaster, Heatcraft, Aerofin, Greenheck

2.15 STEAM HEATING COILS

A. Provide steam heating coils of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications. Coils to be selected with maximum face velocity of 700 fpm; maximum tube length of 8 ft.

B. Coils shall be non-freeze type heating coils. Coils shall have 1" seamless copper condensing tubes and 5/8" OD seamless copper distribution tubes, 0.035" tube wall thickness, 0.0075" (select) aluminum / copper fins, and steel headers. Coil casings shall be minimum 16 gauge galvanized steel; aluminum or stainless steel casings required for coils located downstream of cooling coils or humidifiers. Coil fin spacing shall not exceed 10 fpi.

C. The coil design shall allow for one end of the tubes to be free floating to allow for expansion.

D. Complete coils shall be tested to 315 psig under water and shall be guaranteed for 250 psig working pressure.

E. Coils shall be individually supported by an all-aluminum rack system. This rack shall allow any one (1) coil to be removed though the unit casing without disturbing any other coil.

F. Supply and return connections are to extended and sealed through the casing wall.

G. The coils shall be located in the unit such that the condensate connections shall be a minimum of 18" above the unit base to allow for proper trapping.

H. Acceptable coil manufacturers: Coilmaster, Heatcraft, Aerofin, Greenheck

2.16 INTEGRAL FACE & BYPASS HEATING COILS (STEAM/HOT WATER)

A. Provide heating coils with integral face and bypass dampers of number, size and capacity as required for air handling system indicated on drawings and as stated in these specifications. Coils to be selected with maximum face velocity of 750 fpm; maximum head pressure loss of 10 ft.

B. Coils shall consist of built-in series of finned heating elements and by-passes with interlocked dampers controlled by a damper motor and air-stream thermostat. Dampers shall completely enclose and isolate the heating coil passes when no heating is required. Face & bypass arrangements not utilizing an integral coil and damper are not acceptable.

C. Coils shall have minimum 0.035" thick, 5/8" diameter, copper tubes, 0.0075” (select) aluminum / copper fins, steel headers, galvanized finish steel dampers, and galvanized steel casing. Coil fin spacing shall not exceed 11 fpi.

D. Coils shall be provided with coil manufacturer supplied destratification baffles and minimum 36” downstream clearance to next component for proper mixing of air downstream of coil.

E. Complete coils shall be tested to 250 psig under water and shall be guaranteed for 200 psig working pressure.

F. Damper motor to be provided and installed by (select) others / air handling unit manufacturer. Air handling unit manufacturer to coordinate with supplier of damper motor to assure proper mounting bracket is provided with the coil.

G. (optional) Airstream thermostat shall be provided with the coil by the air handling unit manufacturer.

H. Provide removable access plug panels on each side of the unit for ease of coil removal.

I. Supply and return connections are to be extended and sealed through the casing wall; drain and vent connections shall be terminated internally. (optional) piped with ball valves and hose bibs for the drain.

J. Acceptable coil manufacturers: Aerofin, Wing, Marlo ‘Stratomizer’

2.17 HUMIDIFIERS:

A. Provide panel type, steam dispersion humidifier designed for short absorption distribution of size, arrangement, and capacity as required for air handling system indicated on drawings and as stated in these specifications. Multiple dispersion tube type distribution will not be acceptable. (Is this trying to prohibit, multiple single tubes? Most manifolds are assemblies of tubes, so I would not prohibit that type of dispersion.)Humidifier panel to be selected with maximum face velocity of 650 fpm.

B. Absorption distance shall not exceed 24” at desired conditions. Air handling manufacturer shall be responsible for proper absorption distance for steam between humidifier and downstream components.

C. Dispersion panel to be provided with stainless steel casings. Panel to be mounted on a stainless steel support structure with stainless flashing between humidifier and casing walls to prevent air bypass.

D. Steam supply and condensate return connections are to be extended and sealed through the casing wall. The condensate connections shall be a minimum of 18” above the unit base to allow for proper trapping; if required, condensate trap to be installed by AHU manufacturer internal to unit.

E. Humidifier is to be provided with pneumatic or electric operator with pilot positioner, F&T traps as required and Y-type strainer for steam supply line.

F. Acceptable humidifier manufacturers: Armstrong, Carel, Dri-Steem, Neptronic.

2.18 SOUND ATTENUATOR SECTION:

A. Sound attenuator sections shall be complete with individual battens the full height and full width of the section in order to provide uniform leaving air velocities and lower pressure drops. Modularized sound attenuator assemblies with horizontal air restrictions are not acceptable.

B. The battens shall be of aluminum construction; filled with a fibrous inert core. Each batten shall consist of a solid aerodynamically styled nose piece with parallel perforated walls. Core material is to be covered with a tight weave cloth to prevent out-migration of fiber materials into the airstream; covering shall be porous material not diminishing the attenuating properties of the attenuators. Unit manufacturer shall guarantee lining cloth provided prevents out-migration of fibers.

The attenuator manufacturer shall have published literature documented by independent test laboratories for acoustic performance of the sound attenuators. or have documentation that published data has been obtained using a NAVLAP certified laboratory.

C. Minimum Net Insertion Loss (db) of the attenuators shall be as follows:

Octave Band No.	2	3	4	5	6	7	8
Center Frequency (kHz)	.125	.25	.5	1	2	4	8
Supply Air	-	-	-	-	-	-	-
Return Air	-	-	-	-	-	-	-

D. Custom air handling unit inlet and outlet airborne sound power levels and radiated sound pressure levels shall be guaranteed to meet the specified sound levels and shall be the responsibility of the unit manufacturer

2.19 UNIT DISCHARGE SECTION

A. Discharge section with exit velocities exceeding 2000 fpm shall be complete with aerodynamically designed framed discharge openings or spun bellmouth fittings in order to reduce overall system static pressures.

B. Bellmouth fittings shall have minimum radius equal to 20% of the diameter (round or oval) or shortest side (rectangular) to provide optimum performance. Bellmouths with radius less than 2” are not acceptable. Bellmouth to be mounted flush with unit interior edge to minimize exit loss.

C. Openings shall conform to the size and configuration of the ductwork where shown.

D. Smoke dampers shall be furnished and installed by the unit manufacturer for supply air (and return air) openings as shown on the drawings. Dampers shall be as specified below:

1. Dampers shall be parallel blade design capable of with standing 8” wg differential pressure at 2,000 fpm approach velocity. Damper shall meet requirements of Leakage Class II.
2. Damper frames shall be made of extruded aluminum. Damper blades shall be extruded aluminum airfoil shape to withstand high velocities and static pressures. Dampers shall be provided with stainless steel blade end seals and flexible synthetic blade edge seals to keep leakage to a minimum.

3. Damper linkage to be concealed in frame channel outside of the airstream. Dampers shall be provided with extended shaft for connection to actuators.
4. Damper actuators to be mounted by unit manufacturer. Provide a minimum of one pneumatic damper actuator per 16 $ft.^2$ maximum damper area. Damper actuator to be Johnson Controls - model D3153 or equal. Actuators for dampers with modulating control to be provided with pilot positioners.
5. Smoke dampers and operators shall be qualified under UL555S to a minimum elevated temperature of 250^{o}F.
6. Acceptable dampers: Ruskin ‘SD-50’ or equivalent by Greenheck, Air Balance

2.20 (optional for outdoor units) SERVICE CORRIDORS / SERVICE CLOSETS:

A. Unit to be provided with an (select) integral service vestibule / service closet.

(use for service vestibule) Access corridor to be minimum five (5) ft. clear wide by full height and length of the unit. Access corridor to be of the same construction as the unit previously described. Access corridor floor shall be level without obstructions such as at joining sections that might act as trip points.

(use for service closet) Provide a minimum 3 ft. wide service closet extending from the upstream side of the heating coils to the downstream side of the cooling coils to house and protect coil piping. The service closet shall be provided with dual full height access doors to allow complete access to closet interior and piping

B. Provide a 3KW 3/60/460V electric unit heater with wall mounted thermostat for maintaining a minimum of 50°F temperature during winter operation. Provide factory mounted and wired heater, disconnect switch and thermostat. Provide ventilation for removing heat of variable speed drives and other devices within the vestibule.

C. The service corridor shall provide for floor supporting of field piping installations. The support structure shall include a means for pipe hangers to be attached to supporting members. The support members shall be three feet on center and sized to support a uniform piping load of 250 lbs./ft.

2.21 ELECTRICAL:

A. All electrical work shall be installed in full compliance with the National Electric Code, and all local codes and requirements. Where applicable, components shall be UL approved. All wiring and components inside air handling plenums shall be weatherproof and rated for such use. All equipment shall contain a grounding conductor.

1. WIRING: 600 volt rated, type #12 THHN copper (minimum size).
2. CONDUIT: EMT (optional) Aluminum rigid / Galvanized rigid conduit utilizing compression type fittings. All conduit penetrations in the unit housing and penetrations across the cooling coil sections and humidifier sections shall be internally sealed with foam sealant to prevent the migration of water vapor in the conduit.

B. Unit manufacturer shall furnish, install and wire a complete lighting system to one (1) identified 120 volt feed location. Lighting system to include light fixtures, switches, and a GFCI receptacle per the following:

1. LIGHT FIXTURES: vapor tight incandescent marine type guarded service light fixture, 100 watt (A-21) R.S. bulb. (optional) 120 volt, dust and moisture resistant, fluorescent light fixture, (2) 40 watt, cool white, rapid start bulbs. Each access section to be provided with minimum of one (1) light fixture. (use for incandescent systems) Fan sections and filter sections to be provided with minimum of two (2) light fixtures. Access corridors to have a minimum of three (3) light fixtures.

2. LIGHT SWITCHES: 20 AMP, single pole, specification grade, toggle switch in lug type device box with (select) (indoor applications) stainless steel / (outdoor applications) weatherproof cover.

3. GFCI CONVENIENCE OUTLETS: 20 AMP, specification grade, NEMA 5-20R, duplex receptacle in lug type device box with (select) (indoor applications) stainless steel / (outdoor applications) weatherproof cover. Unit to be provided with one (1) convenience outlet on unit exterior at the fan section.

C. Unit manufacturer shall furnish , install and wire a (select) safety switch / fan motor disconnect for each fan motor to one (1) identified 460 volt feed location. Final connection to motors shall be made through Sealtight flexible conduit.

1. FAN SAFETY SWITCH: 3-pole, heavy duty, horsepower rated, non-fusible, visible blade, disconnect switch in a NEMA (select) (indoor use) 12 / (outdoor use) 3R or 4 enclosure.

or FAN MOTOR DISCONNECTS: 3 pole, 600V, horsepower rated, heavy duty, visible blade, non-fused, NEMA (select) (indoor use) 12 / (outdoor use) 3R or 4 safety switch with 2 pole control circuit interlock if used in conjunction with variable speed drive.

2.22 AIR-TO-AIR ENERGY RECOVERY

A. Runaround Coil Heat Exchangers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. American Energy Exchange, Inc.
   b. Des Champs Technologies.
   c. Exothermics Inc.; a brand of Eclipse, Inc.
   d. Nutech Brands Inc.
   e. RenewAire LLC.

2. Casing: [**Aluminum**] [**Galvanized steel**] [**Enameled steel, with galvanized-steel liner**] [**Enameled steel**].
3. Plates: Evenly spaced and sealed and arranged for counter airflow.
4. Plate Material: [**Embossed aluminum**] [**Stainless steel**] [**Polypropylene copolymer (high-density plastic)**].

   a. Plate Coating: [**Epoxy**] [**Air-dried phenolic**].

5. Bypass: Plenum within casing, with gasketed face-and-bypass dampers that have operating rods extended outside casing.
6. Water Wash: Automatic system, with spray manifold to individual spray tubes or traversing type with stainless-steel-screw operating mechanism and electric motor drive; activated by time clock[**, with detergent injection**].

Heat-Exchanger Prefilters: [**1 inch (25 mm) thick, disposable**] [**2 inches (50 mm) thick, disposable**] [**Medium efficiency**] [**Electrostatic**].

