Division 23

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SECTION 230005

COORDINATED SHOP DRAWINGS

PART 1 - GENERAL

1.01 DESCRIPTION

A. CONTRACTORS shall prepare and submit coordinated shop drawings for Owner's, Architect's and Engineer's review.
   1. Note that contract drawings are schematic only, and CONTRACTOR shall not scale drawings or build from as shown.
   2. CONTRACTOR is responsible to field verify all field conditions and install equipment and systems to meet all required clearances and provides all necessary access.
   3. CONTRACTOR shall field determine final locations and elevations that best suits the needs of the Project.
   4. Submittals:
      a. Coordinated Shop Drawings shall be drawn to a scale not smaller than 3/8 inch equals 1 foot.
         i. Drawing sheets shall be same size as the Contract Drawings.
      b. Coordinated Shop Drawings shall depict fabrication, assembly, and installation details. Drawings shall show equipment/system plans, elevations and sections. Details of components, and attachments to other work shall also be included
      c. Contractors shall submit ten (10) hard copies of final coordinated shop drawings and one (1) electronic copy.
         i. Electronic copies shall be provided in AutoCad format, and each trade shall have their work separated in "layers".

B. Work responsibility abbreviations:
   1. MC - Mechanical Contractor
   2. EC - Electrical Contractor
   3. PC - Plumbing Contractor
   4. CM - Construction Manager

1.02 PROCEDURE

A. The contract documents are to be coordinated in the following manner:
   1. The MC shall have his sheet metal subcontractor prepare a first submission of ductwork shop drawings to 3/8" scale. These drawings are to incorporate all ductwork (including bottom of duct elevations), equipment and accessories as specified and shown on the contract drawings.
      a. All existing and proposed penetrations through walls, floor and decks must be shown on the drawings.
      b. All conflicts with buildings' construction will be resolved by the CM.
      c. The completed 3/8" scale drawings will be used for coordination with all other trades.
      d. The sheet metal subcontractor will submit the 3/8" ductwork shop drawings to the MC.

2. The MC will then forward the ductwork shop drawings to the CM.
3. The CM will forward the ductwork shop drawings to the PC.
    a. The PC will incorporate his/her scope of work on the 3/8" ductwork shop drawings illustrating all plumbing equipment, piping, hangers, etc.
        i. The PC will also prepare 3/8" shop drawings depicting all subsurface work.
        ii. The PC will include invert of pipes; elevations and pipe sizes allowing for insulation.
        iii. Any conflicts between the plumbing and ductwork shall be keyed by the PC with a red circle.
        iv. Coordination meetings will be requested by the PC to resolve the conflicts.
        v. All conflicts that arise between the plumbing and ductwork layouts must be resolved.
        vi. The CM will resolve any conflicts.
        vii. The PC shall complete his/her drawings depicting all resolutions.
    b. The PC shall "sign off" on each drawing when it is ascertained that no conflicts exist between the ductwork and plumbing work and forward the "signed of" drawings to the CM.
4. The CM will forward the final ductwork/plumbing shop drawings to the MC.
    a. The MC will incorporate all other heating and air conditioning: piping, equipment, hangers, including elevations and pipe sizes including insulation on the 3/8" scale drawings.
        i. Any conflicts between the MC, PC and ductwork should be “red circled”.
        ii. Coordination meetings will be requested by the MC to resolve the conflicts. All conflicts that arise between the MC, ductwork and PC must be resolved.
        iii. The CM will resolve any conflicts.
        iv. The MC shall complete his/her drawings depicting all resolutions.
    b. The MC shall "sign off" on each drawing when it is ascertained that no conflicts exist between the MC, ductwork and PC and forward the signed off drawings to the CM.

5. The CM will forward the final Ductwork/plumbing/MC shop drawing to the EC.
    a. The EC will incorporate all electrical equipment including but not limited to light fixtures, switchgear, conduit & hangers.
        i. The EC will also include any subsurface work on the drawings prepared by the PC.
        ii. The EC will include elevations of light fixtures, conduit & conduit sizes. Any conflicts with the ductwork, PC and/or MC shall be keyed by the EC with a red circle.
        iii. Coordination meetings will be requested by the EC to resolve any conflicts. All conflicts that arise between the EC, MC, PC and ductwork must be resolved.
        iv. The CM will resolve any conflicts.
        v. The EC shall complete his/her drawings depicting all resolutions.
    b. The EC shall "sign off" on each drawing when it is ascertained that no conflicts exist between the EC, MC, PC and ductwork and forward the signed off drawings to the CM.

c. CM shall then, and only then, disburse to the Design Team for review.

1.03 SCHEDULE OF SUBMISSIONS

A. The MC shall commence the ductwork shop drawings within two (2) weeks after award of contract (or authorization to proceed).

B. The sheet metal subcontractor (MC) shall submit the first submission ductwork shop drawings to the CM for review within the time frame and schedule as dictated by the CM.

C. After review of first submission ductwork shop drawings, corrections shall be made prior to transmitting to the plumbing contractor for his phase of the coordinated drawings.

D. Turn-around time for each Contractor shall be two (2) weeks maximum.

E. Upon completion of all work of all trades as described above, all trades shall sign off on drawings indicating Company name, date of sign off and signature of Company Representative.
1. Signatures shall be understood to verify that each Contractor has shown their respective work on the drawings and have resolved all points of conflict and interference with other trades.
a. Completed signed off prints of coordinated drawings will be transmitted to all Contractors as outlined above for construction and installation. Revised and re-coordinated drawings may be required to attain approval for construction drawings.

1.04 RECORD AND "AS BUILT" DRAWINGS

A. Each Contractor, after completing his segment of the coordinated drawings, shall print copies of the completed drawings and maintain same for his/her records.

B. At the completion of the project and at the option of the Owner's Representative, "as built" corrections will be made to these drawings by each of the aforementioned Contractors and returned to the Owner's Representative for his permanent files and records.

C. These "as builts" do not remove the obligation of "as builts" and record drawings as outlined under other sections of the specifications unless the Owner's Representative elects to do so.

END OF SECTION 230005

SECTION 230007

CODES, REGULATIONS, STANDARDS AND FEES

PART 1 - GENERAL

1.01 DESCRIPTION

A. The contract work, materials and equipment shall conform to the applicable requirements of all governing codes, rules and regulations of current issue including, but not necessarily limited to the following:
   1. All equipment shall meet the requirements of the 2020 Energy Conservation Construction Code of New York State.
   2. Ductwork, including all components and accessories, shall conform to requirements of the latest editions of the various standards published by Sheetmetal and Air Conditioning Contractor's National Association, Inc. (SMACNA).
   3. All installations shall conform to design standards as outlined in ASHRAE handbooks, latest edition.
   4. All installations and materials shall conform to the 2020 New York State Building Code, 2020 New York State Mechanical Code, and any applicable New York State and Local building construction codes.
   5. All system testing, inspection and balancing shall be conform to the requirements of the Associated Air Balance Council (AABC).
   6. Electrical systems shall comply with NEC.
   7. When codes or regulations are not consistent, the more stringent code or regulation shall apply.

1.02 NON-COMPLIANCE

A. Should the Contractor perform any work that does not comply with the requirements of the applicable building codes, state laws, local ordinances and industry standards, he shall bear all costs arising in correcting the deficiencies.

1.03 INSPECTIONS

A. During and upon completion of the work, the Contractors shall obtain and submit to the Owner's Representative:
   1. Any local certificate required.
   2. Said certificate(s) shall be submitted to the Owner's Representative before final payment is made.

B. The Contractor is responsible for all fees associated with any required inspections.

1.04 APPLICABLE CODES

A. All workmanship and materials shall conform to all state laws, local ordinances, local utility company regulations, and applicable Codes and Standards. In case of conflict with the Contract Drawings and Specifications, such laws, regulations and codes shall govern, except that the Contract Drawings and Specifications shall apply wherever they may require workmanship or materials other than required by the Codes and Standards. Applicable Codes and Standards

shall include all pertinent requirements of the following Organizations:

1. 2020 Building Code of New York State
2. 2020 Fire Code of New York State
3. 2020 Mechanical Code of New York State
4. 2020 Plumbing Code of New York State
5. 2020 Fuel Gas Code of New York State
6. 2020 Energy Conservation Code of New York State
7. Local Codes
8. National Fire Protection Association (NFPA)
9. Public Health Service Regulations
10. Local Utility Standards & Regulations
11. American Society of Mechanical Engineers (ASME)
12. American Society of Civil Engineers (ASCE)
13. American National Standards Institute (ANSI)
14. American Refrigeration Institute (ARI)
15. Certified Ballast Manufacturer (CBM)
16. Electrical Testing Laboratories (ETL)
17. Independent Testing Laboratories (ITL)
18. International Organization for Standardization (ISO)
19. National Electrical Code (NEC) Latest Edition
20. National Environmental Balancing Bureau (NEBB)
21. National Electrical Manufacturers Association (NEMA)
22. Structural Engineering Institute (SEI)
23. Underwriters Laboratories (UL)
24. American Society for Testing & Materials (ASTM)
25. Insulated Power Cable Engineers Association (IPCEA)
26. Institute of Electrical and Electronic Engineers, Inc. (IEEE)

1.05 PERMITS

A. If any permits are required, it shall be the full responsibility of the CONTRACTOR to obtain and pay for all appropriate permits from all applicable agencies, prior to installation of any equipment.

END OF SECTION 230007

SECTION 230513

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. 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.

1.03 COORDINATION

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

1.04 MOTOR CONTROLLERS

A. Torque, speed, and horsepower requirements of the load.

B. Ratings and characteristics of supply circuit and required control sequence.

C. Ambient and environmental conditions of installation location.

1.05 WARRANTY

A. Manufacturer’s standard form in which manufacturer agrees to repair or replace components of equipment that fails in material or workmanship for a period of one year.

PART 2 - PRODUCTS

2.01 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

B. Furnish and install all motor starters for a complete system as specified by the work of Division 23.

C. Starters:
1. Each motor, except as noted, shall be provided with a combination disconnect and across-the-line magnetic starters with H-O-A (Hand-Off-Auto) and pilot lights mounted on

cover, unless a dedicated disconnect has been provided by the respective equipment manufacturer.

2. For automatically or remotely controlled motors furnish H-O-A or H-O-R (Hand-Off-Remote) selector switches in place of the push buttons.
3. Furnish manually operated motor starters of the proper size for all motors less than 1/2 HP which are not automatically controlled.
4. Each manually controlled starter shall be equipped with heaters properly sized to protect motor.
5. Starters for motors 175 watts or less shall consist of a snap switch with thermal overload protection where such protection is not an integral part of the motor.

6. Magnetic starters for all motors shall have thermal overload and low voltage protection in all three phases.
7. Include a control transformer for each magnetic starter to provide 120 volt control power.
8. All starters shall have provisions for padlocking in an open position.
9. All starters shall be assembled and internally wired with all devices in conformance with NEMA standards.
10. Provide two (2) spare auxiliary contacts (1-N.O. and 1-N.C.) in each starter. Pilot lights shall be the transformer type.
11. All starters shall be provided with fuses for protection of control circuits.
12. Starters for two-speed motors shall be of the two winding type.

D. Starter Enclosures:
1. Interlock covers of combination starters with operating handle providing access to inside of enclosure only when disconnect is in "OFF" position. Provide means to attach three padlocks for locking external operating handle in either the "ON" or "OFF" position.
2. Provide red colored RESET Button in cover of magnetic starter.
3. Provide and secure wiring diagram corresponding to motor and control wiring of associated equipment on inside of each magnetic and combination starter.
4. Manual starter shall have means for externally locking operating mechanism in "OFF" position."
5. In general, mount starters in NEMA- 1 enclosures: mount starters outdoors and indoors where in damp or wet locations as follows: in NEMA type 4 enclosures up to and including size 4 starters, starters larger than size 4 in NEMA 3R enclosures. Starters in hazardous locations shall be explosion proof.

2.02 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 degrees Centigrade and at altitude of 3300 feet above sea level.
1. 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.

2.03 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.
1. Efficiency: Premium efficient.
2. Service Factor: 1.15.
3. Multispeed Motors: Variable torque.

4. For motors with 2:1 speed ratio, consequent pole, single winding.
5. For motors with other than 2:1 speed ratio, separate winding for each speed.
6. Rotor: Random-wound, squirrel cage.
7. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
8. Temperature Rise: Match insulation rating.
9. Insulation: Class F.
10. Code Letter Designation:
    a. Motors 15 HP and Larger: NEMA starting Code F or Code G.
    b. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
11. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.04 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

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

B. 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.
   1. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
   2. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
   3. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.05 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:

B. Permanent-split capacitor.

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

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

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

F. 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 230515

ADJUSTABLE SPEED DRIVES FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 DESCRIPTION

A. The CONTRACTOR shall furnish the Adjustable Speed Drives (ASD) for Motor Control as shown on the drawings, and/or as specified herein.