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Equipment Mounting: Install air-handling units on concrete bases [using elastomeric pads] [using elastomeric mounts] [using restrained spring isolators] [without vibration isolation devices]. Secure units to anchor bolts installed in concrete bases. Comply with requirements for concrete bases specified in [Section 033000 "Cast-in-Place Concrete."] [Section 033053 "Miscellaneous Cast-in-Place Concrete."] Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [1/2 inch (13 mm)] [1 inch (25 mm)] [2 inches (50 mm)] [3 inches (75 mm)].
2. Install [galvanized] [stainless]-steel plate to equally distribute weight over elastomeric pad.
3. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
4. Install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
5. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
6. Install anchor bolts to elevations required for proper attachment to supported equipment.

B. Equipment Mounting: Install air-handling unit [using elastomeric pads] [using elastomeric mounts] [using restrained spring isolators] [without vibration isolation devices]. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [1/4 inch (6 mm)] [1/2 inch (13 mm)] [1 inch (25 mm)] [2 inches (50 mm)] [3 inches (75 mm)].
2. Install [galvanized] [stainless]-steel plate to equally distribute weight over elastomeric pad.

C. Suspended Units: Suspend[and brace] units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Arrange installation of units to provide access space around air-handling units for service and maintenance.

E. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

F. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to air-handling unit to allow service and maintenance.

C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.

D. Connect condensate drain pans using NPS 1-1/4 (DN 32), ASTM B 88, Type M (ASTM B 88M, Type C) copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.

E. Hot- and Chilled-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.

F. Steam and Condensate Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping." Install shutoff valve at steam supply connections, float and thermostatic trap, and union or flange at each coil return connection. Install gate valve and inlet strainer at supply connection of dry steam humidifiers, and inverted bucket steam trap to condensate return connection.

G. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.

H. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:

1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
2. Charge refrigerant coils with refrigerant and test for leaks.
3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. HEPA-Filter Operational Test: Pressurize housing to a minimum of 3-inch wg (750 Pa) or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.
5. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that shipping, blocking, and bracing are removed.
3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
6. Verify that zone dampers fully open and close for each zone.
7. Verify that face-and-bypass dampers provide full face flow.
8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
9. Comb coil fins for parallel orientation.
10. Verify that proper thermal-overload protection is installed for electric coils.
11. Install new, clean filters.
12. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

B. Starting procedures for air-handling units include the following:

1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
2. Measure and record motor electrical values for voltage and amperage.
3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.6 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.7 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 237313

SECTION 238123 - COMPUTER-ROOM AIR-CONDITIONERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Floor-mounted computer-room air conditioners, 6 tons (21 kW) and larger.
2. Floor-mounted computer-room air conditioners, 5 tons (18 kW) and smaller.
3. Ceiling-mounted computer-room air conditioners.
4. Console computer-room air conditioners.

1.3 DEFINITION

A. BAS: Building automation system.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Computer-room air conditioners shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. LEED Submittals:

1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.
2. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings: For computer-room air conditioners. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Wiring Diagrams: For power, signal, and control wiring.

D. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.

1.6 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, using input from Installers of the items involved.

B. Seismic Qualification Certificates: For computer-room air conditioners, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

D. Warranty: Sample of special warranty.

1.7 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For computer-room air conditioners to include in emergency, operation, and maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan Belts: One set for each belt-driven fan.

1.9 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. ASHRAE Compliance:

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

D. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

1.10 COORDINATION

A. Coordinate layout and installation of computer-room air conditioners and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

B. Coordinate installation of computer-room air conditioners with computer-room access flooring Installer.

C. Coordinate sizes and locations of concrete bases with actual equipment provided.

D. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.11 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
2. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Substantial Completion.
3. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FLOOR-MOUNTED UNITS 6 TONS (21 kW) AND LARGER

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Liebert Corporation.

B. Description: Packaged, factory assembled, prewired, and prepiped; consisting of cabinet, fans, filters, humidifier, and controls.

C. Cabinet and Frame: Welded steel, braced for rigidity, and supporting compressors and other mechanical equipment and fittings.

1. Doors and Access Panels: Galvanized steel with polyurethane gaskets, hinges, and concealed fastening devices.
2. Insulation: Thermally and acoustically insulate cabinet interior with 1-inch- (25-mm-) thick duct liner.
3. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
4. Finish of Exterior Surfaces: Baked-on, textured vinyl enamel; color [**as selected from manufacturer's standard colors**] [**to match computer equipment**].
5. Floor Stand: Welded tubular steel, **<Insert required height>** high, with adjustable legs and vibration isolation pads.

D. Supply-Air Fan(s):

1. Double-inlet, forward-curved centrifugal fan(s); statically and dynamically balanced.
2. Drive: V-belt, with steel shaft with self-aligning ball bearings and cast-iron or steel sheaves, variable- and adjustable-pitch motor sheave, minimum of two matched belts, with drive rated at a minimum of two times the nameplate rating of motor.

E. Refrigeration System:

[Retain one of first three subparagraphs below.]

1. Compressors: Semihermetic reciprocating; with suction-gas-cooled, 1750-rpm motors; thermal overloads; oil sight glass; suction-line strainer; and reversible oil pumps; with oil strainer, internal motor overload protection, resilient suspension system, crankcase heater, manual-reset high-pressure switch, and pump-down low-pressure switch.
2. Compressors: Hermetic reciprocating; with oil strainer, internal motor overload protection, resilient suspension system, crankcase heater, manual-reset high-pressure switch, and pump-down low-pressure switch.
3. Compressors: Hermetic scroll; with oil strainer, internal motor overload protection, resilient suspension system, crankcase heater, manual-reset high-pressure switch, and pump-down low-pressure switch.
4. Refrigeration Circuits: Two; each with hot-gas mufflers, thermal-expansion valve with external equalizer, liquid-line solenoid valve, liquid-line filter-dryer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
5. Refrigerant Evaporator Coil: Alternate-row or split-face-circuit, direct-expansion coil of seamless copper tubes expanded into aluminum fins.

   a. Mount coil assembly over stainless-steel drain pan[**complying with ASHRAE 62.1**] [**and**] [**having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir**].

6. Integral, Water-Cooled Refrigerant Condenser: [**Shell-and-tube type fabricated and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII**]

[**Coaxial tube-in-tube type**] with liquid-line stop valve and head-pressure-actuated, [**two**] [**three**]-way regulating valve. Terminate fluid connections outside cabinet.

a. Cooling Medium: Glycol solution.

7. Remote Air-Cooled Refrigerant Condenser: Corrosion-resistant cabinet, copper-tube aluminum-fin coils arranged for two circuits, multiple direct-drive propeller fans with permanently lubricated ball bearings, and single-phase motors with internal overload protection and integral electric control panel and disconnect switch. Control capacity by [**cycling fans**] [**modulating fan speeds**] [**three-way refrigerant bypass with receiver and isolation valve**].

F. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating [**two**] [**three**]-way control valve.

1. Cooling Medium: [**Water**] [**Glycol solution**].
2. Control Valve: Class 125 body.

a. Maximum Pressure Drop: [**3 psig (21 kPa)**] [**5 psig (35 kPa)**] at design flow rate.
b. Close-Off (Differential) Pressure Rating: 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

3. Mount coil assembly over stainless-steel drain pan[**complying with ASHRAE 62.1**] [**and**] [**having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir**].

G. Remote, Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, multiple direct-drive propeller fans with fan guards, and single-phase motors with internal overload protection and integral electric control panel. Control capacity by cycling fans.

1. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

H. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing [**one**] [**two**] centrifugal pump(s) with mechanical seals; electrical-control cabinet with starters, lead-lag switch, automatic switchover, and alarm light.

1. Piping: Interconnecting piping, to and from remote, air-cooled, glycol-solution cooler, with shutoff valves, flow switches, check valves in pump discharge, unions, and pressurized expansion tank with air purge vent and system-charging connection.
2. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of minus 40 deg F (minus 40 deg C).
3. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

I. Electric-Resistance Heating Coil: Enclosed finned-tube electric elements arranged for minimum of three stages, with thermal safety switches, manual-reset overload protection, and branch-circuit overcurrent protection.

J. Refrigerant Heating Coil: Hot-gas coil of seamless copper tubes expanded into aluminum fins with three-way solenoid valve on first-stage refrigerant circuit.

K. Hot-Water Heating Coil: Seamless copper tubes expanded into aluminum fins with two-way modulating control valve and strainer.

1. Control Valve: Class 125 body.

   a. Maximum Pressure Drop: [**3 psig (21 kPa)**] [**5 psig (35 kPa)**] at design flow rate.
   b. Close-Off (Differential) Pressure Rating: 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

L. Steam Heating Coil: Seamless copper tubes expanded into aluminum fins with two-way modulating control valve, strainer, and float-and-thermostatic trap.

1. Control Valve: Class 125 body.

   a. Maximum Pressure Drop (15-psig (103-kPa) Steam): 80 percent of inlet steam pressure.
   b. Close-Off (Differential) Pressure Rating: 150 percent of operating (inlet) pressure.

M. Extended-Surface, Disposable, Panel Filter: Pleated, lofted, nonwoven, reinforced cotton fabric; supported and bonded to welded-wire grid; enclosed in cardboard frame[**with 2-inch- (50-mm-) thick, disposable, glass-fiber prefilter**].

1. Thickness: [**2 inches (50 mm)**] [**4 inches (100 mm)**].
2. Initial Resistance: <**Insert inches wg (Pa)**>.
3. Recommended Final Resistance: <**Insert inches wg (Pa)**>.
4. Arrestance (ASHRAE 52.1): 90 percent.
5. Merv (ASHRAE 52.2): 7.

N. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepiped and using condensate water from cooling coils with stainless-steel or brass float-valve mechanism; located in bypass airstream; with flush-cycle timer and solenoid drain valve.

O. Evaporative Pan Humidifier: Stainless-steel pan and cover, serviceable without disconnecting water, drain, or electrical connections; prepiped with stainless-steel or brass float-valve mechanism; electric-resistance heating coil; low-water-cutoff switch; flush-cycle timer; and solenoid drain valve.

P. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders, and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.

1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
2. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
3. Drain Cycle: Field-adjustable drain duration and drain interval.

Q. Integral Electrical Controls: Unit-mounted electrical enclosure with piano-hinged door, grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, and fusible control-circuit transformer.

R. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

S. Electronic-Control System: Solid state, with start button, stop button, temporary loss of power indicator, manual-reset circuit breakers, temperature control, humidity control, and monitor panel.

1. Monitor Panel: Backlighted, with no visible indicator lights until operating function is activated; indicators include cooling, humidification, loss of airflow, change filters, high temperature, low temperature, high humidity, low humidity, high head pressure (each compressor), and low suction pressure (each compressor).
2. Temperature- and Humidity-Control Modules: Solid state, plug-in; with adjustable set point, push-to-test calibration check button, and built-in visual indicators to show mode of operation.
3. Location: Behind hinged door in front of unit; isolated from conditioned airstream to allow service while system is operating.

T. Microprocessor-Control System: Continuously monitors operation of process cooling system; continuously displays room temperature and room relative humidity; sounds alarm on system malfunction and simultaneously displays problem. If more than one malfunction occurs, system displays fault in sequence with room temperature and continues to display fault when malfunction is cleared until system is reset.

1. Malfunctions:

a. Power loss.
b. Loss of airflow.
c. Clogged air filter.
d. High room temperature.
e. Low room temperature.
f. High humidity.
g. Low humidity.
h. Smoke/fire.
i. Water under floor.
j. Supply fan overload.
k. Compressor No. 1 - Overload.
l. Compressor No. 1 - Low Pressure.
m. Compressor No. 1 - High Pressure.
n. Compressor No. 2 - Overload.
o. Compressor No. 2 - Low Pressure.
p. Compressor No. 2 - High Pressure.

2. Digital Display:

a. Control power on.
b. Humidifying.
c. Dehumidifying.

d. Compressor No. 1 - Operating.
e. Compressor No. 2 - Operating.
f. Heat operating.
g. Economy cooling.

3. Push buttons shall stop and start process cooling system, silence audible alarm, test indicators, and display room's relative humidity.
4. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display unit status and alarms.

a. Hardwired Points:

1) Monitoring: On-off status, common trouble alarm, space temperature, space relative humidity.
2) Control: On-off operation, [**space temperature set-point adjustment**] [**space relative humidity set-point adjustment**].

b. ASHRAE 135 (BACnet), [**LonTalk**] [**Modbus**] [**Industry-accepted, open-protocol**] **[SiteScan on main campus]** communication interface with the BAS shall enable the BAS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the BAS.

2.2 FLOOR-MOUNTED UNITS 5 TONS (18 kW) AND SMALLER

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Liebert Corporation.

B. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for vertical floor mounting in upflow or downflow configuration.

C. Cabinet and Frame: Welded tubular-steel frame with removable steel panels with baked-enamel finish, insulated with 1-inch- (25-mm-) thick duct liner.

1. Floor Stand: Welded tubular steel, **<Insert required height>** high, with adjustable legs and vibration isolation pads.
2. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Supply-Air Fan: Forward curved, centrifugal, and with adjustable V-belt drive.

E. Refrigeration System:

1. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
2. Refrigeration Circuit: Low-pressure switch, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.

3. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins, with two circuits, each with solenoid valve.

    a. Mount coil assembly over stainless-steel drain pan[**complying with ASHRAE 62.1**] [**and**] [**having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir**].

4. Integral, Water-Cooled Refrigerant Condenser: Brazed-plate type with liquid-line stop valve and head-pressure-actuated, two-way regulating valve.

    a. Cooling Medium: [**Water**] [**Glycol solution**].

5. Remote Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with [**propeller**] [**centrifugal**] fan, [**direct**] [**belt**] driven.
6. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

F. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating three-way control valve.

1. Cooling Medium: [**Water**] [**Glycol solution**].
2. Mount coil assembly over stainless-steel drain pan[**complying with ASHRAE 62.1**] [**and**] [**having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir**].

G. Remote Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, direct-drive propeller fan with fan guards, and single-phase motors with internal overload protection.

1. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

H. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing centrifugal pump with mechanical seal.

1. Piping: Interconnecting piping, from suction to discharge, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
2. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of minus 40 deg F (minus 40 deg C).
3. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

I. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor and high-temperature-limit switches.

J. Filter: 2-inch- (50-mm-) thick, disposable, glass-fiber media.

1. Initial Resistance: <**Insert inches wg (Pa)**>.
2. Recommended Final Resistance: <**Insert inches wg (Pa)**>.
3. Arrestance (ASHRAE 52.1): 90 percent.

4. Merv (ASHRAE 52.2): 7.

K. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepiped and located in bypass airstream; with flush-cycle timer and solenoid drain valve.

L. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.

1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
2. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
3. Drain Cycle: Field-adjustable drain duration and drain interval.

M. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

N. Control System: Unit-mounted panel with main fan contactor, compressor contactor, compressor start capacitor, control transformer with circuit breaker, solid-state temperature-[**and humidity-**]control modules[**, humidity contactor**], time-delay relay, heating contactor, and high-temperature thermostat. Provide solid-state, wall-mounted control panel with start-stop switch[**, adjustable humidity set point,**] and adjustable temperature set point.

2.3 CEILING-MOUNTED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Liebert Corporation.

B. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for horizontal ceiling mounting to fit T-bar ceiling opening of 24 by 48 inches (610 by 1220 mm).

C. Cabinet: Galvanized steel with baked-enamel finish, insulated with 1/2-inch- (13-mm-) thick duct liner.

[Retain first subparagraph below for units where grilles are available, usually 1.5 tons (5.2 kW) and smaller.]

1. Integral factory-supplied supply and return grille to fit ceiling grid kit of 24 by 48 inches (610 by 1220 mm), with filter.
2. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Supply-Air Fan: Forward curved, centrifugal, and directly driven by two-speed motor.

E. Refrigeration System:

1. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
2. Refrigeration Circuit: Low-pressure switch, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
3. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.

   a. Mount coil assembly over stainless-steel drain pan[**complying with ASHRAE 62.1**] [**and**] [**having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir**].

4. Integral, Water-Cooled Refrigerant Condenser: [**Coaxial, counterflow, tube-in-tube**] [**Brazed-plate**] type with liquid-line stop valve and head-pressure-actuated, water-regulating valve.

   a. Cooling Medium: [**Water**] [**Glycol solution**].

5. Remote Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with [**propeller**] [**centrifugal**] fan, direct driven.
6. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

F. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with two-way control valve.

1. Cooling Medium: [**Water**] [**Glycol solution**].
2. Mount coil assembly over stainless-steel drain pan[**complying with ASHRAE 62.1**] [**and**] [**having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir**].

G. Remote, Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, direct-drive propeller fan with fan guards, and single-phase motors with internal overload protection.

H. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing centrifugal pump with mechanical seal.

1. Piping: Interconnecting piping, to and from remote, air-cooled glycol-solution cooler, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
2. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of minus 40 deg F (minus 40 deg C).

I. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor, dehumidification relay, and high-temperature-limit switches.

J. Filter: 1-inch- (25-mm-) thick, disposable, glass-fiber media.

1. Initial Resistance: <**Insert inches wg (Pa)**>.
2. Recommended Final Resistance: <**Insert inches wg (Pa)**>.
3. Arrestance (ASHRAE 52.1): 90 percent.
4. Merv (ASHRAE 52.2): 7.

K. Atomizing Humidifier: Centrifugal atomizer with stainless-steel pan, demister pad, and solenoid valve.

L. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders, and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.

1. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
2. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
3. Drain Cycle: Field-adjustable drain duration and drain interval.

M. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

N. Control System: Unit-mounted panel with main fan contactor, compressor contactor, compressor start capacitor, control transformer with circuit breaker, solid-state temperature-[**and humidity-**]control modules[**, humidity contactor**], time-delay relay, heating contactor, and high-temperature thermostat. Provide solid-state, wall-mounted control panel with start-stop switch[**, adjustable humidity set point,**] and adjustable temperature set point.

2.4 CONSOLE UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Liebert Corporation.

B. Description: Split system consisting of evaporator section for floor or wall mounting and remote condensing section.

C. Evaporator Cabinet: Furniture-grade steel with baked-enamel finish; with front access and containing direct-drive centrifugal fans and two-speed motor.

1. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Condenser Cabinet: Steel with baked-enamel finish and containing compressor and condenser.

E. Refrigeration System:

1. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.

2. Refrigeration Circuit: Filter/dryer, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
3. Refrigerant: [**R-22**] [**R-407C**] [**R-410A**].
4. Refrigerant: R-407C or R-410A.
5. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.

   a. Mount coil assembly over stainless-steel drain pan[**complying with ASHRAE 62.1**] [**and**] [**having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir**].

6. Integral, Water-Cooled Refrigerant Condenser: [**Coaxial, counterflow, tube-in-tube**] [**Brazed-plate**] type with liquid-line stop valve and head-pressure-actuated, water-regulating valve.
7. Remote Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with [**propeller**] [**centrifugal**] fan, direct driven.
8. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.

F. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating control valve.

1. Cooling Medium: [**Water**] [**Glycol solution**].
2. Mount coil assembly over stainless-steel drain pan[**complying with ASHRAE 62.1**] [**and**] [**having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir**].

G. Remote, Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, direct-drive propeller fan with fan guards, and single-phase motor with internal overload protection.

H. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing centrifugal pump with mechanical seal.

1. Piping: Interconnecting piping, to and from remote, air-cooled, glycol-solution cooler, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
2. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of minus 40 deg F (minus 40 deg C).

I. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor and high-temperature-limit switches.

J. Filter: Cleanable.

K. Filter: 1-inch- (25-mm-) thick, disposable, glass-fiber media.

1. Initial Resistance: <**Insert inches wg (Pa)**>.
2. Recommended Final Resistance: <**Insert inches wg (Pa)**>.
3. Arrestance (ASHRAE 52.1): 90 percent.

4. Merv (ASHRAE 52.2): 7.

L. Electrode Steam Humidifier: Self-contained and microprocessor controlled; with replaceable cylinder.

M. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.

N. Control System: Unit-mounted panel with contactors, control transformer with circuit breaker, and solid-state temperature-[**and humidity-**]control modules. Provide solid-state, unit-mounted control panel with start-stop switch[**, adjustable humidity set point,**] and adjustable temperature set point.

2.5 FAN MOTORS

A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.

2.6 CAPACITIES AND CHARACTERISTICS

A. Unit Configuration:

1. [**Upflow (preferred)**] [**Downflow**].
2. [**Draw**] [**Blow**] through.

B. Supply-Air Fan:

1. Number of Fans: [**One**] [**Two**].
2. Airflow: **<Insert cfm (L/s)>**.
3. Minimum Static Pressure: **<Insert inches wg (kPa)>**.
4. Motor Size: **<Insert number>** hp.

C. Refrigeration System:

1. Unit Energy Efficiency: **<Insert COP or EER>**.
2. Refrigerant Compressor:

   a. Total Unit Cooling Capacity: **<Insert Btu/h (kW)>**.
   b. Sensible Unit Cooling Capacity: **<Insert Btu/h (kW)>**.
   c. Number of Compressors: [**One**] [**Two**].
   d. Motor Size: **<Insert number>** hp.

3. Refrigerant Evaporator Coil:

a. Cooling Capacity: <**Insert Btu/h (kW)**>.
b. Entering-Air Dry-Bulb Temperature: <**Insert deg F (deg C)**>.
c. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.
d. Leaving-Air Dry-Bulb Temperature: <**Insert deg F (deg C)**>.
e. Leaving-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.

4. Water-Cooled Refrigerant Condenser:

a. Cooling Capacity: <**Insert Btu/h (kW)**>.
b. Condenser Water Flow: <**Insert gpm (L/s)**>.
c. Cooling Medium: [**Water**] [**Glycol solution**].
d. Entering-Water Temperature: <**Insert deg F (deg C)**>.
e. Fluid Pressure Drop: <**Insert feet of head (kPa)**>.

5. Air-Cooled Refrigerant Condenser:

a. Cooling Capacity: <**Insert Btu/h (kW)**>.
b. Entering-Air Temperature: <**Insert deg F (deg C)**>.
c. Number of Condenser Fan Motors: <**Insert number**>.
d. Condenser Fan Motors: <**Insert number**> hp.

D. Hydronic Cooling Coil:

1. Cooling Coil Capacity: <**Insert Btu/h (kW)**>.
2. Entering-Air Dry-Bulb Temperature: <**Insert deg F (deg C)**>.
3. Entering-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.
4. Leaving-Air Dry-Bulb Temperature: <**Insert deg F (deg C)**>.
5. Leaving-Air Wet-Bulb Temperature: <**Insert deg F (deg C)**>.
6. Fluid Flow: <**Insert gpm (L/s)**>.
7. Entering-Fluid Temperature: <**Insert deg F (deg C)**>.
8. Fluid Pressure Drop: <**Insert feet of head (kPa)**>.
9. Cooling Medium: [**Water**] [**Glycol solution**].

E. Remote, Air-Cooled, Glycol-Solution Cooler:

1. Cooling Coil Capacity: <**Insert Btu/h (kW)**>.
2. Entering-Air Temperature: <**Insert deg F (deg C)**>.
3. Leaving-Air Temperature: <**Insert deg F (deg C)**>.
4. Glycol Flow: <**Insert gpm (L/s)**>.
5. Entering-Glycol Temperature: <**Insert deg F (deg C)**>.
6. Number of Fans: <**Insert number**>.
7. Fan Motors: <**Insert number**> hp.
8. Number of Pumps: <**Insert number**>.
9. Pump Motors: <**Insert number**> hp.

F. Hydronic Heating Coil:

1. Total: <**Insert Btu/h (kW)**>.
2. Entering-Air Dry-Bulb Temperature: <**Insert deg F (deg C)**>.
3. Leaving-Air Dry-Bulb Temperature: <**Insert deg F (deg C)**>.
4. Water Flow: <**Insert gpm (L/s)**>.

5. Entering-Water Temperature: <**Insert deg F (deg C)**>.
6. Leaving-Water Temperature: <**Insert deg F (deg C)**>.
7. Fluid Pressure Drop: <**Insert feet of head (kPa)**>.