B. The CONTRACTOR shall furnish all labor, materials, equipment, and services necessary for, and incidental to, the installation of Adjustable Speed Drives for Motor Control as shown on the drawings, and/or as specified herein.

C. The CONTRACTOR shall furnish all labor, materials, equipment, and services necessary for, and incidental to, the control wiring between field-installed controls, indicating devices, unit control panels and building control systems.

D. Note: The acronyms ASD, AFD, VSD and VFD have been used interchangeably throughout the specifications and drawings. They shall all mean “Adjustable Speed Drive”.

E. The requirements of this Section shall govern whether or not Adjustable Speed Drives are furnished “loose” by Contractor or furnished by equipment manufacturer as an integral component of their equipment.

1.02 GENERAL

A. This specification shall cover a complete adjustable speed motor drive of the variable torque type consisting of a pulse width modulated inverter for use on standard NEMA Design B induction or synchronous motors.

B. The adjustable frequency system shall be for continuous industrial duty without any significant sinewave or carrier frequency distortions.

C. Provide integral bypass motor starter package for each Adjustable Speed Drive.

1.03 QUALITY ASSURANCE

A. Manufacturers Qualifications: Firms regularly engaged in the manufacture of adjustable speed drives with characteristics, sizes and capacities required, whose products have been in satisfactory use in similar service for not less than five years.

B. Codes and Standards:
   1. UL and CSA Compliance: Provide adjustable speed drives and accessories which are UL listed and CSA certified.
   2. ANSI, IEEE, NEC Compliance: Adjustable speed drive and accessories shall comply with applicable requirements of the latest standards of ANSI, IEEE, and National Electrical Code.

1.04 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for units showing dimensions, weights, capacities, ratings, certified test performance, accessories, control features, and installation instructions.

B. Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, required clearances, construction details, and field connection details.

C. Wiring Diagrams: Submit manufacturer's electrical requirements for power supply wiring to units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.

D. Maintenance Data: Submit maintenance instructions, including spare parts lists. Include this data, product data, shop drawings, and wiring diagrams in maintenance manuals in accordance with requirements of Division 1.

1.05 WARRANTY

A. Provide a full parts and labor warranty for a period of two years.

B. Warranty will commence on the date the balancing report is submitted.

C. For any problems occurring within the warranty period, Contractor shall provide a qualified service technician to be at the site within 48-hours of notification, and will repair the drive without cost to Owner.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
   1. ABB

2.02 MATERIALS

A. Adjustable Speed Drive shall be provided with NEMA 1 enclosure, unless noted otherwise on the drawings or specifications.

B. Adjustable Speed Drive shall be supplied with the following:
   1. Digital key pad controller.
   2. Three-phase fast acting drive input fuse protection.
   3. Electronic Motor Overload Protection with option for Bimetallic Ambient Compensated overload relay.
   4. Hand-Off-Auto selector buttons.
   5. Fault/Reset Lighted Push Button.
   6. Manual speed selector buttons.
   7. "Run" and "Stop" pilot lights.

8. Frequency Meter.

C. The drive shall be rated at 480 vac and will be able to accept three phase input of 460V, 60 HZ. Voltage variation of +/-10% and frequency +/-2HZ. System shall be capable of three phase output only.

D. The drive shall have a diode bridge rectifier and integral 5-percent impedance reactor, Swing Choke used fractional through amp on front end to minimize the generation of electrical noise back to the line and provide near unit power factor.

E. The drive's output shall be a sinusoidal wave, pulse width modulated, voltage wave form for reduced harmonic heat in the motor.

F. The system shall include all the necessary control circuits, synchronizing the equipment and protective devices.

G. The drive unit shall be able to withstand a phase to phase short circuit without damage to the drive unit.

H. The drive shall shut down on power loss without component failure and automatically return to normal operation on return of the power. The drive unit shall safely shut down on momentary power loss without component failure and automatically return to normal operations upon the return of power. The drive shall be capable of starting into a rotating motor.

I. The adjustable speed drive shall have a minimum output current rating equal to or greater than 105% of the current which will be required by the motor under actual operating conditions.

J. System Protection
1. Current Limit
2. Electronic Motor Overload
3. Overcurrent
4. Short Circuit — phase to phase (trips fault)
5. Over Voltage
6. Under Voltage
7. Ground Fault — phase to ground (trips fault)
8. Momentary Power Failure
9. Burn-Out-DC Bus Fuse Protection or 3 phase
10. Input Fusing
11. Phase loss in drive mode and bypass mode

K. The following operating information displays shall be standard on the ASD digital display. 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. Calculated Motor Torque
5. Calculated Motor Power
6. DC Bus Voltage
7. Output Voltage
8. Heatsink Temperature
9. Analog Input Valves

10. Keypad Reference Values
11. Real Time Clock
12. kWh Meter
13. Fault logger, Interactive Maintenance/
14. Diagnostic/Start Up assistance.

L. The ASD shall have the following protection circuits. In the case of a protective trip, the drive shall stop, and announce the fault condition in complete words (alpha-numeric codes are not acceptable).
1. Overcurrent trip 315% instantaneous (110% RMS) of the ASD's variable torque current rating.
2. Overvoltage trip 130% of the ASD's rated voltage.
3. Undervoltage trip 65% of the ASD's rated voltage.
4. Overtemperature +104oF.
5. Ground fault either running or at start.
6. Adaptable electronic motor overload (I2t). The electronic motor overload protection shall protect the motor based on speed, load curve, and external fan parameter. Circuits which are not speed dependent are unacceptable. The electronic motor overload protection shall be UL listed for this function.

M. A common ready, run and fault (3) Form C relays.

N. The keypad type controller shall be capable of field adjusting the parameters of the drive. One key will toggle between panel, control and terminal control.

O. The Adjustable Speed Drive shall have the following control parameters
1. Control System:
   a. Digital Voltage Source
   b. Sinusoidal PWM Wave Form
2. Output Voltage:
   a. 3 phase 420-480 Volt
3. Frequency Accuracy:
   a. +/-0.5% of highest Frequency at 25oC, +/-10oC
4. Frequency Resolution:
   a. 0.01 HZ
5. Frequency Range:
   a. -500 to 500HZ
6. Volts per Hertz:
   a. 3 to 60HZ, V/HZ Constant
7. Ratio:
   a. 60HZ and up, Voltage Constant
8. Overload Capacity:
   a. 110% Variable Torque, 150% Constant Torque
9. PWM Carrier Frequency:
   a. Adjustable 1, 4, 8, 12 kHZ flux optimization.

P. The drive shall be capable of operation under any combination of the following environmental parameters without mechanical or electrical damage.
1. Ambient Temperature:
   a. 32 to 104ºF
2. Storage Temperature:

a. 4 to 140°F
3. Relative Humidity:
   a. 0 to 95% Non-Condensing
4. Vibration:
   a. Acceleration at 0.5G
   b. Maximum (20-50HZ)
   c. Amplitude at 0.1 mm
   d. Maximum (50-100HZ)

Q. The drive shall be equipped with the following operational features
1. Acceleration and Deceleration Time:
   a. 0.1 to 1,800 seconds (2 separate acceleration and deceleration times with a choice of linear, S or C curves.
2. Keypad or signal follower 4-20MA, 0-10VDC.
3. P.I.D. setpoint controller standard.
4. Seven preset speeds, including jog if desired, capable of remote selection. Operation in a continuous pattern run will also be a standard programmable feature.
5. Ramp to stop feature (fault causes coast to stop).
6. Unit will have a microprocessor which will monitor the input and fault information as well as select the optimum number of pulses per wave form
7. Drive unit will be able to be disconnected from the load for setup or troubleshooting.
8. Optional RS485 communication interface shall be available. Monitoring and setting of all operating and fault parameters will be a standard feature of this option. A working software demonstration package shall be available upon request.
9. Three resident serial communications protocols Johnson N2, Siemens FLN, Modbus, where required BACnet (embedded), LonWorks, Profibus and DeviceNet available field bus adapters.

R. The adjustable speed drive shall be equipped with the following additional features:
1. Manual bypass contactors including motor thermal overload for bypass operation.
2. Two contactor bypass includes (normal, bypass) to control the bypass contractors and the drive output contactors.
   a. "Normal" mode: bypass contactor is “OPEN" and the drive output contactor is "CLOSED".
   b. "Bypass" mode: bypass contactor is "CLOSED" and the drive output contactor is "OPEN".
   c. "Test" mode: bypass contactor is "OPEN" and the drive output contactor is "OPEN".
3. Start/stop signal and safety interlock shall be operational in Normal and Bypass modes. Damper control contacts shall allow damper to open before motor is allowed to operate in drive or bypass mode. Provide single phase protection in drive and bypass mode. Provide manual and/or automatic transfer bypass.
4. Provide LEDs on the drive enclosure to indicate "Normal" and "Bypass" operation and "External Fault".
   a. All LEDs shall be push-to-test type.
5. The drive input manual service switch shall isolate the drive for servicing while in the bypass mode.
   a. The motor shall remain operational when the drive is in the bypass mode.
6. Provide an adjustable class 20 or 30 bi-metallic thermal motor overload relay to protect the motor while the drive is in the bypass mode.

S. Tests
   1. Adjustable Speed Drive Factory Test
      a. All printed circuit boards shall be completely tested and burned-in before being assembled into the completed ASD. The ASD shall then be subjected to a preliminary functional test, minimum eight hour burn-in, and computerized final test. The burn-in shall be at 104° F (40° C), at full rated load, or cycled load. Drive input power shall be continuously cycled for maximum stress and thermal variation.

PART 3 - EXECUTION

3.01 GENERAL

A. Adjustable speed drive shall be protected against damage, and stored in a dry environment with temperature and humidity within the range specified by drive manufacturer.

3.02 INSPECTION

A. Examine area and conditions where variable speed drive will be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to manufacturer.

3.03 INSTALLATION/START-UP

A. Drive shall be installed by or under the supervision of the manufacturer in strict accordance with manufacturer's instructions. No portion of the drive system shall be energized without authorization of the drive manufacturer.
B. Drive manufacturer shall provide start-up service which includes inspection, final adjustments, operational and functional checks, and coordination with control devices. Schedule variable speed drive start-up to coincide with automatic temperature control system start-up and check-out.

3.04 If not possible for both start-up and check-out procedures to coincide, arrange for temperature control manufacturer's representatives to be present during variable speed drive start-up.

END OF SECTION 230515

SECTION 230517

SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
1. Sleeves.
2. Sleeve-seal systems.
3. Grout.

1.03 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.01 SLEEVE-SEAL SYSTEMS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
1. Advance Products & Systems, Inc.
2. CALPICO, Inc.
3. Metraflex Company (The).

B. Pipeline Seal and Insulator, Inc.

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

D. Sealing Elements: EPDM-rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

E. Pressure Plates: Carbon steel.

F. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating, of length required to secure pressure plates to sealing elements.

2.02 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.

PART 3 - EXECUTION

3.01 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 annular clear space between piping and concrete slabs and walls.

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

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

E. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.

F. Cut sleeves to length for mounting flush with both surfaces.

G. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

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

I. Install sleeves for pipes passing through interior partitions.

J. Cut sleeves to length for mounting flush with both surfaces.

K. Install sleeves that are large enough to provide 1/4-inchannular clear space between sleeve and pipe or pipe insulation.

L. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint.

M. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials.

3.02 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.

3.03 SLEEVE-SEAL-FITTING INSTALLATION

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

3.04 SLEEVE AND SLEEVE-SEAL SCHEDULE

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

B. Exterior Concrete Walls above Grade:
   1. Piping Smaller Than NPS 3: Galvanized-steel-pipe sleeves.

C. Exterior Concrete Walls below Grade:
   1. Piping Smaller Than NPS 3: Cast-iron wall sleeves with sleeve-seal system.
      a. Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

D. Concrete Slabs-on-Grade:
   1. Piping Smaller Than NPS 3: Galvanized-steel-pipe sleeves with sleeve-seal system.
      a. Select sleeve size to allow for 1-inch annular clear space between piping and sleeve for installing sleeve-seal system.

E. Interior Partitions:
   1. Piping Smaller Than NPS 3: Galvanized-steel-pipe sleeves.

END OF SECTION 230517

SECTION 230518

ESCUTCHEONS FOR HVAC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Escutcheons.
   2. Floor plates.