G. Steam Heating Coil:

1. Total: <**Insert Btu/h (kW)**>.
2. Entering-Air Dry-Bulb Temperature: <**Insert deg F (deg C)**>.
3. Leaving-Air Dry-Bulb Temperature: <**Insert deg F (deg C)**>.
4. Steam Flow: <**Insert lb/h (kg/h)**>.
5. Steam Pressure: <**Insert psig (kPa)**>.

H. Electric-Resistance Heating Coil:

1. Total Capacity: <**Insert kW**>.
2. Stages of Heating: [**1**] [**2**].

I. Humidifier:

1. Total: <**Insert lb/h (kg/h)**>.
2. Input: <**Insert Btu/h (kW)**>.

J. Electrical Characteristics:

1. Volts: [**120**] [**208**] [**240**] [**277**] [**480**].
2. Phase: [**Single**] [**Three**].
3. Hertz: 60.
4. Full-Load Amperes: <**Insert value**>.
5. Minimum Circuit Ampacity: <**Insert value**>.
6. Maximum Overcurrent Protection: <**Insert amperage**>.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for hydronic piping systems to verify actual locations of piping connections before equipment installation.

C. Examine walls, floors, and roofs for suitable conditions where computer-room air conditioners will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. **Install according to ARI Guideline B.**

B. Computer-Room Air-Conditioner Mounting: Install using [**elastomeric pads**] [**elastomeric mounts**] [**restrained spring isolators**]. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1 inch (25 mm)**].

C. Suspended Computer-Room Air Conditioners: Install using continuous-thread hanger rods and [**elastomeric hangers**] [**spring hangers**] [**spring hangers with vertical-limit stop**] of size required to support weight of computer-room air conditioner.

1. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment." Fabricate brackets or supports as required.
2. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

D. Air-Cooled Refrigerant Condenser Mounting: Install using [**elastomeric pads**] [**elastomeric mounts**] [**restrained spring isolators**]. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1 inch (25 mm)**].

E. Remote, Air-Cooled, Glycol-Solution Cooler Mounting: Install using [**elastomeric pads**] [**elastomeric mounts**] [**restrained spring isolators**]. Comply with requirements for vibration isolation devices specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Minimum Deflection: [**1/4 inch (6 mm)**] [**1 inch (25 mm)**].

F. Glycol-Solution Pump Package Mounting: Install using [**elastomeric pads**] [**elastomeric mounts**]. Comply with requirements for vibration isolation devices specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.3 CONNECTIONS

A. Piping installation requirements are specified in other heating, ventilating, and air-conditioning Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Water and Drainage Connections: Comply with applicable requirements in Section 221116 "Domestic Water Piping." Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.

D. Hot-Water Heating Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping." Provide shutoff valves in inlet and outlet piping to heating coils.

E. Steam and Condensate Piping: Comply with applicable requirements in Section 232213 "Steam and Condensate Heating Piping." Provide shutoff valves in steam inlet and steam trap in condensate outlet piping to heating coils.

F. Condenser-Water Piping: Comply with applicable requirements in Section 232113 "Hydronic Piping." Provide shutoff valves in water inlet and outlet piping on water-cooled units.

G. Refrigerant Piping: Comply with applicable requirements in Section 232300 "Refrigerant Piping." Provide shutoff valves and piping.

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:

1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

E. After startup service and performance test, change filters and flush humidifier.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION 238123

SECTION 238213 - VALANCE HEATING AND COOLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Electric radiant heaters.
2. Hydronic heating and cooling panels.

1.3 ACTION SUBMITTALS

A. Product Data: Include rated capacities, specialties, and accessories for each product indicated.

B. Shop Drawings:

1. Include plans, elevations, sections, details, and attachments to other work. Detail equipment assemblies and suspension and attachment.
2. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Samples for Initial Selection: For units with factory-applied color finishes.

D. Samples for Verification: For each type of exposed finish required, prepared on Samples of size indicated below.

1. Radiant Heater Finishes: **4 by 4 inches (100 by 100 mm)**.
2. Radiant Panel Finishes: **12 by 12 inches (300 by 300 mm)**.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which heaters and suspension systems will be attached.
3. Size and location of initial access modules for acoustical tile.
4. Items penetrating finished ceiling, including the following:

a. Lighting fixtures.
b. Air outlets and inlets.
c. Speakers.
d. Sprinklers.
e. Access panels.

5. Perimeter moldings.

B. Seismic Qualification Certificates: Submit certification that suspended radiant heaters and panels, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric radiant heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 ELECTRIC RADIANT HEATERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Chromalox Inc.; a division of Emerson Electric Company.
2. Markel Products; a division of TPI Corporation.
3. QMark Electric Heating; a division of Marley Engineered Products.

B. Quartz Lamp Heating Elements: Coiled tungsten-wire heating element enclosed in clear quartz tube.

C. Quartz Tube Heating Elements: Nickel-chromium-wire heating element enclosed in quartz tube.

D. Metal-Sheathed Heating Elements: Nickel-chromium-wire heating element embedded in magnesium oxide powder enclosed in metal sheath. Comply with UL 1030.

E. Comply with [**UL 499**] [**and**] [**UL 2021**].

F. Enclosures: [**Aluminized**] [**Stainless**] [**Painted**]-steel housing with anodized-aluminum reflector.

1. Finish: Baked-enamel finish in manufacturer's [**standard**] [**custom**] paint color as selected by Architect.

G. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

H. Unit Controls:

1. Line-voltage thermostat.
2. Enclosed contactor for remote thermostat.
3. Snow and ice detector with moisture sensor and integral temperature sensor.

I. Capacities and Characteristics:

1. See schedule on drawings.

2.2 HYDRONIC HEATING[**AND COOLING**] PANELS – REQUIRES APPROVAL PRIOR TO USE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. AIRTEX Radiant Systems; a division of Engineered Air Ltd.
2. Rosemex Products.
3. Sun-El Corporation.
4. Twa Panel Systems Inc.

B. Description: [**Modular**] [**Linear**] sheet-metal panel with serpentine water piping, suitable for [**lay-in installation flush with T-bar ceiling grid**] [**surface mounting**] [**recessed mounting**].

1. Panels: Minimum [**0.0336-inch- (0.86-mm-) thick, galvanized-steel**] [**0.0396-inch- (1.0-mm-) thick, aluminum**] sheet.
2. Backing Insulation: Minimum [**1-inch- (25-mm-)**] [**2-inch- (50-mm-)**] thick, mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB with factory-applied jacket.
3. Exposed-Side Panel Finish: Baked-enamel finish in manufacturer's [**standard**] [**custom**] paint color as selected by Architect.
4. Factory Piping: **ASTM B 88, Type L (ASTM B 88M, Type B)** copper tube with ASME B16.22 wrought-copper fittings and brazed joints. Piping shall be mechanically bonded to panel.
5. Surface-Mounted Trim: Sheet metal with baked-enamel finish in manufacturer's [**standard**] [**custom**] paint color as selected by Architect.

6. Accessories:

a. [**5-inch (127-mm)**] [**6-inch (152-mm)**] [**8-inch (203-mm)**] panel with drape track recess.
b. 5-inch (127-mm) male bullnose panel.
c. 5-inch (127-mm) female bullnose panel.
d. 4-inch (102-mm) male corner panel.
e. 4-inch (102-mm) female corner panel.
f. Inside corner panel.
g. 1/2-inch (13-mm) filler panel.

C. Capacities and Characteristics:

1. See schedule on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive radiant heating and cooling units for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for [**hydronic piping**] [**electrical**] connections to verify actual locations before radiant heating and cooling unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install radiant heating and cooling units level and plumb.

B. Suspend radiant heaters from structure.

C. Coordinate layout and installation of radiant heaters and suspension-system components with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, communications system, security system, and partition assemblies.

D. Support for Radiant Heating and Cooling Panels in or on Grid-Type Suspended Ceilings: Use grid as a support element.

1. Install a minimum of four ceiling support-system rods or wires for each panel. Locate not more than 6 inches (150 mm) from panel corners.
2. Support Clips: Fasten to panel and to ceiling grid members at or near each panel corner with clips designed for the application.
3. Panels of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans, or center in acoustical panel and support panels independently with at least two 3/4-inch (19-mm) metal channels spanning and secured to ceiling tees.

4. Install at least one independent support rod or wire from structure to a tab on panel. Wire or rod shall have breaking strength of the weight of panel at a safety factor of three.

E. Install devices **60 inches** **(1525 mm)** above finished floor.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 232113 "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Unless otherwise indicated, install shutoff valve and union or flange at each connection.

C. Install piping adjacent to unit to allow service and maintenance.

D. Ground electric units according to Section 260526 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Operate electric heating elements through each stage to verify proper operation and electrical connections.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and units.

B. Remove and replace malfunctioning units and retest as specified above.

C. After installing panels, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

D. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain radiant heaters and panels. See Section 017900 "Demonstration and Training."

END OF SECTION 238213

SECTION 238219 - FAN COIL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes fan-coil units and accessories.

1.3 DEFINITIONS

A. BAS: Building automation system.

1.4 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. LEED Submittals:

1. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.
2. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

D. Samples for Initial Selection: For units with factory-applied color finishes.

E. Samples for Verification: For each type of fan-coil unit indicated.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Ceiling suspension components.
2. Structural members to which fan-coil units will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:
    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
6. Perimeter moldings for exposed or partially exposed cabinets.

B. Manufacturer Seismic Qualification Certification: Submit certification that fan-coil units, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
    b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control test reports.

D. Warranty: Special warranty specified in this Section.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fan-coil units to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:

1. Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fan-Coil-Unit Filters: Furnish two spare filters for each filter installed.
2. Fan Belts: Furnish one spare fan belt for each unit installed.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

1.9 COORDINATION

A. Coordinate layout and installation of fan-coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

B. Coordinate size and location of wall sleeves for outdoor-air intake.

1.10 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

   a. Compressor failure.
   b. Condenser coil leak.

2. Warranty Period: Four years from date of Substantial Completion.
3. Warranty Period (Compressor Only): Five years from date of Substantial Completion.
4. Warranty Period (Condenser Coil Only): Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

B. In the Fan-Coil-Unit Schedule where titles below are column or row headings that introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
3. Basis-of-Design Product: The design for each fan-coil unit is based on the product named. Subject to compliance with requirements, provide either the named product or a comparable product by one of the other manufacturers specified.

2.2 FAN-COIL UNITS

A. Manufacturers:

1. Carrier Corporation.
2. McQuay International.
3. Trane.
4. YORK International Corporation.

B. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.

C. Coil Section Insulation: [**1/2-inch (13-mm)**] [**1-inch (25-mm)**] thick, sheet metal covered glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.

1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Main and Auxiliary Drain Pans: Stainless steel. Fabricate pans and drain connections to comply with ASHRAE 62.1. Drain pans shall be removable.

E. Chassis: Galvanized steel where exposed to moisture. Floor-mounting units shall have leveling screws.

F. Cabinet: Steel with [**factory prime coating, ready for field painting**] [**baked-enamel finish in manufacturer's standard paint color as selected by Architect**] [**baked-enamel finish in manufacturer's custom paint color as selected by Architect**].

1. Vertical Unit Front Panels: Removable, steel, with [**integral stamped**] [**polyethylene**] [**steel**] discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
2. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with [**integral stamped**] [**cast-aluminum**] discharge grilles.
3. Stack Unit Discharge and Return Grille: Aluminum double-deflection discharge grille, and louvered- or panel-type return grille; color as selected by Architect from

manufacturer's [**standard**] [**custom**] colors. Return grille shall provide maintenance access to fan-coil unit.

4. Steel recessing flanges for recessing fan-coil units into ceiling or wall.

G. Outdoor-Air Wall Box: Minimum 0.1265-inch- (3.2-mm-) thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.

1. Louver Configuration: [**Horizontal**] [**Vertical**], rain-resistant louver.
2. Louver Material: [**Aluminum**] [**Steel**].
3. Bird Screen: 1/2-inch (13-mm) mesh screen on interior side of louver.
4. Decorative Grille: On outside of intake.
5. Finish: [**Anodized aluminum**] [**Baked enamel**], color as selected by Architect from manufacturer's [**standard**] [**custom**] colors.

H. Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with [**electronic**] [**pneumatic**], [**two-position**] [**modulating**] actuators.

I. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Washable Foam: 70 percent arrestance and 3 MERV.
2. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
3. Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.

J. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.

K. Steam Coils: Copper[**distributing**] tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 75 psig (517 kPa).

L. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

M. Fan and Motor Board: Removable.

1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
3. Wiring Termination: Connect motor to chassis wiring with plug connection.

N. Factory, Hydronic Piping Package: **ASTM B 88, Type L (ASTM B 88M, Type B)** copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.

1. Two-way, modulating control valve for chilled-water coil.
2. Two-way, modulating control valve for heating coil.
3. Two-way, modulating control valve for hot-water reheat coil.
4. Hose Kits: Minimum 400-psig (2758-kPa) working pressure, and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.

    a. Length: [**24 inches (600 mm)**] [**36 inches (900 mm)**].
    b. Minimum Diameter: Equal to fan-coil-unit connection size.

5. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig (4140-kPa) minimum CWP rating and blowout-proof stem.
6. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig (860-kPa) working pressure, 250-deg F (121-deg C) maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
7. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig (2070-kPa) working pressure at 250 deg F (121 deg C), with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
8. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig (860-kPa) working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 (DN 15) hose-end, full-port, ball-type blowdown valve in drain connection.
9. Wrought-Copper Unions: ASME B16.22.
10. Risers: **ASTM B 88, Type L (ASTM B 88M, Type B)** copper pipe with hose and ball valve for system flushing.

O. Control devices and operational sequences are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence and Operations for HVAC Controls."

P. Basic Unit Controls:

1. Control voltage transformer.
2. [**Wall-mounting**] [**Unit-mounted**] thermostat with the following features:

    a. Heat-cool-off switch.
    b. Fan on-auto switch.
    c. Fan-speed switch.
    d. Automatic changeover.
    e. Adjustable deadband.
    f. Exposed set point.
    g. Exposed indication.
    h. Degree F indication.

3. [**Wall-mounting**] [**Unit-mounted**] humidistat.

    a. Exposed set point.
    b. Exposed indication.

4. [**Wall-mounting**] [**Unit-mounted**] temperature sensor.

5. Unoccupied-period-override push button.
6. Data entry and access port.

    a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
    b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

Q. [**DDC**]Terminal Controller:

1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
2. Unoccupied Period Override Operation: Two hours.
3. Unit Supply-Air Fan Operation:

    a. Occupied Periods: Fan runs continuously.
    b. Unoccupied Periods: Fan cycles to maintain room setback temperature.

4. Hydronic-Cooling-Coil Operation:

    a. Occupied Periods: Modulate control valve to maintain room temperature.
    b. Unoccupied Periods: Close control valve.

5. Heating-Coil Operation:

    a. Occupied Periods: [**Modulate control valve**] [**Energize electric-resistance coil**] to provide heating if room temperature falls below thermostat set point.
    b. Unoccupied Periods: Start fan and [**modulate control valve**] [**energize electric-resistance coil**] if room temperature falls below setback temperature.

6. Reheat-Coil Operation:

    a. Humidity Control for Occupied Periods:

        1) Humidistat [**modulates control valve**] [**energizes electric-resistance coil**] to provide heating. As space temperature rises above the set point, cooling coil valve modulates to maintain room temperature.

    b. Humidity Control for Unoccupied Periods: [**Close control valve**] [**De-energize**].
    c. Occupied Periods:

        1) Heating Operations: [**Modulate control valve**] [**Energize electric-resistance coil**] to provide heating if room temperature falls below thermostat set point.
        2) Humidity-Control Operations: Humidistat [**modulates control valve**] [**energizes electric-resistance coil**] to provide heating. As space temperature rises above the set point, cooling coil valve modulates to maintain room temperature.

d. Unoccupied Periods: Start fan and [**modulate control valve**] [**energize electric-resistance coil**] if room temperature falls below setback temperature. Humidity control is not available.

7. Outdoor-Air Damper Operation:

a. Occupied Periods: Open damper to fixed position for 25 percent outdoor air.
b. Unoccupied periods: Close damper.

8. Controller shall have volatile-memory backup.

R. BAS Interface Requirements:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation.
3. Provide BACnet interface for central BAS workstation for the following functions:

a. Adjust set points.
b. Fan-coil-unit start, stop, and operating status.
c. Data inquiry, including [**outdoor-air damper position,**]supply- and room-air temperature[**and humidity**].
d. Occupied and unoccupied schedules.

S. Electrical Connection: Factory wire motors and controls for a single electrical connection.

T. Capacities and Characteristics:

1. See schedule on drawings

2.3 DUCTED FAN-COIL UNITS

A. Manufacturers:

1. Carrier Corporation.
2. McQuay International.
3. Trane.
4. YORK International Corporation.

B. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.

C. Coil Section Insulation: [**1/2-inch (13-mm)**] [**1-inch (25-mm)**] thick solid metal covered glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.

1. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
2. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Drain Pans: Stainless steel. Fabricate pans and drain connections to comply with ASHRAE 62.1.

E. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panels.

F. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.

1. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis[**with mill-finish, aluminum, double-deflection grille**].
2. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
3. Mixing Plenum: Sheet metal plenum finished and insulated to match the chassis with outdoor- and return-air, formed-steel dampers.
4. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.

G. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Washable Foam: 70 percent arrestance and 3 MERV.
2. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
3. Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.

H. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain.

I. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and brazed joints at fittings. Comply with ARI 210/240, and leak test to minimum 450 psig (3105 kPa) for a minimum 300-psig (2070-kPa) working pressure. Include thermal expansion valve.

J. Steam Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), rated for a minimum working pressure of 75 psig (517 kPa).

K. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

L. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

M. Belt-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, single-speed motor installed on an adjustable fan base resiliently mounted in the cabinet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.

1. Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

N. Factory, Hydronic Piping Package: **ASTM B 88, Type L (ASTM B 88M, Type B)** copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.

1. Two-way, modulating control valve for chilled-water coil.
2. Two-way, modulating control valve for heating coil.
3. Two-way, modulating control valve for reheat coil.
4. Hose Kits: Minimum 400-psig (2758-kPa) working pressure, and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.

    a. Length: [**24 inches (600 mm)**] [**36 inches (900 mm)**].
    b. Minimum Diameter: Equal to fan-coil-unit connection size.

5. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig (4140-kPa) minimum CWP rating and blowout-proof stem.
6. Calibrated-Orifice Balancing Valves: Bronze body, ball type; 125-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
7. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig (2070-kPa) working pressure at 250 deg F (121 deg C); with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
8. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig (860-kPa) working pressure, with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 (DN 15) hose-end, full-port, ball-type blowdown valve in drain connection.
9. Wrought-Copper Unions: ASME B16.22.

O. Remote condensing units are specified in Section 236200 "Packaged Compressor and Condenser Units."

P. Remote Condensing Units: Factory assembled and tested, consisting of compressors, condenser coils, fans, motors, refrigerant receiver, and operating controls. Construct, test, and rate condensing units according to ARI 210/240 and ASHRAE 15.

1. Casing: Steel with baked-enamel finish, removable panels for access to controls, weep holes for water drainage, and mounting holes in base.
2. Compressor: Hermetic, [**scroll**] [**reciprocating**] type; internally isolated for vibration with factory-installed safety devices as follows:

    a. Antirecycle timer.
    b. High-pressure cutout.
    c. Low-pressure cutout or loss-of-charge switch.
    d. Internal thermal-overload protection.
    e. Current and voltage sensitive safety devices.

3. Compressor Motor: Start capacitor, relay, and contactor. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

4. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."
5. Refrigerant Piping Materials: ASTM B 743 copper tube with wrought-copper fittings and brazed joints.
6. Refrigerant: [**R-22**] [**R-407C**] [**R-410A**].
7. Refrigerant: R-407C or R-410A.
8. Low ambient controls to permit operation down to 45 deg F (7 deg C).
9. Crankcase heater.
10. Charging and service fittings on exterior of casing.
11. Filter dryer.
12. Air-to-Air Heat Pump: Pilot-operated, sliding-type reversing valve with replaceable magnetic coil, and controls for air-to-air heat pump operation with supplemental heat operation.
13. Hot-gas-bypass, constant-pressure expansion valve and controls to maintain continuous refrigeration system operation at 10 percent of full load.
14. Condenser: Copper-tube, aluminum-fin coil, with liquid subcooler.
15. Condenser Fan: Direct-drive, aluminum propeller fan.

    a. Motor: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

16. Accessories: Polyethylene mounting base to provide a permanent foundation.

Q. Control devices and operational sequence are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

R. Basic Unit Controls:

1. Control voltage transformer.
2. [**Wall-mounting**] [**Unit-mounted**] thermostat with the following features.

    a. Heat-cool-off switch.
    b. Fan on-auto switch.
    c. Fan-speed switch.
    d. Automatic changeover.
    e. Adjustable deadband.
    f. Exposed set point.
    g. Exposed indication.
    h. Degree F indication.

3. [**Wall-mounting**] [**Unit-mounted**] humidistat.

    a. Exposed set point.
    b. Exposed indication.

4. [**Wall-mounting**] [**Unit-mounted**] temperature sensor.
5. Unoccupied-period-override push button.
6. Data entry and access port.

    a. Input data includes room temperature, and humidity set points and occupied and unoccupied periods.

b. Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.

S. [**DDC**]Terminal Controller:

1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
2. Unoccupied Period Override Operation: Two hours.
3. Unit Supply-Air Fan Operation:

   a. Occupied Periods: Fan runs continuously.
   b. Unoccupied Periods: Fan cycles to maintain room setback temperature.

4. Hydronic-Cooling-Coil Operation:

   a. Occupied Periods: Modulate control valve to maintain room temperature.
   b. Unoccupied Periods: Close control valve.

5. Refrigerant-Coil Operation:

   a. Occupied Periods: Start compressor to maintain room temperature or humidistat set point.
   b. Unoccupied Periods: Stop compressor cooling and cycle compressor for heating to maintain setback temperature.

6. [**Supplemental**] Heating-Coil Operation:

   a. Occupied Periods: [**Modulate control valve**] [**Energize electric-resistance coil**] to provide heating if room temperature falls below thermostat set point.
   b. Unoccupied Periods: Start fan and [**modulate control valve**] [**energize electric-resistance coil**] if room temperature falls below setback temperature.
   c. Switch refrigerant-reversing valve to operate supplemental coil for heating when outdoor temperature is below **25 deg F** **(4 deg C)**.

7. Reheat-Coil Operation:

   a. Humidity Control for Occupied Periods: Humidistat [**modulates control valve**] [**energizes electric-resistance coil**] to provide heating. As room temperature rises above the set point, cooling coil valve modulates to maintain room temperature.
   b. Humidity Control for Unoccupied Periods: [**Close control valve**] [**De-energize**].
   c. Occupied Periods:

      1) Heating Operations: [**Modulate control valve**] [**Energize electric-resistance coil**] to provide heating if room temperature falls below thermostat set point.
      2) Humidity-Control Operations: Humidistat [**modulates control valve**] [**energizes electric-resistance coil**] to provide heating. As room temperature rises above the set point, cooling coil valve modulates to maintain room temperature.

d. Unoccupied Periods: Start fan and [**modulate control valve**] [**energize electric-resistance coil**] if room temperature falls below setback temperature. Humidity control is not available.

8. Outdoor-Air Damper Operation:

a. Occupied Periods: Open damper to fixed position for 25 percent outdoor air.
b. Unoccupied Periods: Close damper.

9. Outdoor-Air Damper Operation:

a. Occupied Periods:

1) Outdoor-Air Enthalpy below Room Enthalpy: If room temperature is above room-temperature set point, modulate outdoor-air damper to maintain room temperature (outdoor-air economizer). If room temperature is below set point, position damper to fixed minimum position for 25 percent outdoor air.
2) Outdoor-Air Enthalpy above Room Enthalpy: Position damper to fixed minimum position for 25 percent outdoor air.

b. Unoccupied Periods: Close outdoor-air damper and open return-air damper.

10. Controller shall have volatile-memory backup.

T. BAS Interface Requirements:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at the central workstation.
3. Provide BACnet interface for central BAS workstation for the following functions:

a. Adjust set points.
b. Fan-coil-unit start, stop, and operating status.
c. Data inquiry including [**outdoor-air damper position,**]supply- and room-air temperature[**and humidity**].
d. Occupied and unoccupied schedules.