1.03 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.01 ESCUTCHEONS

A. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with chrome-plated finish and spring-clip fasteners.
B. Split-Plate, Stamped-Steel Type: With chrome-plated finish, concealed hinge, and spring-clip fasteners.

2.02 FLOOR PLATES

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

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.

C. Escutcheons for New Piping:
   1. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.

D. Insulated Piping: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge.
   1. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

3.2 FIELD QUALITY CONTROL

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

END OF SECTION 230518

SECTION 230523

GENERAL-DUTY VALVES FOR HVAC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
1. Bronze ball valves.
2. Bronze swing check valves.
3. Iron, center-guided check valves.
4. Bronze gate valves.
5. Bronze globe valves.

1.03 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.

1.04 ACTION SUBMITTALS

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

1.05 QUALITY ASSURANCE

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

B. ASME Compliance:

C. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.

D. ASME B31.1 for power piping valves.

E. ASME B31.9 for building services piping valves.

1.06 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.
3. 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

2.01 GENERAL REQUIREMENTS FOR VALVES

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

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

C. Valve Actuator Types:
1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 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.

D. Valves in Insulated Piping: With 2-inch stem extensions and the following features:

E. Gate Valves: With rising stem.

F. 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.

G. Butterfly Valves: With extended neck.

H. 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.

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

2.02 BRONZE BALL VALVES

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

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Conbraco Industries, Inc.; Apollo Valves.
2. Crane Co.; Crane Valve Group; Crane Valves.
3. Hammond Valve.
4. Milwaukee Valve Company.

C. Description:
1. Standard: MSS SP-110.
2. SWP Rating: 150 psig.
3. CWP Rating: 600 psig.
4. Body Design: Two piece.
5. Body Material: Bronze.
6. Ends: Threaded or soldered.
7. Seats: PTFE or TFE.
8. Stem: Stainless steel.
9. Ball: Stainless steel, vented.
10. Port: Full.

2.03 BRONZE SWING CHECK VALVES

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

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but re not limited to, the following:
1. Crane Co.; Crane Valve Group; Jenkins Valves.
2. Kitz Corporation.
3. Milwaukee Valve Company.
4. NIBCO INC.

C. Description:
1. Standard: MSS SP-80, Type 3.
2. CWP Rating: 300 psig.
3. Body Design: Horizontal flow.
4. Body Material: ASTM B 62, bronze.
5. Ends: Threaded or soldered.
6. Disc: Bronze.

2.04 IRON, CENTER-GUIDED, CHECK VALVES

A. Class 150, Iron, Globe, Center-Guided Check Valves with Resilient Seat:

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering

products that may be incorporated into the Work include, but are not limited to, the following:
1. APCO Willamette Valve and Primer Corporation.
2. Crispin Valve.
3. DFT Inc.

C. Description:
1. Standard: MSS SP-125.
2. NPS 2-1/2 to NPS 12, CWP Rating: 300 psig.
3. NPS 14 to NPS 24, CWP Rating: 250 psig.
4. Body Material: ASTM A 395/A 395M or ASTM A 536, ductile iron.
5. Style: Globe, spring loaded.
6. Ends: Flanged.
7. Seat: EPDM or NBR.

2.05 BRONZE GATE VALVES

A. Class 150, NRS Bronze Gate Valves:

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work includethe following:
1. Hammond Valve.
2. Kitz Corporation.
3. Milwaukee Valve Company.

C. Description:
1. Standard: MSS SP-80, Type 1.
2. CWP Rating: 300 psig.
3. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
4. Ends: Threaded or soldered.
5. Stem: Bronze.
6. Disc: Solid wedge; bronze.
7. Packing: Asbestos free.
8. Handwheel: Malleable iron, bronze, or aluminum.

2.06 BRONZE GLOBE VALVES

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

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
1. Kitz Corporation.
2. Milwaukee Valve Company.
3. NIBCO INC.
4. Powell Valves.

C. Description:
1. Standard: MSS SP-80, Type 2.
2. CWP Rating: 300 psig.
3. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
4. Ends: Threaded or soldered.
5. Stem: Bronze.

6. Disc: PTFE or TFE.
7. Packing: Asbestos free.
8. Handwheel: Malleable iron, bronze, or aluminum.

PART 3 - EXECUTION

3.01 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.

3.02 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 valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches 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. Center-Guided Check Valves: In horizontal or vertical position, between flanges.

3.03 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.

3.04 VALVE SCHEDULE

A. Pipe NPS 3 and Smaller:
1. Ball Valves: Soldered or threaded ends.
2. Bronze Swing Check Valves: Soldered or threaded ends.

END OF SECTION 230523

SECTION 230529

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
1. Metal pipe hangers and supports.
2. Trapeze pipe hangers.
3. Metal framing systems.
4. Fastener systems.
5. Pipe stands.

1.03 DEFINITIONS

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

1.04 PERFORMANCE REQUIREMENTS

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

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

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

1.05 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:

C. Trapeze pipe hangers.

D. Metal framing systems.

E. Equipment supports.

1.06 QUALITY ASSURANCE

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

PART 2 - PRODUCTS

2.01 METAL PIPE HANGERS AND SUPPORTS

A. Carbon-Steel Pipe Hangers and Supports:

B. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.

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

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

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

F. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.02 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.

2.03 METAL FRAMING SYSTEMS

A. MFMA Manufacturer Metal Framing Systems:

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Allied Tube & Conduit.
2. Cooper B-Line, Inc.
3. Flex-Strut Inc.
4. or equal

C. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
1. Standard: MFMA-4.
2. Channels: Continuous slotted steel channel with inturned lips.
3. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
4. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
5. Metallic Coating: Electroplated zinc.

2.04 FASTENER SYSTEMS

A. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated 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.

2.05 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 stainless-steel base unit with plastic roller, for roof installation without membrane penetration.

2.06 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, non-shrink and nonmetallic grout; suitable for interior and exterior applications.

C. Properties: Non-staining, noncorrosive, and nongaseous.

D. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.01 HANGER AND SUPPORT INSTALLATION

A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments 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.

C. 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.

D. 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.

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

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

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

H. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts,

washers, and other accessories.

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

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

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

L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

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

N. 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.

O. Insulated Piping:
   1. Attach clamps and spacers to piping.
   2. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
   3. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
   4. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
   5. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
   6. Shield Dimensions for Pipe: Not less than the following:
      a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
      b. NPS 4: 12 inches long and 0.06 inch thick.
      c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
      d. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation

P. Piping shall be prohibited from being used as a hanger or support for other piping, conduits, etc.

3.02 METAL FABRICATIONS

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

3.03 ADJUSTING

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

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

3.04 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 stainless-steel attachments for hostile environment applications.

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

H. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to 1,050 deg F, pipes NPS 4 to NPS 24, requiring up to 4 inches of insulation.

2. Pipe Hangers (MSS Type 5): For suspension of pipes NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
3. U-Bolts (MSS Type 24): For support of heavy pipes NPS 1/2 to NPS 30.
4. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes NPS 2-1/2 to NPS 24, from single rod if horizontal movement caused by expansion and contraction might occur.
5. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes NPS 2 to NPS 30if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

I. 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.

2. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
3. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
4. Steel Clevises (MSS Type 14): For 120 to 450 deg F piping installations.

J. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction, to attach to top flange of structural shape.
2. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
3. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

K. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.

L. 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. 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.
3. 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.

M. 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:
1. Vertical (MSS Type 55): Mounted vertically.

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

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

P. Use mechanical-expansion anchors instead of building attachments where required in concrete constructions.

END OF SECTION 230529

SECTION 230553

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Equipment labels.
   2. Warning signs and labels.
   3. Pipe labels.
   4. Duct labels.
   5. Stencils.
   6. Valve tags.
   7. Warning tags.

1.03 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.

1.04 COORDINATION

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

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

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

PART 2 - PRODUCTS

2.01 EQUIPMENT LABELS

A. Metal Labels for Equipment:
   1. Material and Thickness: Aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
   3. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   4. Fasteners: Stainless-steel rivets or self-tapping screws.

B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
   1. Letter Color: Black.
   2. Background Color: White.
   3. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
   4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
   5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   6. Fasteners: Stainless-steel rivets or self-tapping screws.
   7. Label Content: Include caution and warning information, plus emergency notification instructions.

2.03 PIPE LABELS

A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
   1. Pre-tensioned Pipe Labels: Pre-coiled, semi-rigid plastic formed to partially cover circumference of pipe and to attach to pipe without fasteners or adhesive.
   2. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
   3. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.

B. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
   1. Lettering Size: At least 1-1/2 inches high.

2.04 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
   1. Letter Color: White.
   2. Background Color: Black.
   3. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
   4. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
   5. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
   6. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
   7. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.

B. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
   1. Lettering Size: At least 1-1/2 inches high.

2.05 STENCILS

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

B. Stencil Material: Aluminum.

2.06 VALVE TAGS

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

B. Tag Material: Aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
   1. Fasteners: Brass wire-link or beaded chain; or S-hook.

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

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

2.07 WARNING TAGS

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

B. Size: 3 by 5-1/4 inches minimum.

C. Fasteners: Brass grommet and wire.

D. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."

E. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.01 PREPARATION

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

3.02 EQUIPMENT LABEL INSTALLATION

A. Install or permanently fasten labels on each major item of mechanical equipment.

B. Locate equipment labels where accessible and visible.
C. Label after painting and finishing within the space.

3.03 PIPE LABEL INSTALLATION

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

B. Identification Paint: Use for contrasting background.

C. Stencil Paint: Use for pipe marking.

D. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
   1. Near each valve and control device.
   2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
   3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
   4. At access doors, manholes, and similar access points that permit view of concealed piping.
   5. Near major equipment items and other points of origination and termination.
   6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
   7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.

E. Pipe Label Color Schedule:
   1. Glycol Water Piping:
      a. Background Color: Green
      b. Letter Color: White
   2. Refrigerant Piping:
      a. Background Color: Black.
      b. Letter Color: White.

3.04 DUCT LABEL INSTALLATION

A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
   1. Blue: For cold-air supply ducts.
   2. Yellow: For hot-air supply ducts.
   3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
   4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.
   1. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.05 VALVE-TAG INSTALLATION

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

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

C. Valve-Tag Size and Shape:
   1. Refrigerant: 1-1/2 inches, round.
   2. Hot Water: 1-1/2 inches, round.
   3. Glycol Water: 1-1/2 inches, round.
   4. Gas: 1-1/2 inches, round.

D. Valve-Tag Color:
   1. Refrigerant: Natural.
   2. Hot Water: Natural.
   3. Glycol Water: Natural.
   4. Gas: Natural.

E. Letter Color:
   1. Refrigerant: Black.
   2. Hot Water: Black.
   3. Glycol Water: Black.
   4. Gas: Black.

3.06 WARNING-TAG INSTALLATION

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

END OF SECTION 230553

SECTION 230593

TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Balancing Air and Hydronic Systems:
      a. Supply air systems.
      b. Return air systems.
      c. Outdoor air systems.
      d. Exhaust air systems.
      e. Hot water supply.
      f. Hot water return.

1.03 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.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 15 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 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 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.

1.05 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC or TABB.

B. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC or TABB.

C. TAB Technician: Employee of the TAB contractor and who is certified by AABC or TABB as a TAB technician.

D. TAB Conference: Meet with Commissioning Authority 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.

E. Agenda Items:
   1. The Contract Documents examination report.

F. The TAB plan.

G. Coordination and cooperation of trades and subcontractors.

H. Coordination of documentation and communication flow.

I. 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.
      a. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

J. TAB Report Forms: Use standard TAB contractor's forms approved by Commissioning Authority.

K. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

L. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

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

1.06 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

3.01 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 verify that they meet the leakage class of connected ducts as specified in Section 23 31 13 "Metal Ducts" and 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.

G. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

H. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

I. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

J. Examine test reports specified in individual system and equipment Sections.

K. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

L. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

M. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

N. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

O. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

P. Examine system pumps to ensure absence of entrained air in the suction piping.

Q. Examine operating safety interlocks and controls on HVAC equipment.

R. 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.

3.02 PREPARATION

A. Prepare a TAB plan that includes strategies and step-by-step procedures.

B. Complete system-readiness checks and prepare reports. Verify the following:

C. Permanent electrical-power wiring is complete.

D. Hydronic systems are filled, clean, and free of air.

E. Automatic temperature-control systems are operational.

F. Equipment and duct access doors are securely closed.

G. Balance, smoke, and fire dampers are open.

H. Isolating and balancing valves are open and control valves are operational.

I. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.

J. Windows and doors can be closed so indicated conditions for system operations can be met.

3.03 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and in this Section.

B. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

C. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.

D. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.

E. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 23 33 00 "Air Duct Accessories."

F. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 23 07 13 "Duct Insulation" and Section 23 07 19 "HVAC Piping Insulation."

G. 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.

H. Take and report testing and balancing measurements in inch-pound (IP) units.

3.04 GENRAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
B. Prepare schematic diagrams of systems' "as-built" duct layouts.
C. For variable-air-volume systems, develop a plan to simulate diversity.
D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
E. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
G. Verify that motor starters are equipped with properly sized thermal protection.
H. Check dampers for proper position to achieve desired airflow path.
I. Check for airflow blockages.
J. Check condensate drains for proper connections and functioning.
K. Check for proper sealing of air-handling-unit components.
L. Verify that air duct system is sealed as specified in Section 23 31 13 "Metal Ducts."

3.05 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 5 percent.

1. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

B. Open all manual valves for maximum flow.

1. Check liquid level in expansion tank.

2. Check makeup water-station pressure gage for adequate pressure for highest vent.
3. Check flow-control valves for specified sequence of operation, and set at indicated flow.
4. 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.
5. Set system controls so automatic valves are wide open to heat exchangers.

6. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
7. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.06 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.

3.07 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

A. Balance the primary circuit flow first and then balance the secondary circuits.

3.08 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.

3.09 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Efficiency rating.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter thermal-protection-element rating.

B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.10 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

B. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.

C. Air Outlets and Inlets: Plus or minus 10 percent.

3.11 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.

3.12 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

B. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
   1. Include a list of instruments used for procedures, along with proof of calibration.

C. Final Report Contents: In addition to certified field-report data, include the following:
   1. 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.

D. 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.
   12. Notable characteristics of systems.
   13. Description of system operation sequence if it varies from the Contract Documents.
   14. Nomenclature sheets for each item of equipment.
   15. Data for terminal units, including manufacturer's name, type, size, and fittings.
   16. Notes to explain why certain final data in the body of reports vary from indicated values.
   17. Test conditions for fans and pump performance forms including the following:

a. Settings for outdoor-, return-, and exhaust-air dampers.
b. Conditions of filters.
c. Cooling coil, wet- and dry-bulb conditions.
d. Face and bypass damper settings at coils.
e. Fan drive settings including settings and percentage of maximum pitch diameter.
f. Inlet vane settings for variable-air-volume systems.
g. Settings for supply-air, static-pressure controller.
h. Other system operating conditions that affect performance.

E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outdoor, supply, return, and exhaust airflows.
2. Water and steam flow rates.
3. Duct, outlet, and inlet sizes.
4. Pipe and valve sizes and locations.
5. Terminal units.
6. Balancing stations.
7. Position of balancing devices.

F. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data:
a. Unit identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Unit arrangement and class.
g. Discharge arrangement.
h. Sheave make, size in inches, and bore.
i. Center-to-center dimensions of sheave, and amount of adjustments in inches.
j. Number, make, and size of belts.
k. Number, type, and size of filters.
2. Motor Data:
a. Motor make, and frame type and size.
b. Horsepower and rpm.
c. Volts, phase, and hertz.
d. Full-load amperage and service factor.
e. Sheave make, size in inches, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
3. Test Data (Indicated and Actual Values):
a. Total air flow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Filter static-pressure differential in inches wg.
f. Preheat-coil static-pressure differential in inches wg.
g. Cooling-coil static-pressure differential in inches wg.
h. Heating-coil static-pressure differential in inches wg.
i. Outdoor airflow in cfm.
j. Return airflow in cfm.
k. Outdoor-air damper position.

l. Return-air damper position.
m. Vortex damper position.

G. Apparatus-Coil Test Reports:
1. Coil Data:
a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch o.c.
f. Make and model number.
g. Face area in sq. ft.
h. Tube size in nominal pipe size (NPS).
i. Tube and fin materials.
j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values):
a. Air flow rate in cfm.
b. Average face velocity in fpm.
c. Air pressure drop in inches wg.
d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
e. Return-air, wet- and dry-bulb temperatures in deg F.
f. Entering-air, wet- and dry-bulb temperatures in deg F.
g. Leaving-air, wet- and dry-bulb temperatures in deg F.
h. Water flow rate in gpm.
i. Water pressure differential in feet of head or psig.
j. Entering-water temperature in deg F.
k. Leaving-water temperature in deg F.
l. Refrigerant expansion valve and refrigerant types.
m. Refrigerant suction pressure in psig.
n. Refrigerant suction temperature in deg F.

H. Gas- Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
1. Unit Data:
a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btu/h.
h. Ignition type.
i. Burner-control types.
j. Motor horsepower and rpm.
k. Motor volts, phase, and hertz.
l. Motor full-load amperage and service factor.
m. Sheave make, size in inches, and bore.
n. Center-to-center dimensions of sheave, and amount of adjustments in inches.
2. Test Data (Indicated and Actual Values):
a. Total air flow rate in cfm.
b. Entering-air temperature in deg F.

c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Low-fire fuel input in Btu/h.
i. High-fire fuel input in Btu/h.
j. Manifold pressure in psig.
k. High-temperature-limit setting in deg F.
l. Operating set point in Btu/h.
m. Motor voltage at each connection.
n. Motor amperage for each phase.
o. Heating value of fuel in Btu/h.

I. Chilled Water Cooling Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
1. Unit Data:
a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Motor horsepower and rpm.
g. Motor volts, phase, and hertz.
h. Motor full-load amperage and service factor.
i. Sheave make, size in inches, and bore.
j. Center-to-center dimensions of sheave, and amount of adjustments in inches.
2. Test Data (Indicated and Actual Values):
a. Total air flow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Operating set point in Btu/h.
i. Motor voltage at each connection.
j. Motor amperage for each phase.

J. Fan Test Reports: For supply, return, and exhaust fans, include the following:
1. Fan Data:
a. System identification.
b. Location.
c. Make and type.
d. Model number and size.
e. Manufacturer's serial number.
f. Arrangement and class.
g. Sheave make, size in inches, and bore.
h. Center-to-center dimensions of sheave, and amount of adjustments in inches.

2. Motor Data:
    a. Motor make, and frame type and size.
    b. Horsepower and rpm.
    c. Volts, phase, and hertz.
    d. Full-load amperage and service factor.
    e. Sheave make, size in inches, and bore.
    f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
    g. Number, make, and size of belts.
3. Test Data (Indicated and Actual Values):
    a. Total airflow rate in cfm.
    b. Total system static pressure in inches wg.
    c. Fan rpm.
    d. Discharge static pressure in inches wg.
    e. Suction static pressure in inches wg.

K. 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 and serial number.
    f. Water flow rate in gpm.
    g. Water pressure differential in feet of head or psig.
    h. Required net positive suction head in feet of head or psig.
    i. Pump rpm.
    j. Impeller diameter in inches.
    k. Motor make and frame size.
    l. Motor horsepower and rpm.
    m. Voltage at each connection.
    n. Amperage for each phase.
    o. Full-load amperage and service factor.
    p. Seal type.
2. Test Data (Indicated and Actual Values):
    a. Static head in feet of head or psig.
    b. Pump shutoff pressure in feet of head or psig.
    c. Actual impeller size in inches.
    d. Full-open flow rate in gpm.
    e. Full-open pressure in feet of head or psig.
    f. Final discharge pressure in feet of head or psig.
    g. Final suction pressure in feet of head or psig.
    h. Final total pressure in feet of head or psig.
    i. Final water flow rate in gpm.
    j. Voltage at each connection.
    k. Amperage for each phase.

L. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
1. Report Data:
    a. System and air-handling-unit number.
    b. Location and zone.

c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft.
g. Indicated air flow rate in cfm.
h. Indicated velocity in fpm.
i. Actual air flow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.

M. Air-Terminal-Device Reports:
1. Unit Data:
a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.
i. Effective area in sq. ft.
2. Test Data (Indicated and Actual Values):
a. Air flow rate in cfm.
b. Air velocity in fpm.
c. Preliminary air flow rate as needed in cfm.
d. Preliminary velocity as needed in fpm.
e. Final air flow rate in cfm.
f. Final velocity in fpm.
g. Space temperature in deg F.

N. 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.
e. Flowmeter type.
2. Test Data (Indicated and Actual Values):
a. Air flow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

O. Instrument Calibration Reports:
1. Report Data:
a. Instrument type and make.
b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.13 INSPECTIONS

A. Initial Inspection:
   1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
   2. Check the following for each system:
      a. Measure airflow of at least 10 percent of air outlets.
      b. Measure water flow of at least 5 percent of terminals.
      c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
      d. Verify that balancing devices are marked with final balance position.
   3. Note deviations from the Contract Documents in the final report.

B. Final Inspection:
   1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Commissioning Authority.
   2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Commissioning Authority.
   3. Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
   4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
   5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
   6. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:
      a. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
      b. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.
   7. Prepare test and inspection reports.

3.14 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

3.15 ASSISTANCE WITH COMMISSIONING

A. General Requirements
   1. This section provides brief descriptions of the testing and support the Contractor will be required to provide to perform the functional testing of the plumbing equipment included in this project.
   2. A functional performance test shall be performed on each complete system. Each function shall be demonstrated to the satisfaction of the CxA based on the written test procedure developed by the CxA to demonstrate conformance with the requirements of the Contract Documents.
   3. Contractor shall be present during commissioning period to assist with adjustment, measurements, etc. needed by CxA.

END OF SECTION 230593

SECTION 230713

DUCT INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes insulating the following duct services:
1. Indoor, concealed ductwork.

1.03 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. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

C. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.

D. Detail insulation application at elbows, fittings, dampers, specialties and flanges for each type of insulation.

E. Detail application of field-applied jackets.

F. Detail application at linkages of control devices.

G. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:

H. Sheet Form Insulation Materials: 12 inches square.

I. Sheet Jacket Materials: 12 inches square.

J. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.04 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.

1.05 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.

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

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

1.06 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.

1.07 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.

1.08 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

2.01 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule," articles for where insulating materials shall be applied.

1. Products shall not contain asbestos, lead, mercury, or mercury compounds.
2. 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.
3. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
4. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

B. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include 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.

C. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include the following:
a. Johns Manville; 800 Series Spin-Glas.
b. Knauf Insulation; Insulation Board.
c. Manson Insulation Inc.; AK Board.
d. Owens Corning; Fiberglas 700 Series.

2.02 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

B. Color: White.

C. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:

D. 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).

2.03 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

B. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.04 TAPES

A. 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, available products that may be incorporated into the Work include 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.
   2. Width: 3 inches.
      a. Thickness: 6.5 mils.
      b. Adhesion: 90 ounces force/inch in width.
      c. Elongation: 2 percent.
      d. Tensile Strength: 40 lbf/inch in width.
      e. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

2.05 SECUREMENTS

A. Bands:
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
      a. 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 thick, 1/2 inch wide with closed seal.
   3. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with 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.

2.06 CORNER ANGLES

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

B. Stainless-Steel Corner Angles: 0.024 inch thick, minimum 1 by 1 inch, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 or Type 316.

PART 3 - EXECUTION

3.01 EXAMINATION

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

B. Verify that systems to be insulated have been tested and are free of defects.

C. Verify that surfaces to be insulated are clean and dry.

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

3.02 PREPARATION

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

3.03 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.

J. Install insulation continuously through hangers and around anchor attachments.

K. 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.

L. 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.

M. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

N. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.

4. For below ambient services, apply vapor-barrier mastic over staples.
5. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
7. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
8. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
9. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.04 PENETRATIONS

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

B. Seal penetrations with flashing sealant.

C. 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.

D. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.

E. Seal jacket to roof flashing with flashing sealant.

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

G. Seal penetrations with flashing sealant.
   1. 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.
   2. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   3. Seal jacket to wall flashing with flashing sealant.

H. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
   1. 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.

I. 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.

2. Seal penetrations through fire-rated assemblies.

3.05 INSTALLATION OF MINERAL-FIBER INSULATION

A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

B. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
   1. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
   2. 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:
   3. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.

C. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
   1. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
   2. Do not over-compress insulation during installation.
   3. Impale insulation over pins and attach speed washers.
   4. 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.

D. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
   1. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

E. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

F. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
   1. 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.
   2. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

G. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
   1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
      a. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
      b. 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:

H. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c. On duct sides with dimensions larger than 18 inches space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

I. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.

J. Do not over-compress insulation during installation.

K. 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.

L. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

M. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

N. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

O. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

P. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

Q. For exterior, exposed, supply and return duct installations, board insulation system shall be externally wrapped with roofing membrane. Top side shall be tapered/sloped for drainage purposes.

3.06 FIELD QUALITY CONTROL

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

B. Tests and Inspections:

C. 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.

3.07 DUCT INSULATION SCHEDULE

A. Refer to schedule on drawings.

END OF SECTION 230713

SECTION 230719

HVAC PIPING INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 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. 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.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.

D. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.

E. Sheet Form Insulation Materials: 12 inches square.

F. Jacket Materials for Pipe: 12 inches long by NPS 2.

G. Sheet Jacket Materials: 12 inches square.

H. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.03 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.

1.04 QUALITY ASSURANCE

A. 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.

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

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

1.05 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.

1.06 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.

1.07 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

2.01 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. 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, available products that may be incorporated into the Work include the following:
      a. Aeroflex USA, Inc.; Aerocel.
      b. Armacell LLC; AP Armaflex.
      c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

G. Mineral-Fiber Rigid Pipe Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
   1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include the following:
      a. Johns Manville; Microlite.
      b. Knauf Insulation; Friendly Feel Duct Wrap.
      c. Owens Corning; SOFTR All-Service Duct Wrap.

H. 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, available products that may be incorporated into the Work include the following:
      a. Armacell LLC; Tubolit.
      b. Nomaco Insulation; IMCOLOCK, IMCOSHEET, NOMALOCK, and NOMAPLY.
      c. Aprofoam.

2.02 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. 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. 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).

2.03 SEALANTS

A. Joint Sealants:
   1. 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. 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. 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).

2.04 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
   1. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

B. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105, or 5005, Temper H-14.
   1. Sheet and roll stock ready for shop or field sizing.
   2. Finish and thickness are indicated in field-applied jacket schedules.

C. Moisture Barrier for Outdoor Applications: 3-mil- thick, heat-bonded polyethylene and kraft paper.

D. 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.

2.05 TAPES

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

B. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include the following:
   1. ABI, Ideal Tape Division; 491 AWF FSK.
   2. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
   3. Compac Corporation; 110 and 111.

C. Width: 3 inches.

D. Thickness: 6.5 mils.

E. Adhesion: 90 ounces force/inch in width.

F. Elongation: 2 percent.

G. Tensile Strength: 40 lbf/inch in width.

H. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

2.06 SECUREMENTS

A. Bands:
   1. Products: Subject to compliance with requirements, available products that may be

incorporated into the Work include, but are not limited to, the following:
   a. ITW Insulation Systems; Gerrard Strapping and Seals.
   b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with closed seal.
3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

PART 3 - EXECUTION

3.01 EXAMINATION

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

B. Verify that systems to be insulated have been tested and are free of defects.

C. Verify that surfaces to be insulated are clean and dry.

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

3.02 PREPARATION

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

B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
   1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
   2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 degrees Fahrenheit with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
   3. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
   4. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.03 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.

K. Install insulation continuously through hangers and around anchor attachments.
   1. 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.
   2. 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.
   3. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

L. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

M. Install insulation with factory-applied jackets as follows:
   1. Draw jacket tight and smooth.
   2. Cover circumferential joints with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
   3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
      a. For below-ambient services, apply vapor-barrier mastic over staples.

N. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
   1. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

O. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

P. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

Q. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt

joints.

R. 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.

3.04 PENETRATIONS

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

B. Seal penetrations with flashing sealant.

C. 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.

D. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.

E. Seal jacket to roof flashing with flashing sealant.

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

G. Seal penetrations with flashing sealant.
   1. 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.
   2. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
   3. Seal jacket to wall flashing with flashing sealant.

H. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
   1. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

I. Insulation Installation at Floor Penetrations:
   1. Pipe: Install insulation continuously through floor penetrations.
   2. Seal penetrations through fire-rated assemblies.

3.05 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:

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

D. 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.

E. Install removable insulation covers at locations indicated. Installation shall conform to the following:
   1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
   2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.

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

3.06 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.

3.07 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 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, 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.

3.08 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.

3.09 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:
   1. Draw jacket material smooth and tight.
   2. Install lap or joint strips with same material as jacket.
   3. Secure jacket to insulation with manufacturer's recommended adhesive.
   4. Install jacket with 1-1/2-inchlaps at longitudinal seams and 3-inch-wide joint strips at end joints.
   5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Where metal jackets are indicated, install with 2-inchoverlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.10 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."

B. 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.
   1. Finish Coat Material: Interior, flat, latex-emulsion size.

C. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
   1. Do not field paint aluminum or stainless-steel jackets.

3.11 FIELD QUALITY CONTROL

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

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

3.12 PIPING INSULATION SCHEDULE

A. See schedule on drawings.

END OF SECTION 230719

SECTION 230720

REFRIGERANT PIPING INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes insulating the following HVAC piping systems:
   1. Refrigerant suction and hot-gas piping, indoors and outdoors.

1.03 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. 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.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.

D. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.

E. Sheet Form Insulation Materials: 12 inches square.

F. Jacket Materials for Pipe: 12 inches long by NPS 2.

G. Sheet Jacket Materials: 12 inches square.

H. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.04 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.

1.05 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.

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

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

1.06 DELIVERY, STORAGE, AND HANDLING

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

PART 2 - PRODUCTS

2.01 QUALITY ASSURANCE

A. Insulation shall have flame-spread rating of 25 or less and a smoke density rating of 50 or less as tested by ASTM E-84 method.

B. Ratings:
1. Upper rating of 210 deg. F.
2. Lower rating of -110 deg. F.
3. UV stabilized for ten year life.
4. Thermal conductivity of 0.24.
5. Water vapor transmission of .03 perms per inch.
6. Material to be polyolefin food grade.

2.02 FLEXIBLE FOAMED PIPE INSULATION

A. Approved Manufacturers:
   1. Armaflex;
   2. Halstead "Insul-tube";
   3. Rubatex;
   4. Therma-Cel.

2.03 JOINT SEALER

A. Approved Manufacturers:
   1. Armaflex 520;
   2. BFG Construction Adhesive #105;
   3. Therma-Cel 950.

PART 3 - EXECUTION

3.01 INSULATION SCHEDULE

A. See schedule on drawings.

3.02 INSTALLATION

A. Install insulation in snug contact with pipe and in accordance with manufacturer's recommendations.

B. Insulation shall be installed according to manufacturer's recommendations.

C. Exterior exposed insulation shall be finished with two coats of factory approved finish.
   1. Color shall be selected by the Architect.

D. Stagger joints on layered insulation.

E. Slip insulation on tubing before tubing sections and fittings are assembled keeping slitting of insulation to a minimum.

F. Seal joints in insulation.

G. Insulate flexible pipe connectors.

H. Insulate thermal expansion valves with insulating tape.

I. Insulation exposed outside building shall have "slit" joint seams placed on bottom of pipe.

J. Insulate fittings with sheet insulation and as recommended by Manufacturer.

END OF SECTION 230720

SECTION 230800

COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 DESCRIPTION

A. The owner will engage with a third party to provide commissioning services

B. Contractor shall make available staff to assist the Commissioning Agent (Cx) during commissioning. This assistance may include (but not necessarily be limited to) opening valves, operating the building management system controls, etc.

1. For bidding purposes, allow two (2) days of commissioning activities.

1.03 EQUIPMENT AND SYSTEMS TO BE COMMISSIONED

A. The following equipment and systems will be commissioned in this project:
1. Energy recovery ventilator units.
2. Variable refrigerant flow (VRF) units.
3. Exhaust fans.
4. Vehicle exhaust extraction system.
5. Heating hot water system boilers.
6. Heating hot water system boiler pumps.
7. Baseboard, cabinet and unit heaters.
8. Building Automation System (BAS).

B. The Owner and the CxA reserve the right to amend this list at any time during the construction and acceptance process.

PART 2 - PRODUCTS (NOT APPLICABLE)

PART 3 - EXECUTION

3.01 FUNCTIONAL TESTING SUPPORT REQUIREMENTS

A. General Requirements
1. This section provides brief descriptions of the testing and support the Contractor will be required to provide to perform the functional testing of the plumbing equipment included in this project.
2. A functional performance test shall be performed on each complete system. Each function shall be demonstrated to the satisfaction of the CxA based on the written test procedure developed by the CxA to demonstrate conformance with the requirements of

the Contract Documents.

3. Each functional performance test shall be performed, witnessed and signed off by the CxA. The CxA and CTRs will perform the functional testing together. Any exceptions to this will be made clear to the Owner as to the reason and justification.
4. The functional performance testing shall be conducted in accordance with prior approved procedures and documented as required.
5. The Contractor shall notify the contracting team, CxA and design consultants at least two weeks prior to the date of scheduled functional performance tests. The seasonal functional performance test periods shall be scheduled over a single block of days. The schedule of functional performance tests shall be based on the construction completion schedule.
6. Commissioning Documentation:
    a. The Controls Representative shall provide the following documentation prior to commencement of the formal acceptance phase:
        i. Full “as-built” set of submittals, control drawings and sequence of operations.
        ii. List of schedules and setpoints.
        iii. Copy of control software on hard media.
        iv. Screenshots of all operator workstation graphics.
        v. Marking of all system sensors, control valves and dampers, and thermostats on the mechanical drawings and floor plans.
    b. Test Equipment: Where special testing equipment, tools and instruments are required to accomplish start-up, testing, adjustments, provide such at no extra cost to the Owner and/or Commissioning Agent for use during acceptance testing.
7. Point-to-Point Checkout: Each input/output device and control point shall be inspected and verified for proper installation and functionality. Each control point's wiring, signal and response shall be checked and documented by the controls representative. A checkout sheet itemizing each device shall be filled out, dated and approved by the Contractor for submission to the Commissioning Agent. The point-to-point checkout must be complete before the commencement of the commissioning functional tests.
8. All alarms. Any alarm that is to be annunciated will include the appropriate text describing the alarm. System code or any other code that is not immediately intuitive to the system operator is not acceptable. The owner will not be responsible for programming or developing any text for the annunciation of the alarms on any device. This includes local panels, BAS interface or remote wireless annunciation or notification.

B. Air Delivery and Distribution Systems Testing
1. The Cx Authority will further define the tests and procedures in the Functional Testing Summary as well as the individuals required to support the testing.
2. Test all terminal device safeties including freezestats, high pressure and low pressure switches. Smoke and fire shutdowns will be tested when the fire alarm and smoke systems are completed and interconnected.
3. All sequence of operations pertaining to each unit’s start/stop, temperature control, damper control, airflow control, and air flow delivery performance will be tested.

C. Exhaust Fan Testing
1. The Cx Authority will further define the tests and procedures in the Functional Testing Summary as well as the individuals required to support the testing.
2. Test all EF safeties including, high pressure and low pressure switches. Smoke and fire shutdowns will be tested when the fire alarm and smoke systems are completed and interconnected.

3. All sequence of operations pertaining to the EF will be tested.
4. Integration with any third-party controls and equipment will be verified for kitchen exhaust fans.

D. Heating Hot Water System Testing
1. The Cx Authority will further define the tests and procedures in the Functional Testing Summary as well as the individuals required to support the testing.
2. Verify the operation of all safeties including loss of flow, high temperature and high pressure.
3. Test operation of all local controls including hot water supply setpoint, lead/lag and alarming.
4. Test pump operation and verify flow and temperature enable/disable.
5. Test for pump staging, pressure delivery, alarms and safeties.
6. Verify all input and output points to the BAS. The point verification by the CxA will be performed only after the BAS graphics are completed, all points for the equipment are mapped to the graphics and the BAS contractor has completed and documented their checkout.
7. The installer(s) will be required to demonstrate any local controls (including temperature control) and integrated third-party Building Management System controls (including all related devices and sequence of operations).
8. All sequence of operations will be tested.

E. Pump System Testing
1. The Cx Authority will further define the tests and procedures in the Functional Testing Summary as well as the individuals required to support the testing.
2. The installer(s) and the manufacturer's representative will be required to demonstrate that all pumps are properly aligned, lubricated, the pumps operate in the proper direction and that the overload protective devices are installed properly and set to the proper settings. All shipping bolts, blocks or straps should be removed and all required labels should be installed and visible.
3. The controls representative will be required to demonstrate that the pumps can start, stop, modulate speed, and that the lead/lag sequence performs as per the sequence of operations. In addition, a Contractor’s Representative will be required to manually operate all hand valves.

F. Cabinet and Unit Heater Testing.
1. The Cx Authority will further define the tests and procedures in the Functional Testing Summary as well as the individuals required to support the testing.
2. Verify all input and output points to the BAS. The point verification by the CxA will be performed only after the BAS graphics are completed, all points for the equipment are mapped to the graphics and the BAS contractor has completed and documented their checkout.
3. All sequence of operations pertaining to the baseboards, CHs and UHs will be tested.

END OF SECTION 230800

SECTION 231316

CONDENSATE PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
1. Condensate (cold) drain piping.