U. Electrical Connection: Factory wire motors and controls for a single electrical connection.

V. Capacities and Characteristics:

1. See schedule on drawings

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive fan-coil units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil-unit installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install fan-coil units level and plumb.

B. Install fan-coil units to comply with NFPA 90A.

C. Suspend fan-coil units from structure with elastomeric hangers. Vibration isolators are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices **60 inches (1525 mm)** above finished floor.

E. Install new filters in each fan-coil unit within two weeks after Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.
3. Connect condensate drain to indirect waste.

    a. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

B. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Section 233300 "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

C. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature and humidity set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain fan-coil units. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 238219

SECTION 238239 - UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:

1. Cabinet unit heaters with centrifugal fans and [**hot-water**] [**steam**] [**electric-resistance heating**] coils.
2. Propeller unit heaters with [**hot-water**] [**steam**] [**electric-resistance heating**] coils.
3. Wall and ceiling heaters with propeller fans and electric-resistance heating coils.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. CWP: Cold working pressure.

C. PTFE: Polytetrafluoroethylene plastic.

D. TFE: Tetrafluoroethylene plastic.

1.4 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.

B. LEED Submittals:

1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Plans, elevations, sections, and details.
2. Location and size of each field connection.
3. Details of anchorages and attachments to structure and to supported equipment.

4. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.
5. Location and arrangement of piping valves and specialties.
6. Location and arrangement of integral controls.
7. Wiring Diagrams: Power, signal, and control wiring.

D. Samples for Initial Selection: Finish colors for units with factory-applied color finishes.

E. Samples for Verification: Finish colors for each type of cabinet unit heater and wall and ceiling heaters indicated with factory-applied color finishes.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, reflected ceiling plans, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which unit heaters will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.
   d. Sprinklers.
   e. Access panels.

6. Perimeter moldings for exposed or partially exposed cabinets.

B. Manufacturer Seismic Qualification Certification: Submit certification that cabinet unit heaters, accessories, and components will withstand seismic forces defined in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For cabinet unit heaters to include in emergency, operation, and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Cabinet Unit Heater Filters: Furnish one spare filter(s) for each filter installed.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

PART 2 - PRODUCTS

2.1 CABINET UNIT HEATERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Chromalox, Inc.; a division of Emerson Electric Company.
2. Markel Products; a division of TPI Corporation.
3. QMark Electric Heating; a division of Marley Engineered Products.
4. Trane.

B. Description: A factory-assembled and -tested unit complying with ARI 440.

1. Comply with UL 2021.

C. Coil Section Insulation: ASTM C 1071; surfaces exposed to airstream shall be [**aluminum-foil facing**] [**erosion-resistant coating**] to prevent erosion of glass fibers.

1. Thickness: [**1/2 inch (13 mm)**] [**1 inch (25 mm)**] [**1-1/2 inches (38 mm)**].
2. Thermal Conductivity (k-Value): 0.26 Btu x in./h x sq. ft. at 75 deg F (0.037 W/m x K at 24 deg C) mean temperature.

3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
4. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Coil Section Insulation: Comply with NFPA 90A or NFPA 90B. Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C 534, Type II, except for density.

1. Thickness: [**3/8 inch (9 mm)**] [**1/2 inch (13 mm)**] [**3/4 inch (19 mm)**] [**1 inch (25 mm)**].
2. Thermal Conductivity (k-Value): 0.24 Btu x in./h x sq. ft. at 75 deg F (0.034 W/m x K at 24 deg C) mean temperature.
3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.
4. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

E. Cabinet: Steel with [**factory prime coating, ready for field painting**] [**baked-enamel finish with manufacturer's standard paint, in color selected by Architect**] [**baked-enamel finish with manufacturer's custom paint, in color selected by Architect**].

1. Vertical Unit, Exposed Front Panels: Minimum [**0.0528-inch- (1.35-mm-)**] [**0.0677-inch- (1.7-mm-)**] thick, [**galvanized,**] sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
2. Horizontal Unit, Exposed Bottom Panels: Minimum [**0.0528-inch- (1.35-mm-)**] [**0.0677-inch- (1.7-mm-)**] thick, [**galvanized,**] sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
   [Retain first subparagraph below for units that are semirecessed or fully recessed in walls or ceilings.]
3. Recessing Flanges: Steel, finished to match cabinet.
4. Control Access Door: Key operated.
   [Retain first subparagraph below for surface, vertical, wall-mounting units.]
5. Base: Minimum 0.0528-inch- (1.35-mm-) thick steel, finished to match cabinet, [**4 inches (100 mm)**] [**6 inches (150 mm)**] high with leveling bolts.
6. Extended Piping Compartment: [**8-inch- (200-mm-)**] wide piping end pocket.
   [Accessories described in two subparagraphs below are furnished for vertical, wall-mounting units only.]
7. False Back: Minimum 0.0428-inch- (1.1-mm-) thick steel, finished to match cabinet.
8. Outdoor-Air Wall Box: Minimum 0.1265-inch- (3.2-mm-) thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen. Aluminum louver with [**anodized**] [**baked-enamel**] finish in color selected by Architect from manufacturer's [**standard**] [**custom**] colors.

   a. Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with [**manual**] [**electronic**] [**pneumatic**], two-position actuators.

F. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

1. Pleated: 90 percent arrestance and 7 MERV.

G. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 200 psig (1378 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain.

H. Steam Coil: Copper[**distributing**] tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 75 psig (517 kPa).

I. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

J. Fan and Motor Board: Removable.

1. Fan: Forward curved, [**high static,**]double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."
3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

K. Factory, Hot-Water Piping Package: [**ASTM B 88, Type L (ASTM B 88M, Type B)**] copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet and outlet.

1. Two-way, modulating control valve.
2. Hose Kits: Minimum 400-psig (2758-kPa) working pressure, and operating temperatures from 33 to 211 deg F (0.5 to 99 deg C). Tag hose kits to equipment designations.

   a. Length: [**24 inches (600 mm)**] [**36 inches (900 mm)**].
   b. Minimum Diameter: Equal to cabinet unit heater connection size.

3. Two-Piece, Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and 600-psig (4140-kPa) minimum CWP rating and blowout-proof stem.
4. Calibrated-Orifice Balancing Valves: Bronze body, ball type, 125-psig (860-kPa) working pressure, 250 deg F (121 deg C) maximum operating temperature; with calibrated orifice or venture, connection for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
5. Automatic Flow-Control Valve: Brass or ferrous-metal body, 300-psig (2068-kPa) working pressure at 250 deg F (121 deg C), with removable, corrosion-resistant, tamperproof, self-cleaning, piston-spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
6. Y-Pattern, Hot-Water Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig (860-kPa) minimum working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 (DN 15) threaded pipe and full-port ball valve in strainer drain connection.

7. Wrought-Copper Unions: ASME B16.22.

L. Control devices and operational sequences are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls."

M. Basic Unit Controls:

1. Control voltage transformer.
2. [**Wall-mounting**] [**Unit-mounted**] thermostat with the following features.

    a. Heat-off switch.
    b. Fan on-auto switch.
    c. Manual fan speed switch.
    d. Adjustable deadband.
    e. Exposed set point.
    f. Exposed indication.
    g. Deg F (Deg C) indication.

3. [**Wall-mounting**] [**Unit-mounted**] temperature sensor.
4. Unoccupied period override push button.
5. Data entry and access port.

    a. Input data includes room temperature, and occupied and unoccupied periods.
    b. Output data includes room temperature, supply-air temperature, entering-water temperature, operating mode, and status.

N. [**DDC**]Terminal Controller:

1. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
2. Unoccupied Period Override: Two hours.
3. Unit Supply-Air Fan Operations:

    a. Occupied Periods: Fan runs continuously.
    b. Unoccupied Periods: Fan cycles to maintain setback room temperature.

4. Heating Coil Operations:

    a. Occupied Periods: [**Modulate control valve**] [**Energize electric-resistance coil**] to provide heating if room temperature falls below thermostat set point.
    b. Unoccupied Periods: Start fan and [**modulate control valve**] [**energize electric-resistance coil**] if room temperature falls below setback temperature.

5. Outdoor-Air Damper Operation:

    a. Occupied Periods: Open dampers. Delay damper opening if room temperature is more than three degrees below set point.
    b. Unoccupied Periods: Close damper.

6. Controller shall have volatile-memory backup.

O. BAS Interface Requirements:

1. Interface relay for scheduled operation.
2. Interface relay to provide indication of fault at central workstation.
3. Interface shall be BAC-net compatible for central BAS workstation and include the following functions:

    a. Adjust set points.
    b. Cabinet unit heater start, stop, and operating status.
    c. Data inquiry, including [**outdoor-air damper position,**]supply-air and room-air temperature.
    d. Occupied and unoccupied schedules.

P. Electrical Connection: Factory wire motors and controls for a single field connection.

Q. Capacities and Characteristics:

1. See schedule on drawings

2.2 PROPELLER UNIT HEATERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Chromalox, Inc.; a division of Emerson Electric Company.
2. Markel Products; a division of TPI Corporation.
3. QMark Electric Heating; a division of Marley Engineered Products.
4. Trane.

B. Description: An assembly including casing, coil, fan, and motor in [**vertical**] [**and**] [**horizontal**] discharge configuration with adjustable discharge louvers.

[Retain paragraph below for electric unit heaters.]

C. Comply with UL 2021.

[Retain paragraph below for explosion-proof electric unit heaters.]

D. Comply with UL 823.

E. Cabinet: Removable panels for maintenance access to controls.

F. Cabinet Finish: Manufacturer's [**standard**] [**custom**] baked enamel applied to factory-assembled and -tested propeller unit heater before shipping.

G. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

H. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

I. General Coil Requirements: Test and rate [**hot-water**] [**steam**] propeller unit heater coils according to ASHRAE 33.

J. Hot-Water Coil: Copper tube, minimum 0.025-inch (0.635-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 325 deg F (163 deg C), with manual air vent. Test for leaks to 350 psig (2413 kPa) underwater.

K. Hot-Water Coil: Vertical steel tube, minimum 0.065-inch (1.65-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 400 psig (2760 kPa) and a maximum entering-water temperature of 450 deg F (232 deg C), with steel headers at top and bottom. Test for leaks to 600 psig (4137 kPa) underwater.

L. Steam Coil: Copper tube, minimum 0.025-inch (0.635-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of 75 psig (520 kPa).

M. Steam Coil: Vertical steel tube, minimum 0.065-inch (1.65-mm) wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm) and rated for a minimum working pressure of [**100 psig (690 kPa)**] [**200 psig (1380 kPa)**], with steel headers at top and bottom.

N. Electric-Resistance Heating Elements: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16 inch (4 mm). Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550 deg F (288 deg C) at any point during normal operation.

1. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
2. Wiring Terminations: Stainless-steel or corrosion-resistant material.

O. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

P. Fan Motors: Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Motor Type: Permanently lubricated, [**explosion proof**] [**multispeed**] [**variable speed**].

Q. Control Devices:

1. [**Unit-mounted**] [**Wall-mounting**], [**variable**]fan-speed switch.
2. [**Unit-mounted**] [**Wall-mounting**] thermostat.

R. Capacities and Characteristics

1. See schedule on drawings

2.3 WALL AND CEILING HEATERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Chromalox, Inc.; a division of Emerson Electric Company.
2. Markel Products; a division of TPI Corporation.
3. QMark Electric Heating; a division of Marley Engineered Products.
4. Trane.

B. Description: An assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

C. Cabinet:

1. Front Panel: [**Stamped-steel louver**] [**Extruded-aluminum bar grille**], with removable panels fastened with tamperproof fasteners.
2. Finish: Baked enamel over baked-on primer with manufacturer's [**standard**] [**custom**] color selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

D. Surface-Mounting Cabinet Enclosure: Steel with finish to match cabinet.

E. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high temperature protection.[**Provide integral circuit breaker for overcurrent protection.**]

F. Fan: Aluminum propeller directly connected to motor.

1. Motor: Permanently lubricated[**, multispeed**]. Comply with requirements in Section 230513 "Common Motor Requirements for HVAC Equipment."

G. Controls: Unit-mounted thermostat.[**Low-voltage relay with transformer kit.**]

H. Electrical Connection: Factory wire motors and controls for a single field connection[**with disconnect switch**].

I. Capacities and Characteristics:

1. See schedule on drawings

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for [**piping and**]electrical connections to verify actual locations before unit heater installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Section 079200 "Joint Sealants."

B. Install cabinet unit heaters to comply with NFPA 90A.

C. Install propeller unit heaters level and plumb.

D. Suspend cabinet unit heaters from structure with elastomeric hangers[**and seismic restraints**]. Vibration isolators[**and seismic restraints**] are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

E. Suspend propeller unit heaters from structure with all-thread hanger rods and [**elastomeric hangers**] [**spring hangers**] [**spring hangers with vertical-limit stop**]. Hanger rods and attachments to structure are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment." Vibration hangers are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

F. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.

G. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

3.3 CONNECTIONS

A. Piping installation requirements are specified in Section 232113 "Hydronic Piping" and Section 232213 "Steam and Condensate Heating Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.

D. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Section 233300 "Air Duct Accessories."

E. Comply with safety requirements in UL 1995.

F. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of unit heater. Hydronic specialties are specified in Section 232113 "Hydronic Piping."

G. Unless otherwise indicated, install union and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of unit heater. Steam specialties are specified in Section 232213 "Steam and Condensate Heating Piping."

H. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

I. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning units and retest as specified above.

3.5 ADJUSTING

A. Adjust initial temperature set points.

B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain cabinet unit heaters. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 238239

SECTION 238316 - RADIANT-HEATING HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes radiant heating piping, including pipes, fittings, and piping specialties.

1.3 DEFINITIONS

A. EPDM: Ethylene-propylene-diene terpolymer rubber.

B. PEX: Crosslinked polyethylene.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of radiant heating pipe, fitting, manifold, specialty, and control.

1. For radiant heating piping and manifolds, include pressure and temperature rating, oxygen-barrier performance, fire-performance characteristics, and water flow and pressure drop characteristics.

B. Shop Drawings: Show piping layout and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.

1. Shop Drawing Scale: **1/4 inch = 1 foot (1:50)**.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Suspended ceiling components.
2. Structural members to which radiant heating piping will be attached.
3. Items penetrating finished ceiling, including the following:

   a. Lighting fixtures.
   b. Air outlets and inlets.
   c. Speakers.

d. Sprinklers.
e. Access panels.

4. Perimeter moldings.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For radiant heating piping valves and equipment to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 PEX PIPE AND FITTINGS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Uponor Wirsbo Co.

B. Pipe Material: PEX plastic according to ASTM F 876.

C. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) according to DIN 4726.

D. Fittings: ASTM F 1807, metal insert and copper crimp rings.

E. Pressure/Temperature Rating: Minimum 100 psig (690 kPa) and 180 deg F (82 deg C).

2.2 DISTRIBUTION MANIFOLDS

A. Manifold: Minimum NPS 1 (DN 25), copper.

B. Main Shutoff Valves:

1. Factory installed on supply and return connections.
2. [**Two**] [**Three**]-piece body.
3. Body: Brass or bronze.
4. Ball: Chrome-plated bronze.
5. Seals: PTFE.
6. CWP Rating: 150 psig (1035 kPa).
7. Maximum Operating Temperature: 225 deg F (107 deg C).

C. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Key furnished with valve, or screwdriver bit.

4. Inlet Connection: NPS 1/2 (DN 15).
5. Discharge Connection: NPS 1/8 (DN 6).
6. CWP Rating: 150 psig (1035 kPa).
7. Maximum Operating Temperature: 225 deg F (107 deg C).

D. Balancing Valves:

1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
2. Ball or Plug: Brass or stainless steel.
3. Globe Cartridge and Washer: Brass with EPDM composition washer.
4. Seat: PTFE.
5. Visual Flow Indicator: Flowmeter with visible indication in a clear plastic cap at top of valve.
6. Differential Pressure Gage Connections: Integral seals for portable meter to measure loss across calibrated orifice.
7. Handle Style: Lever or knob, with memory stop to retain set position if used for shutoff.
8. CWP Rating: Minimum 125 psig (860 kPa).
9. Maximum Operating Temperature: 250 deg F (121 deg C).

E. Zone Control Valves:

1. Body: Plastic or bronze, ball or plug, or globe cartridge type.
2. Ball or Plug: Brass or stainless steel.
3. Globe Cartridge and Washer: Brass with EPDM composition washer.
4. Seat: PTFE.
5. Actuator: Replaceable electric motor.
6. CWP Rating: Minimum 125 psig (860 kPa).
7. Maximum Operating Temperature: 250 deg F (121 deg C).

F. Thermometers:

1. Mount on supply and return connections.
2. Case: Dry type, metal or plastic, **2-inch (50-mm)** diameter.
3. Element: Bourdon tube or other type of pressure element.
4. Movement: Mechanical, connecting element and pointer.
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Black metal.
7. Window: Plastic.
8. Connector: Rigid, back type.
9. Thermal System: Liquid- or mercury-filled bulb in copper-plated steel, aluminum, or brass stem.
10. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

G. Mounting Brackets: Copper, or plastic or copper-clad steel, where in contact with manifold.

2.3 PIPING SPECIALTIES

A. Cable Ties:

1. Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
2. Minimum Width: 1/8 inch (3 mm).
3. Tensile Strength: 20 lb (9 kg), minimum.
4. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).

B. Floor-Mounting Staples:

1. Steel, with corrosion-resistant coating and smooth finish without sharp edges.
2. Minimum Thickness: 3/32 inch (2.4 mm).
3. Width: Minimum, wider than tubing.

C. Floor-Mounting Clamps:

1. Two bolt, steel, with corrosion-resistant coating and smooth finish without sharp edges.
2. Minimum Thickness: 3/32 inch (2.4 mm).
3. Width: Minimum, wider than tubing.

D. Floor Mounting Tracks:

1. Aluminum or plastic channel track with smooth finish, no sharp edges.
2. Minimum Thickness: 1/16 inch (1.6 mm).
3. Slot Width: Snap fit to hold tubing.
4. Slot Spacing: [**2-inch (50-mm)**] [**3-inch (75-mm)**] intervals.

E. Channeled Subfloor:

1. Plywood, APA-rated subfloor panel, composed of premium, tongue-and-groove, 7-layer, Douglas fir structural subfloor panels.
2. Particleboard manufactured to meet Federal Housing Authority standards of less than 0.3-ppm formaldehyde.
3. Clad panel with minimum 0.025-inch- (0.635-mm-) thick aluminum recessed in the grooves sized to maintain contact with radiant piping.

F. Modular Interlocking Blocks:

1. Polypropylene snap-together blocks with grooves to support piping.
2. Galvanized sheet metal or aluminum emission plates.
3. Natural mineralboard cover panel.

G. Heat-Emission Plates:

1. Formed aluminum suitable for radiant heating piping.
2. Minimum Thickness: 1/16 inch (1.6 mm).
3. Slot Width: Snap fit to maintain pressure fit on tubing.

2.4 CONTROLS

A. Temperature-control devices and sequence of operations are specified in Section 230900 "Instrumentation and Control for HVAC" and Section 230993 "Sequence of Operations for HVAC Controls."

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Uponor Wirsbo Co.

C. Wall-Mounting Thermostat:

1. Minimum temperature range from **50 to 90 deg F (10 to 32 deg C)**.
2. Manually operated with on-off switch.
3. Day and night setback and clock program with minimum four periods per day.
4. Operate pumps or open zone control valves if room temperature falls below the thermostat setting, and stop pumps or close zone control valves when room temperature rises above the thermostat setting.

D. Heated-Panel Thermostat:

1. Remote bulb unit with adjustable temperature range from **50 to 90 deg F (10 to 32 deg C)**.
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected pump or zone control valve.
3. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant panel temperature.
4. Stop pump or close zone control valves if heated-panel thermostat setting is exceeded.
5. Corrosion-resistant, waterproof control enclosure.

E. Heated-Panel Thermostat with Outdoor Temperature Reset:

1. Remote bulb unit with adjustable temperature range from **50 to 90 deg F (10 to 32 deg C)**.
2. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected pump and zone control valve.
3. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant panel temperature.
4. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing outdoor-air temperature.
5. Operate zone control valves to reset supply-water temperature inversely with outdoor-air temperature as follows:

    a. Low outdoor-air temperature, **zero deg F (minus 18 deg C)** with high supply-water temperature **110 deg F (43 deg C)**.
    b. High outdoor-air temperature, **60 deg F (16 deg C)** with low supply-water temperature **70 deg F (21 deg C)**.

6. Corrosion-resistant, waterproof control enclosure.

F. Precipitation and Temperature Sensor:

1. [**Microprocessor-based**] [**Automatic**] control with manual on, automatic, and standby/reset switch.
2. Precipitation and temperature sensors shall sense the surface conditions of pavement and shall be programmed to operate pump and zone control valves as follows:

a. Temperature Span: **34 to 44 deg F (1 to 7 deg C)**.
b. Adjustable Delay Off Span: 30 to 90 minutes.
c. Start Pump or Open Zone Control Valves: Following two-minute delay if ambient temperature is below set point and precipitation is detected.
d. Stop Pump or Close Zone Control Valves: On detection of a dry surface plus time delay.

3. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
4. Minimum 30-A contactor to start pump and open valves.
5. Precipitation sensor shall be mounted in pavement.
6. Provide relay with contacts to indicate operational status, on or off, for interface with central HVAC control system workstation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive radiant heating piping for compliance with requirements for installation tolerances and other conditions affecting performance.

1. Ensure that surfaces and pipes in contact with radiant heating piping are free of burrs and sharp protrusions.
2. Ensure that surfaces and substrates are level and plumb.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

A. Install the following types of radiant heating piping for the applications described:

1. Piping in Exterior Pavement: PEX.
2. Piping in Interior Reinforced-Concrete Floors: PEX.
3. Piping in Level Fill Concrete Floors (Not Reinforced): PEX.
4. Piping in Ceilings: PEX.
5. Piping in Subfloors: PEX.
6. Piping below Wood Floors: PEX.

3.3 INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop or Coordination Drawings.

B. Install radiant heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.

C. Connect radiant piping to manifold in a reverse-return arrangement.

D. Do not bend pipes in radii smaller than manufacturer's minimum bend radius dimensions.

E. Install manifolds in accessible locations, or install access panels to provide maintenance access as required in Section 083113 "Access Doors and Frames."

F. Refer to Section 232113 "Hydronic Piping" for pipes and connections to hydronic systems and for glycol-solution fill requirements.

G. Fire- and Smoke-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials according to Section 078413 "Penetration Firestopping."

H. Piping in Exterior Pavement:

1. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
2. Space cable ties a maximum of **18 inches (457 mm)** o.c., and at center of turns or bends.
3. Maintain **3-inch (75-mm)** minimum cover.
4. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of **10 inches (250 mm)** on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
5. Maintain minimum 40-psig (275-kPa) pressure in piping during concrete placement and continue for 24 hours after placement.

I. Piping in Interior Reinforced-Concrete Floors:

1. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
2. Space cable ties a maximum of **18 inches (457 mm)** o.c., and at center of turns or bends.
3. Maintain **2-inch (50-mm)** minimum cover.
4. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of **10 inches (250 mm)** on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
5. Maintain minimum 40-psig (275-kPa) pressure in piping during concrete placement and continue for 24 hours after placement.

J. Piping in Level Fill Concrete Floors (Not Reinforced):

1. Secure piping in concrete floors by attaching pipes to subfloor using tracks, clamps, or staples.
2. Space tracks, clamps, or staples a maximum of **18 inches (457 mm)** o.c., and at center of turns or bends.
3. Maintain **3/4-inch (19-mm)** minimum cover.
4. Install a sleeve of 3/8-inch- (9.5-mm-) thick, foam-type insulation or PE pipe around tubing and extending for a minimum of **10 inches (250 mm)** on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
5. Maintain minimum 40-psig (275-kPa) pressure in piping during the concrete pour and continue for 24 hours during curing.