1.03 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.01 PIPING MATERIALS

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

2.02 COPPER TUBE

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

PART 3 - EXECUTION

3.01 PIPING INSTALLATION

A. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

B. 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.

C. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

D. Install piping at indicated slopes.

E. Install piping free of sags and bends.

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

G. Install piping to allow application of insulation.

H. Make changes in direction using appropriate branches, bends, and long-sweep bends. Tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back to back or side by side with common drain pipe. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

I. Install piping at the following minimum slopes unless otherwise indicated:
   1. 2 percent downward in direction of flow.

J. Install aboveground copper tubing according to CDA's "Copper Tube Handbook."

K. Install sleeves for piping penetrations of walls, ceilings, and floors.

L. Install sleeve seals for piping penetrations of concrete walls and slabs.

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

3.02 JOINT CONSTRUCTION

A. Join copper tube and fittings with soldered joints according to ASTM B 828. Use ASTM B 813, water-flushable, lead-free flux and ASTM B 32, lead-free-alloy solder.

3.03 HANGER AND SUPPORT INSTALLATION

A. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
   1. NPS 1-1/4: 72 inches with 3/8-inch rod.
   2. NPS 1-1/2 and NPS 2: 96 inches with 3/8-inch rod.
   3. NPS 2-1/2: 108 inches with 1/2-inch rod.

B. Install supports for vertical copper tubing every 10 feet.

C. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.04 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.05 PIPING SCHEDULE

A. Flanges and unions may be used on aboveground pressure piping unless otherwise indicated.

B. Above-ground condensate (cold) piping:
   1. All piping shall be any of the following:
      a. Type L copper with soldered or press fit joints.

END OF SECTION 231316

SECTION 232113

HYDRONIC PIPING AND ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
   1. Hot-water heating piping.
   2. Makeup-water piping.
   3. Blowdown-drain piping.
   4. Air-vent piping.
   5. Safety-valve-inlet and -outlet piping.
   6. Expansion Tanks.
   7. Air Separators.
   8. Bag Filters / Chemical Feeders.
   9. Balancing Valves.

1.03 DEFNITIONS

A. PTFE: Polytetrafluoroethylene.

B. RTRF: Reinforced thermosetting resin (fiberglass) fittings.

C. RTRP: Reinforced thermosetting resin (fiberglass) pipe.

1.04 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: at 200 deg F.
   2. Makeup-Water Piping: 80 psig at 150 deg F.
   3. Blowdown-Drain Piping: 200 deg F.
   4. Air-Vent Piping: 200 deg F.
   5. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

1.05 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Valves. Include flow and pressure drop curves based on manufacturer's testing for

calibrated-orifice balancing valves and automatic flow-control valves.
2. Air control devices.
3. Hydronic specialties.

1.06 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Welding certificates.

1.07 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

C. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
1. 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

2.01 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. Wrought-Copper Fittings: ASME B16.22.
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:
a. Anvil International, Inc.
b. S. P. Fittings; a division of Star Pipe Products.
c. Victaulic Company.

D. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting.
1. Grooved-End-Tube Couplings: Rigid pattern, unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, pre-lubricated EPDM gasket rated for minimum 230 deg F for use with housing, and steel bolts and nuts.

E. Wrought-Copper Unions: ASME B16.22.

2.02 STEEL PIPE AND FITTINGS

A. Steel Pipe: Schedule 40, ASTM A 53/A 53M, black steel.

B. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

C. Grooved Mechanical-Joint Fittings and Couplings:
   1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
      a. Anvil International, Inc.
      b. S.P. Fittings. A Division of Star Pipe Products.
      c. Victaulic Company.
      d. Or equal.

D. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM a 53/A 53 M, 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.

E. 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.

F. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thickness as pipe in which they are installed.

2.03 JOINING MATERIALS

A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

B. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inchmaximum thickness unless thickness or specific material is indicated.

C. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

D. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

E. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

F. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

G. 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.

H. 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.

I. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working

temperatures and pressures.

2.04 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, available manufacturers offering products that may be incorporated into the Work include the following:
a. Central Plastics Company.
b. Hart Industries International, Inc.
c. McDonald, A. Y. Mfg. Co.

C. Description:
1. Standard: ASSE 1079.
2. Pressure Rating: 150 psig.
3. End Connections: Solder-joint copper alloy and threaded ferrous.

2.05 VALVES

A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 230523 "General-Duty Valves for HVAC Piping."

B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 230900 "Instrumentation and Control for HVAC."

C. Bronze, Calibrated-Orifice, Balancing Valves:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:
a. Armstrong Pumps, Inc.
b. Bell & Gossett Domestic Pump; a division of ITT Industries.
c. Griswold Controls.
d. Taco.
2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig.
10. Maximum Operating Temperature: 250 deg F.

D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:
a. Armstrong Pumps, Inc.
b. Bell & Gossett Domestic Pump; a division of ITT Industries.
c. Griswold Controls.

d. Taco.
2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 125 psig.
11. Maximum Operating Temperature: 250 deg F.

E. Diaphragm-Operated, Pressure-Reducing Valves:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:
a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump; a division of ITT Industries.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Diaphragm-Operated Safety Valves:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:
a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Bell & Gossett Domestic Pump; a division of ITT Industries.
d. Spence Engineering Company, Inc.
e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Wetted, Internal Work Parts: Brass and rubber.
8. Inlet Strainer: removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Comply with ASME Boiler and Pressure Vessel Code: Section IV, and selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

G. Automatic Flow-Control Valves:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:
   a. Flow Design Inc.
   b. Griswold Controls.
   c. Appollo
2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
4. Combination Assemblies: Include bonze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
8. Minimum CWP Rating: 175 psig.
9. Maximum Operating Temperature: 250 deg F.

2.06 AIR CONTROL DEVICES

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the following:
1. Amtrol, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett Domestic Pump; a division of ITT Industries.
4. Taco.

B. Manual Air Vents:
1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

C. Automatic Air Vents:
1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/4.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 240 deg F.

D. Diaphragm -Type Expansion Tanks:
1. Bladder-type, full acceptance type.
2. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F 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.
3. Bladder shall be ASME, removable, heavy-duty, butyl.
4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

E. In-Line Air Separators:
1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
2. Maximum Working Pressure: Up to 175 psig.
3. Maximum Operating Temperature: Up to 300 deg F.
4. Provide with integral strainer.

2.07 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 2and smaller; flanged ends for NPS 2-1/2and larger.
3. Strainer Screen: 40 -mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

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 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40 -mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

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.

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 misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

2.08 HYDRONIC ACCESSORIES

A. Bag Filters / Chemical Feeders:
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
a. Neptune
b. Eaton

c. Fil-Trek
d. Hayward
e. or equal

2. Shall be able to provide both Chemical Addition and High Capacity Filtering.
3. Construction:
   a. Working pressure of 300-psi at 230 deg F.
   b. 10-gauge mild steel shell.
   c. 9-gauge steel tank head.
4. Cap:
   a. 4-inch cast iron with Buna N "O" ring.
   b. Underside of cap shall be epoxy-coated.
5. Basket:
   a. Stainless steel.
   b. Shall fully support filter bag.
6. Filter Bags:
   a. Provide "fine" type filter bags for 5-micron filtration.
   b. Ring-top.
   c. Furnish five (5) spare filter bags to Owner.
7. Accessories:
   a. Provide 9-inch Leg-Set with anchor bolts.

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS

A. Hot-water heating water piping, aboveground, NPS 1-1/2 and smaller, shall be any of the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
   2. Schedule 40 steel pipe; Class 150, malleable-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Hot-water heating water piping, aboveground, NPS 2 and larger, shall be the following:
   1. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints – flexible joints shall be used.

C. Make-up water piping installed aboveground shall be either of the following:
   1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or press-fit joints.

D. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

E. 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, annealed-temper copper tubing with soldered or flared joints.

F. Safety-Valve-Inlet and -Outlet Piping for Hot-Water and Chilled 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.

3.02 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 throttling-duty valves at each branch connection to return main.

C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. 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.

F. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.03 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 ball valve, and short NPS 3/4 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 branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Section 230523 "General-Duty Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. 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 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

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 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."

W. 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."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.04 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. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
   2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
   3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet 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.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.

D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.

E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.05 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. 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.

G. Copper Tees – shall be tee fittings meeting ASME B16.22.

3.06 HYDRONIC SPECIALTIES INSTALLATION

A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.

B. 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.

C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.

D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.

E. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

F. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches above the floor. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections. Install NPS 3/4 pipe from chemical feeder drain, to nearest equipment drain and include a full-size, full-port, ball valve.

G. 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.

H. Install tank fittings that are shipped loose.

I. 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.

J. 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.

3.07 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.

3.08 CHEMICAL TREATMENT

A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:
   1. pH: 9.0 to 10.5.
   2. "P" Alkalinity: 100 to 500 ppm.
   3. Boron: 100 to 200 ppm.
   4. Chemical Oxygen Demand: Maximum 100 ppm. Modify this value if closed system contains glycol.
   5. Corrosion Inhibitor:
      a. Sodium Nitrate: 1000 to 1500 ppm.
   6. Molybdate: 200 to 300 ppm.
   7. Chromate: 200 to 300 ppm.
   8. Sodium Nitrate Plus Molybdate: 100 to 200 ppm each.
   9. Chromate Plus Molybdate: 50 to 100 ppm each.
   10. Soluble Copper: Maximum 0.20 ppm.
   11. Tolyiriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum 10 ppm.
   12. Total Suspended Solids: Maximum 10 ppm.
   13. Ammonia: Maximum 20 ppm.
   14. Free Caustic Alkalinity: Maximum 20 ppm.
   15. Microbiological Limits:
      a. Total Aerobic Plate Count: Maximum 1000 organisms/ml.
   16. Total Anaerobic Plate Count: Maximum 100 organisms/ml.
   17. Nitrate Reducers: 100 organisms/ml.
   18. Sulfate Reducers: Maximum 0 organisms/ml.
   19. Iron Bacteria: Maximum 0 organisms/ml.

B. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.

C. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

D. Fill systems indicated to have antifreeze or glycol solutions with the following concentrations:
   1. Glycol Heating-Water Piping: Minimum 40 percent propylene glycol.

3.09 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

B. Leave joints, including welds, uninsulated and exposed for examination during test.

C. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.

D. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.

E. 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.

F. 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.

G. 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.

H. 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

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Close-coupled, in-line centrifugal pumps.

1.03 DEFINITIONS

A. Buna-N: Nitrile rubber.

B. EPT: Ethylene propylene terpolymer.

1.04 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.

1.05 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.01 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
   1. Armstrong
   2. Taco
   3. Bell and Gossett

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 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.
   4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
   5. Pump Bearings: Permanently lubricated ball bearings.

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."
   3. Enclosure: Open, drip-proof.
   4. Enclosure Materials: Cast iron.
   5. Motor Bearings: Permanently lubricated ball bearings.
   6. Efficiency: Premium efficient.

2.02 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:
1. Angle pattern.
2. 175-psigpressure rating, cast -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-psigpressure rating, cast -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

3.01 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.

3.02 PUMP INSTALLATION

A. Comply with HI 1.4 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.

3.03 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 non-shrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.

3.04 CONNECTIONS

A. Comply with requirements for piping specified in Section 232123 "Hydronic Piping and Accessories." 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 valve and throttling valve with memory stop 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 pups 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.

3.05 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.
   1. Check piping connections for tightness.
   2. Clean strainers on suction piping.
   3. Perform the following startup checks for each pump before starting:
      a. Verify bearing lubrication.

C. 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.

D. Verify that pump is rotating in the correct direction.

E. Prime pump by opening suction valves and closing drains, and prepare pump for operation.

F. Start motor.

G. Open discharge valve slowly.

3.06 DEMONSTRATION

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

END OF SECTION 232123

SECTION 232300

REFRIGERANT PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

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

1.03 PERFORMANCE REQUIREMENTS

A. Line Test Pressure for Refrigerant R-410A:
   1. Suction Lines for Air-Conditioning Applications: 330 psig.
   2. Suction Lines for Heat-Pump Applications: 535 psig.
   3. Hot-Gas and Liquid Lines: 535 psig.

1.04 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. Strainers.
   5. 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: 3/8 inch equals 1 foot.
   2. Refrigerant piping on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.

1.05 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.07 QUALITY ASSURANCE

A. Brazing: 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."

1.08 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.

1.09 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

2.01 COPPER TUBE AND FITTINGS

A. Copper Tube: ASTM B 280, Type ACR, seamless.
   1. Brazed joints.

2.02 VALVES AND SPECIALTIES

A. 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.

B. 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.
   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.

C. 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.
   7. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and 24 -V ac coil.
   8. End Connections: Socket.
   9. Throttling Range: Maximum 5 psig.
   10. Working Pressure Rating: 500 psig.
   11. Maximum Operating Temperature: 240 deg F.