K. Piping in Ceiling:

1. Secure piping by attaching pipes to ceiling substrate using clamps or staples.
2. Space clamps or staples a maximum of **18 inches (457 mm)** o.c., and at center of turns or bends.
3. Maintain **1-1/2-inch (38-mm)** minimum plaster cover.
4. Maintain minimum 40-psig (275-kPa) pressure in piping during the plaster application and continue for 24 hours during curing.

L. Piping in Subfloor:

1. Secure piping by laying piping in subfloor channels or modular interlocking blocks.
2. Use straight channel panels or blocks in the center, and curved channel panels or blocks at the ends.
3. Finish floor with mineralboard panel cover or finished floor surface.

M. Piping below Wood Floor:

1. Secure piping by attaching pipes to subfloor using heat-emission plates, clamps, or staples.
2. Space heat-emission plates, clamps, or staples a maximum of **4 inches (100 mm)** o.c., and at center of turns or bends.
3. Install heat-emission plates on underside of wood subfloor with maximum space between plates, as noted above, to maintain pipe contact with floor.

N. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Architect.

O. After system balancing has been completed, mark balancing valves to permanently indicate final position.

P. Perform the following adjustments before operating the system:

1. Open valves to fully open position.
2. Check operation of automatic valves.
3. Set temperature controls so all zones call for full flow.
4. Purge air from piping.

Q. After the concrete or plaster heating panel has cured as recommended by concrete or plaster supplier, operate radiant heating system as follows:

1. Start system heating at a maximum of 10 deg F (6 deg C) above the ambient radiant panel temperature, and increase 10 deg F (6 deg C) each following day until design temperature is achieved.
2. For freeze protection, operate at a maximum of 60 deg F (16 deg C) supply-water temperature.

3.4 FIELD QUALITY CONTROL

A. Prepare radiant heating piping for testing as follows:

1. Open all isolation valves and close bypass valves.
2. Open and verify operation of zone control valves.
3. Flush with clean water, and clean strainers.

B. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than **100 psig (690 kPa)**. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace malfunctioning radiant heating piping components that do not pass tests, and retest as specified above.

D. Prepare a written report of testing.

END OF SECTION 238316

SECTION 238413 - HUMIDIFIERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following humidifiers:

1. Steam injection.
2. Self-contained.
3. Heat Exchanger.

1.3 DEFINITION

A. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

1.4 ACTION SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, manifolds, and attachments to other work.

1. Wiring Diagrams: Power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Detail humidifiers and adjacent equipment. Show support locations, type of support, weight on each support, required clearances, and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Structural members to which humidifiers will be attached.
2. Size and location of initial access modules for acoustical tile.

B. Field quality-control test reports.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For humidifiers to include in operation and maintenance manuals.

1.7 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Supply one replacement electrode cylinder with each self-contained humidifier.

1.8 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with ARI 640, "Commercial and Industrial Humidifiers."

1.9 COORDINATION

A. Coordinate location and installation of humidifiers with manifolds in ducts and air-handling units or occupied space. Revise locations and elevations to suit field conditions and to ensure proper humidifier operation.

PART 2 - PRODUCTS

2.1 STEAM-INJECTION HUMIDIFIERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. DRI-STEEM Humidifier Company.

2. Armstrong

B. Manifold: ASTM A 666, Type 304 stainless steel; insulated with **1/2-inch** **(13-mm)** fiberglass and stainless-steel jacket; and extending the full width of duct or plenum with mounting brackets at ends.

C. Discharge Nozzle and Dispersion Fan:

1. Steam-jacketed discharge nozzle, aluminum blade propeller fan with finger guard, and single-speed motor interlocked to operate with humidifier.
2. Fan Mounting: Above and behind discharge outlet on bracket integral to discharge outlet.

D. Steam Separator: [**Cast iron**] [**ASTM A 666, Type 304 stainless steel**] with [**separate**]humidifier control valve.

E. Humidifier Control Valve:

1. Actuator: [**Pneumatic**] [**Electric**] modulating with spring return.

F. Steam Trap: Inverted-bucket type, sized for a minimum of 3 times the maximum rated condensate flow of humidifier at 1/2-psig (3.4-kPa) inlet pressure.

G. Accessories:

1. [**Wall**] [**Return-duct**]-mounting humidistat.
2. Duct-mounting, high-limit humidistat.
3. Aquastat mounted on steam condensate return piping to prevent cold operation of humidifier.
4. In-line strainer.
5. Airflow switch for preventing humidifier operation without airflow.

H. Capacities and Characteristics:

1. Humidification Rate: <**Insert lb/h (g/s).**>
2. Steam Supply Pressure: <**Insert psig (kPa).**>
3. Dry-Bulb Air Temperature at Discharge: <**Insert deg F (deg C).**>
4. Wet-Bulb Air Temperature at Discharge: <**Insert deg F (deg C).**>
5. Maximum Absorption Distance: <**Insert inches (mm).**>
6. Number of Manifolds: <**Insert number.**>
7. Dispersion Fan:

   a. Airflow: <**Insert cfm (L/s).**>
   b. Motor Horsepower: <**Insert horsepower.**>

8. Electrical Characteristics: Single point of connection.

   a. Volts: <**Insert value.**>
   b. Phase: <**Insert value.**>
   c. Hertz: <**Insert value.**>
   d. Full-Load Amperes: <**Insert value.**>
   e. Minimum Circuit Ampacity: <**Insert value.**>
   f. Maximum Overcurrent Protection: <**Insert amperage.**>

2.2 SELF-CONTAINED HUMIDIFIERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. DRI-STEEM Humidifier Company.

2. Armstrong.

B. Electric-Resistance Heater Container: Cleanable, ASTM A 666, Type [**304**] [**316**] stainless steel. Comply with UL 499.

C. Electrode Cylinder: Replaceable plastic assembly[**with disposable ionic bed inserts**]. Comply with UL 499.

D. Gas-Fired Steam Generator: Factory assembled and tested.

1. Standard: Fabricate and label steam generator to comply with CSA.
2. Maximum Steam Pressure: 10 inches wg (2488 Pa).
3. Burner Type: [**Natural-gas**] [**Propane**] fired with modulating, low NOx infrared burner, minimum 82 percent efficient.
4. Gas Train: Safety shutoff valves, gas cock, strainer, pressure-regulating valve.
5. Ignition: Hot-surface ignition with flame safety system.
6. Combustion Chamber: Sealed with outdoor-air and flue-vent connections.
7. Heat-Exchanger Tank: Cleanable, ASTM A 666, Type [**304**] [**316**] stainless steel with corrosion-resistant coating[**and disposable ionic bed inserts**].

E. Manifold: ASTM A 666, Type [**304**] [**316**] stainless-steel tube extending across entire width of duct or plenum and equipped with mounting brackets on ends.

F. Cabinet: Sheet metal enclosure for housing heater cylinder, electrical wiring, components, controls, and control panel. Enclosure shall include baked-enamel finish, hinged or removable access door, and threaded outlet in bottom of cabinet for drain piping.

G. Control Panel:

1. Factory-wired disconnect switch.
2. Liquid-crystal display.
3. Programmable keyboard.
4. Set-point adjustment.
5. Warning signal indicating end of replaceable cylinder[**or ionic bed insert**] life.
6. Low-voltage, control circuit.
7. Diagnostic, maintenance, alarm, and status features.
8. High-water [**sensor**] [**float**] to prevent overfilling.

H. Controls:

1. Microprocessor-based control system for modulating or cycling control, and start/stop and status monitoring for interface to central HVAC instrumentation and controls.
2. Solenoid-fill and automatic drain valves to maintain water level and temper hot drain water.
3. Field-adjustable timer to control drain cycle for flush duration and interval.
4. Controls shall drain tanks if no demand for humidification for more than 72 hours.
5. [**Conductivity**] [**Float**]-type level controls.

I. Accessories:

1. Humidistat: [**Wall**] [**Return-duct**]-mounting, solid-state, electronic-sensor controller capable of full modulation or cycling control.
2. Duct-mounting, high-limit humidistat.

3. Airflow switch for preventing humidifier operation without airflow.

J. Capacities and Characteristics:

1. See schedule on drawings.

2.3 HEAT-EXCHANGER HUMIDIFIERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. DRI-STEEM Humidifier Company.

2. Armstrong.

B. Fabricate and label steam generator to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

C. Heat Exchanger: ASTM A 666, Type [**304**] [**316**] stainless steel with corrosion-resistant coating, overflow, and drain fittings.[**Include disposable ionic bed inserts.**]

D. Manifold: ASTM A 666, Type [**304**] [**316**] stainless-steel[**, steam-jacketed**], duct-mounting, single- or manifold-grid connected to steam generator with flexible hose and extending across width of duct or plenum. Manifold shall have mounting brackets for both ends.[**Insulate with 1/2-inch (13-mm) fiberglass and stainless-steel jacket extending full width of duct or plenum with mounting brackets at ends.**]

E. Controls:

1. Solenoid-fill and automatic drain valves to maintain water level and temper hot drain water.
2. Field-adjustable timer to control drain cycle for flush duration and interval.
3. [**Conductivity**] [**Float**]-type level controls.

F. Accessories:

1. Humidistat: [**Wall**] [**Return-duct**]-mounting, solid-state, electronic-sensor controller capable of full modulation.
2. Duct-mounting, high-limit humidistat.
3. Airflow switch for preventing humidifier operation without airflow.

G. Capacities and Characteristics:

1. See schedule on drawings.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before humidifier installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install humidifiers with required clearance for service and maintenance. Maintain path, downstream from humidifiers, clear of obstructions as required by ASHRAE 62.1.

B. Seal humidifier manifold duct or plenum penetrations with flange.

C. Install humidifier manifolds in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

D. Install [**galvanized**] [**stainless**]-steel drain pan under each manifold mounted in duct.

1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
2. Connect to condensate trap and drainage piping.
3. Extend drain pan upstream and downstream from manifold a minimum distance recommended by manufacturer but not less than required by ASHRAE 62.1.

E. Install manifold supply piping pitched to drain condensate back to humidifier.

F. Install drip leg upstream from steam trap a minimum of **12 inches (300 mm)** tall for proper operation of trap.

G. Equipment Mounting: Install steam generator on cast-in-place concrete equipment base(s). Comply with requirements for equipment bases specified in [**Section 033000 "Cast-in-Place Concrete."**] [**Section 033053 "Miscellaneous Cast-in-Place Concrete."**]

1. Coordinate sizes and locations of concrete bases with actual equipment provided.
2. Construct bases to withstand, without damage to equipment, seismic force required by code.
3. Construct concrete bases [**4-inch (100-mm)**] [**6-inch (150-mm)**] [**8-inch (200-mm)**] high and extend base not less than 6 inches (150 mm) in all directions beyond the maximum dimensions of steam generator, unless otherwise indicated or unless required for seismic anchor support.
4. Minimum Compressive Strength: [**5000 psi (34.5 MPa)**] [**4500 psi (31 MPa)**] [**4000 psi (27.6 MPa)**] [**3500 psi (24.1 MPa)**] [**3000 psi (20.7 MPa)**] at 28 days.

5. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
6. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
7. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
8. Install anchor bolts to elevations required for proper attachment to supported equipment.

H. Install seismic restraints on humidifiers. Seismic restraints are specified in Section 230548 "Vibration and Seismic Controls for HVAC Piping and Equipment."

I. Install gas-fired steam generators according to NFPA 54.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

1. Install piping adjacent to humidifiers to allow service and maintenance.
2. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.

B. Install electrical devices and piping specialties furnished by manufacturer but not factory mounted.

C. Install piping from safety relief valves to nearest floor drain.

D. Connect gas piping full size to steam-generator, gas-train inlet with union. Gas piping materials and specialties are specified in [**Section 231123 "Facility Natural-Gas Piping."**] [**Section 231126 "Facility Liquefied-Petroleum Gas Piping."**]

E. Connect breeching full size to steam-generator outlet. Venting materials are specified in Section 235100 "Breechings, Chimneys, and Stacks."

F. Connect combustion-air inlet to intake terminal using PVC piping with solvent-cemented joints. Run from boiler connection to outside and terminate adjacent to flue termination.

G. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

H. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

C. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Cleveland Clinic maintenance personnel to adjust, operate, and maintain humidifiers. Refer to Section 017900 "Demonstration and Training."

END OF SECTION 238413