D. Receivers: Comply with ARI 495.
   1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
   2. Comply with UL 207; listed and labeled by an NRTL.
   3. Body: Welded steel with corrosion-resistant coating.
   4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.
   5. End Connections: Socket or threaded.
   6. Working Pressure Rating: 500 psig.
   7. Maximum Operating Temperature: 275 deg F.

E. Liquid Accumulators: Comply with ARI 495.
   1. Body: Welded steel with corrosion-resistant coating.
   2. End Connections: Socket or threaded.
   3. Working Pressure Rating: 500 psig.
   4. Maximum Operating Temperature: 275 deg F.

2.03 REFRIGERANTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Atofina Chemicals, Inc.
   2. DuPont Company; Fluorochemicals Div.
   3. Honeywell, Inc.; Genetron Refrigerants.
   4. INEOS Fluor Americas LLC.

B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS FOR REFRIGERANT R-410A

A. Suction Lines for Conventional Air-Conditioning Applications: Copper, Type L, drawn-temper tubing and wrought-copper fittings with brazed joints.

B. Hot-Gas and Liquid Lines, and Suction Lines for Heat-Pump Applications: Copper, Type K, drawn-temper tubing and wrought-copper fittings with Alloy HB brazed joints.

3.02 VALVE AND SPECIALTY APPLICATIONS

A. Install diaphragm packless 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 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.

H. Install valve so diaphragm case is warmer than bulb.
   1. 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.
   2. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.

I. 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.
   1. 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.
   2. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:

J. Solenoid valves.
   1. Thermostatic expansion valves.
   2. Hot-gas bypass valves.
   3. Compressor.

K. Install filter dryers in liquid line between compressor and thermostatic expansion valve, and in the suction line at the compressor.
   1. Install receivers sized to accommodate pump-down charge.
   2. Install flexible connectors at compressors.

3.03 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. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

K. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection.

L. Install refrigerant piping in protective conduit where installed belowground.

M. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.

N. Slope refrigerant piping as follows:

O. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
   1. Install horizontal suction lines with a uniform slope downward to compressor.
   2. Install traps and double risers to entrain oil in vertical runs.
   3. 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.

T. Install sleeves for piping penetrations of walls, ceilings, and floors.

U. Install sleeve seals for piping penetrations of concrete walls and slabs.

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

W. Refrigerant piping installed underground/below slab:
   1. Install Schedule-80 PVC sleeve around entire refrigerant piping system (pipe and insulation).
   2. Refrigerant piping and insulation shall be completely installed in sleeve. Piping shall not "share" a common sleeve.
   3. Interior dimension of sleeve shall be a minimum of 2-inches larger than outer diameter of piping/insulation system.
   4. Sleeve shall be installed continuous over the length of the refrigerant piping.
      a. Sleeve shall terminate a minimum of 12-inches above slab/grade/equipment pad on each end.
         i. At termination, thoroughly seal around annular space between sleeve and piping system.

3.04 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."

E. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
   1. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

3.05 HANGERS AND SUPPORTS

A. Install the following pipe attachments:
   1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
   2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.
   3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet 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.

B. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
   1. NPS 1/2: Maximum span, 60 inches; minimum rod size, 1/4 inch.

2. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
3. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
4. NPS 1-1/4: Maximum span, 72 inches; minimum rod size, 3/8 inch.
5. NPS 1-1/2: Maximum span, 96 inches; minimum rod size, 3/8 inch.
6. NPS 2: Maximum span, 96 inches; minimum rod size, 3/8 inch.

C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch
2. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.

D. Support multi-floor vertical runs at least at each floor.

3.06 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.

C. Fill system with nitrogen to the required test pressure.
1. System shall maintain test pressure at the manifold gage throughout duration of test.
2. Test at initial pressure (20-psi) to confirm joint integrity. Once confirmed, the system may be charged to final test pressure.
3. Test at final test pressure (550-psi) for a minimum of 24-hours.

D. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.

E. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.07 SYSTEM CHARGING

A. Charge system using the following procedures:
1. Evacuate entire refrigerant system with a vacuum pump to 500 micrometers. If vacuum holds for 24 hours, system is ready for charging.
2. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.

3.08 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. Verify that compressor oil level is correct.
   2. Open compressor suction and discharge valves.
   3. Open refrigerant valves except bypass valves that are used for other purposes.
   4. 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 233012

DUCT CLEANLINESS FOR NEW CONSTRUCTION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Brand new and clean HVAC systems shall be turned over to the Owner at the completion of the project.

B. This specification details the Duct Cleanliness Level(s) expected for the project.

C. Should Owner's Representative deem any part of the ductwork/system unclean, the HVAC CONTRACTOR shall be responsible to clean the ductwork per Section 233013 – HVAC Air Duct Cleaning.

1.03 QUALITY ASSURANCE

A. SMACNA - Duct Cleanliness for New Construction Guidelines.

B. ACR 2006 - The Assessment, Cleaning and Restoration of HVAC Systems

C. Standard 180-2008 - The Standard Practice for Inspection and Maintenance of Commercial Building HVAC Systems

PART 2 - CONDITIONS

2.01 DUCT CLEANLINESS LEVELS

A. BASIC LEVEL –
   1. Condition of Ducts
      a. Ductwork leaving the premises of the manufacturer shall include all of the following:
         i. Internal and/or external self-adhesive labels or marking for part(s) identification;
         ii. Exposed mastic sealant;
         iii. Light zinc oxide coating on the metal surface;
         iv. A light coating of oil on machine formed ductwork;
         v. Minor protrusions into the airway of rivets, screws, bolts and other jointing devices;
         vi. Internal insulation and associated fasteners;
         vii. Discoloration marks from plasma cutting process.
   2. Delivery to Site
      a. Unless otherwise specified, ductwork delivered from the premises of the

manufacturer shall have no protection.
    i. However, care must be taken to prevent damage during transportation and off-loading.
3. Installation
    a. Before the installation of individual duct sections they are to be inspected to ensure that they are free from all debris, but not be wiped or specially cleaned.
4. Protection of Ductwork Risers
    a. All risers must be covered to prevent the entry of debris into the duct.
5. Downward Facing and Horizontal Duct Openings
    a. Downward facing and horizontal openings shall not be required to be covered.
6. Access Openings to In-Duct Plant
    a. Access covers shall be firmly fitted in position on completion of each section of the work.

B. INTERMEDIATE LEVEL –
1. In addition to the provisions of the BASIC LEVEL, undertake the following requirements:
    a. Site Storage
        i. The area provided for storage shall be clean, dry and exposure to dust minimized.
    b. Installation
        i. The working area should be clean and dry and protected from the elements;
        ii. The internal surfaces of the uninsulated ductwork shall be wiped to remove excess dust immediately prior to installation;
        iii. Open ends on completed ductwork and overnight work-in-progress shall be sealed.

C. ADVANCED LEVEL –
1. In addition to the provisions of the INTERMEDIATE LEVEL, undertake the following requirements:
    a. Production and site delivery requirements:
        i. All self-adhesive labels for part identification are to be applied to external surfaces only;
        ii. To maintain cleanliness during transportation, all ductwork shall be sealed either by blanking or capping duct ends, bagging small fittings, surface wrapping or shrink wrapping.
    b. Site storage:
        i. A clean and dry environment where the ductwork is protected from dust, must be provided for the storage of ductwork prior to installation;
        ii. All sealed ends shall be visually examined and if damaged resealed with an appropriate material.
    c. Installation:
        i. The working area shall be clean, dry and the ductwork protected from dust. Protective coverings shall only be removed immediately before installation and inspected to determine if additional wipe down is necessary.

PART 3 - EXECUTION

3.01 TEMPORARY STORAGE

A. Contractor shall be responsible to locate job-site duct material storage areas away from high dust generating processes such as masonry or tile cutters, cutoff saws, drywall sanding, mortar and plaster mixers, roof pitch kettles, portable electric generators, and main walkways that will be constantly broom swept.
   1. To prevent ductwork material damage from standing water, storage locations should include pallets or blocking to keep fabricated metal ductwork above the floor surface.
   2. If there is risk of water runoff from above or should dusty work areas not be avoided, coverage should be used to protect stored materials.

3.02 OPERATION OF HVAC SYSTEMS DURING CONSTRUCTION

A. When HVAC systems are operated while the building is still under construction, during startup and continuous operation of the HVAC system, CONTRACTOR shall be responsible to take special care to protect the return air system by installing temporary filters at the air handling unit(s).

3.03 CLEANLINESS LEVEL REQUIREMENTS

A. All HVAC systems shall meet ADVANCED LEVEL requirements.
   1. CONTRACTOR shall be responsible for maintain these requirements throughout construction.

B. During construction, the Owner's Representative will evaluate the cleanliness of the HVAC systems by visual inspection and/or vacuum test methods (as outlined in NADCA standards).
   1. An HVAC interior surface will be considered visibly clean when it is free of non-adhered debris.
   2. Vacuum test methods will include visual surface comparison of "clean" areas before and after vacuuming as well as sampling a known surface area to determine the net weight of debris per area sampled to compare to an acceptable NADCA level.
   3. Particular attention will be paid to:
      a. Coils
      b. Fans
      c. VAV Boxes
      d. Turning Vanes
      e. Dampers
      f. Duct Transitions

C. If the Owner's Representative determines that the ductwork and/or other components of the HVAC system are not clean, the HVAC CONTRACTOR will be directed to clean the ductwork/system per Section 233013.
   1. Ductwork/system shall be returned to "as new" condition.
   2. CONTRACTOR shall bear all costs associated with the duct cleaning.

END OF SECTION 233012

SECTION 233013

HVAC AIR DUCT CLEANING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SECTION INCLUDES

A. Air duct cleaning to include site preparation, source removal of dirt and debris, chemical surface treatment, duct openings, sealing and repair of duct insulation.

B. At the time of Substantial Completion, the entire air distribution system shall be turned over to the Owner clear of construction dust and debris. If the interior surfaces of any ducted air moving equipment or the interior surfaces of any new or modified portion of the ductwork distribution system are found, as determined by the Owner's Representative, to contain significant construction dust and debris, the entire ductwork distribution system shall be cleaned in accordance with this Specification Section.
   1. If proper precautions are taken to prevent construction dust and debris from entering the ductwork during construction, and if the Owner's Representative finds the ductwork to be free from such dust and debris, air duct cleaning shall not be required.
   2. See Section 233012 - Duct Cleanliness for New Construction for additional information.

1.03 QUALITY ASSURANCE

A. NADCA Standard 1992-01, Mechanical Cleaning of Non-Porous Air Conveyance System Components.

B. SMACNA Standards, HVAC Duct Construction Standards - Metal and Flexible (HVACDCS).

1.04 AIR DUCT CLEANING CONTRACTOR

A. Obtain the services of a qualified HVAC system cleaning Subcontractor to perform the air system cleaning as specified herein.
   1. Prior to commencing work under this section of the specifications, the testing organization shall have been approved by the Engineer.
   2. The criteria for determining qualifications shall be recent experience with similar projects done in accordance with National Air Duct Cleaners Association (NADCA) Standard 1992-01.

1.05 SUBMITTALS

A. Submit experience list of similar projects.

B. Submit cleaning methodologies and material safety data sheets (MSDS) for chemicals to be used.

PART 2 - PRODUCTS

2.01 PROCEDURES FOR AIR DUCT CLEANING

A. Perform work in accordance with NADCA Standard 1992-01.

B. Supply materials for cleaning, repairing and inspection work including HEPA filtered collection systems, rotary brushes, air lances, mechanical agitators, fiber optic borescopes, vacuums, or other equipment and materials necessary to perform work specified.
   1. Furnish materials and equipment that are of a reputable manufacturer.
   2. Submit Material Safety Data Sheets for chemicals utilized in this project prior to product usage.

C. Access points shall be constructed of metal or plastic.
   1. Points shall be installed in a hole that is a minimum of 1 inch in diameter.
   2. Access points shall be reusable by Owner's maintenance staff.
   3. If external insulation is removed during the installation process, repair the open edges with a similar color repair tape (to the best extent possible).

D. Access doors shall consist of 3 layers of precision stamped 0.030-inch (23 gauge) electro-galvanized zinc-plated steel.
   1. The inside door shall consist of 2 layers of metal which are spot-welded together at the rim, encapsulating high density fiberglass insulation - UL classified FHC 25/50.
   2. The inside surface shall be smooth to reduce friction.
   3. The gasket which seals the door from the inside to the duct shall consist of a closed cell neoprene gasket which is UL 94HF 1 listed with a service temperature of (ASTM D746) 70 to 220 degrees F.
      a. The gasket shall be permanently bonded to the inside of the door to eliminate leakage. Conical springs shall be installed over the bolts, between the inner and outer door, to facilitate opening. Access shall be accomplished by use of high impact polypropylene molded knobs that have threaded brass inserts to eliminate thread stripping.
      b. Knobs shall be easy to turn by hand without wrenches.
   4. Door shall be tested to 20 in. wg with no leakage noted.
   5. The installed access door shall be a permanent reusable access system that can be utilized for further inspections and/or repair.

E. Clean outdoor air plenums thoroughly.
   1. Vacuum or scrape inlet louvers, bird screens, dampers, turning vanes, moisture deflectors and other irregular surfaces, if necessary.

F. Vacuum the interior surfaces of the mixing chamber, removing gross debris.
   1. Sanitize the plenum, drains, and dampers with an EPA registered sanitizing agent.

G. Remove filters from the rack and prepare the area for cleaning.
   1. If filters are to be reused, clean and store in a dry area.
   2. Scrape debris from the filter rack area.
   3. Vacuum clean and/or pressure wash the filter rack system (ensure proper drainage is available before cleaning).
   4. Sanitize the filter rack system.

H. Remove standing water from the condensate pans or base of the plenum.
   1. Clear the drains associated with each pan, ensuring proper operation before cleaning.
   2. If fins are bent prior to cleaning, straighten fins utilizing a coil combing system after the cleaning process.
   3. High-pressure-water clean the coil section.
      a. First apply a biodegradable cleaning solution to penetrate into the coil section (follow manufacturer's guidelines).
      b. Repeat process on the other side of the coil section.
      c. Rinse each side.
      d. Continue process until clear water can penetrate coil section on entire coil face.
      e. After cleaning, sanitize coil section with an approved biocide-utilizing atomizing system.
      f. Report existing damage to the coil section or improper drainage in writing to the Architect.

I. Vacuum clean the fan housing and motors to remove debris.
   1. Hand scrape fan impellers and remove loose debris from the internal surfaces of the fan housing. Take precautions not to damage the impellers, alter blade shape or weight, or affect impeller balance.

J. Vacuum the internal surfaces of the plenums associated with the air handler.
   1. Remove gross debris and other debris or excess equipment that may be present.
   2. In severe cases, the internal plenum surface may be high-pressure-water cleaned to remove grease, dirt, and debris.
   3. After interior surfaces and equipment are cleaned, sanitize the unit with an approved sanitizer utilizing an atomizing system.

PART 3 - EXECUTION

3.01 DUCTWORK CLEANING PROCESS

A. Equipment used shall be portable and sized to enter these areas.
   1. Coordinate electrical requirements through the Owner's electrical or maintenance department, as appropriate. Modifications to accommodate electrical requirements will be at the Contractor's expense.

B. Address each main duct section by first securing debris collection equipment to diffuser branch ducts or to an isolated section of main trunk ductwork.

C. Collectors shall be fan powered, high velocity dust and particle collection systems which will be utilized in areas where debris is being removed from the system.
   1. Equip collection systems with high-efficiency particulate air (HEPA) filtration (99.97 percent collection efficiency for 0.3 micron size).
   2. The collection systems shall be self-contained, with appropriate components to adequately prevent dirt and debris loosened from upstream duct mains and branches during cleaning operations from entering the diffuser plenums by capturing this debris within the collection device.
   3. The components of the collector that connect the base collection unit to the duct or diffuser plenum shall be air-tight and reusable from area to area.

D. Agitate the loose debris on the interior surfaces to introduce the debris into the air flow

produced and controlled by the collection systems.

1. Collection systems shall be able to produce a minimum of 0.42 in. wg in the targeted section of duct to be cleaned. Debris shall travel through the ductwork to the point of collection.

E. Ductwork shall be cleaned by inserting air powered brush systems, air powered extended whip sections, electric rotary brush systems, skipper balls, or air sweeps through the installed access.
   1. Utilize equipment that will best contact surfaces of the duct regardless of shape or size.

F. Where duct is large enough and able to support the weight of a worker, hand tools and vacuums may be used.
   1. Install collection equipment in the section of duct to be cleaned by hand as a precautionary measure to catch any residual debris.

G. Whenever the grilles, registers, or diffusers are removable, they shall be removed, washed, rinsed, dried, and then replaced.
   1. If for any reason they are not removable, they shall be vacuumed in place.
   2. Contractor is not responsible for existing improperly installed grilles, registers, and diffusers; for example, grilles, registers, or diffusers screwed directly into porous ceiling tiles.
   3. Whenever possible, reinstall grilles, registers, and diffusers that were originally improperly installed to the best of the Contractor's ability in a timely manner.
   4. Report inability to reinstall grilles, registers, and diffusers in a proper manner in writing to the Engineer.

H. Perform sanitizing of the air distribution system as required using an air sprayer or fogging device to cover the interior surfaces of the ductwork.
   1. Make certain that surfaces are kept wet for at least 10 minutes.
   2. Sanitizing fluid shall be registered with the Environmental Protection Agency.
   3. Sanitizing shall be accomplished through installed access doors and access points.

I. Perform duct cleaning and sanitizing only at a time when the targeted air distribution systems can be shut down and the facility cleared of occupants.
   1. Schedule the duct cleaning for an appropriate time.
   2. Note: Occupants does not include maintenance or supervisory personnel who take proper precautions.

J. Replace, at no additional cost to the Owner, any ceiling tiles or gridwork that is/are damaged during the ductwork cleaning process.

K. De-activate and re-activate duct smoke detectors during the duct cleaning process.
   1. Coordinate with and receive approval from the local Fire Department and/or local Code Enforcement Officials prior to the de-activation and re-activation of smoke detectors.

3.02 PROJECT ASSESSMENT

A. Provide inspection access to the Owner's Representative any time during or immediately after the cleaning of the air delivery system or systems.
   1. Inspection shall be visual in nature by means of installed access doors and points with the benefit of a fiber optic borescope where necessary.

B. Meet the guidelines set down in the NADCA Standard 1992-01 for Mechanical Cleaning of Non-Porous Air Conveyance System components.

C. Perform the NADCA vacuum test and submit report for approval.

D. Show exact locations of access doors installed as part of the cleaning process on the Record Drawings.

END OF SECTION 233013

SECTION 233113

METAL DUCTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
1. Single-wall rectangular ducts and fittings.
2. Double-wall/outdoor rectangular ducts and fittings.
3. Single-wall round and flat-oval ducts and fittings.
4. Sheet metal materials.
5. Duct liner.
6. Sealants and gaskets.
7. Hangers and supports.

1.03 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. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.04 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. 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.

1.05 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.

1.06 QUALITY ASSURANCE

A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

B. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.01 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."

2.02 DOUBLE-WALL/OUTDOOR RECTANGULAR DUCTS AND FITTINGS

A. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.

B. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

C. 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."

D. 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."

E. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.

F. Inner Duct: Minimum 0.028-inch galvanized sheet steel.

G. 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."

H. 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."

I. Finished insulation value of double-wall duct system shall be no less than R-12.

2.03 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.

B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

1. Lindab Inc.
2. McGill AirFlow LLC.
3. SEMCO Incorporated.

C. Round Ducts: Shall be spiral-type ductwork.
   1. Absolutely no snap-lock type ductwork is acceptable.

D. 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).

E. 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."

F. 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."

G. 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."

H. Exposed ducts shall have absolutely no duct sealer visible. Shall be gasketed and flanged.

2.04 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.

C. Galvanized Coating Designation: G60.

D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.

E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

F. 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.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.05 DUCT LINER

A. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

B. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.

C. Natural-Fiber Duct Liner: 85 percent cotton, 10 percent borate, and 5 percent polybinding fibers, treated with a microbial growth inhibitor and complying with NFPA 90A or NFPA 90B.

D. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
   1. Bonded Logic, Inc.
   2. Reflectix Inc.
   3. Johns Manville

E. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F at75 deg F mean temperature when tested according to ASTM C 518.

F. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to ASTM E 84; certified by an NRTL.

G. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

H. Insulation Pins and Washers:
   1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
   2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick galvanized steel; with beveled edge sized to hold insulation securely in place but not less than 1-1/2 inches in diameter.

I. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "Flexible Duct Liner Installation."

J. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.

2.06 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Water-Based Joint and Seam Sealant:
   1. Application Method: Brush on.
   2. Solids Content: Minimum 65 percent.

3. Shore A Hardness: Minimum 20.
4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

C. Flanged Joint Sealant: Comply with ASTM C 920.
1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

2.07 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, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

E. 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.

F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

G. Trapeze and Riser Supports:
1. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.

PART 3 - EXECUTION

3.01 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, 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.

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."

3.02 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. 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.

C. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

D. Repair or replace damaged sections and finished work that does not comply with these requirements.

E. All exposed ductwork shall be joined with gasketed flanges, with no visible duct sealant at all shall be permissible.

3.03 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."

3.04 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.

C. Where practical, install concrete inserts before placing concrete.

D. Install powder-actuated concrete fasteners after concrete is placed and completely cured.

E. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.

F. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.

G. Do not use powder-actuated concrete fasteners for seismic restraints.

H. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

I. Hangers Exposed to View: Threaded rod and angle or channel supports.

J. 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.

K. 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.

3.05 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.

3.06 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:
   1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
   2. Test the following systems:
      a. Supply Ducts with a Pressure Class of 2-Inch wg Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.
      b. Return Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.
      c. Exhaust Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.
      d. Outdoor Air Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.

C. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

D. Test for leaks before applying external insulation.

E. 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.

F. Give seven days' advance notice for testing.

G. Duct system will be considered defective if it does not pass tests and inspections.

H. Prepare test and inspection reports.

3.07 DUCT SCHEDULE

A. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
   1. Supply Ducts associated with VRF systems:
      a. All supply air ducts:
         i. Pressure Class: Positive 2-inch wg.
         ii. Minimum SMACNA Seal Class: B.
         iii. SMACNA Leakage Class for Rectangular: 8.
         iv. SMACNA Leakage Class for Round and Flat Oval: 4.
   2. Supply Ducts associated with ERV systems:
      a. All supply air ducts:
         i. Pressure Class: Positive 3-inch wg.
         ii. Minimum SMACNA Seal Class: A.
         iii. SMACNA Leakage Class for Rectangular: 4.
         iv. SMACNA Leakage Class for Round and Flat Oval: 2.

3. Return Ducts:
    a. All Return Air Ducts associated with VRF systems:
        i. Pressure Class: Negative 2-inch wg.
        ii. Minimum SMACNA Seal Class: B.
        iii. SMACNA Leakage Class for Rectangular: 8.
        iv. SMACNA Leakage Class for Round and Flat Oval: 4.
    b. All Return/Exhaust Air Ducts associated with ERVs:
        i. Pressure Class: Negative 3-inch wg.
        ii. Minimum SMACNA Seal Class: A.
        iii. SMACNA Leakage Class for Rectangular: 4.
        iv. SMACNA Leakage Class for Round and Flat Oval: 2.
4. Exhaust Ducts:
    a. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
        i. Pressure Class: Positive (downstream of fan) or Negative (upstream of fan) 2-inch wg.
        ii. Minimum SMACNA Seal Class: B.
        iii. SMACNA Leakage Class for Rectangular: 8.
        iv. SMACNA Leakage Class for Round and Flat Oval: 4.
5. All Exterior Duct Work:
    a. Shall be double-walled.
        i. See Part 2.2 of this specification.
6. General Duct Requirements:
    a. All rectangular ductwork shall be in accordance with SMACNA Standards with regard to duct gauge, reinforcement spacing, bracing, hangers and supports. All longitudinal seams shall be made with a Pittsburgh Lock (Type L-1). Transverse joints shall be in accordance with SMACNA HVAC Duct Design and Construction Standards for ductwork < 3" w.g. For ductwork rated at 3" w.g. and above, the transverse joints shall be made with the Ductmate, Ward, or Nexus ductwork connection system.
    b. Round and oval ductwork shall be spiral seam. Spiral seam ductwork construction shall be in accordance with the latest SMACNA Standards. Drawband and crimp type transverse joints (RT-3 and RT-5 respectively) are not permitted. Pleated, adjustable, and mitered elbows are not permitted, and segmented elbows shall be constructed with five segments, minimum.
    c. Branch Ducts and Volume Dampers: All branch duct takeoffs shall be made with 45° entry fittings; splitter dampers and extractors are not allowed. Volume dampers are required at each supply, return, and exhaust air sub main, branch main, and branch takeoff and must be shown on the floor plans and in the specifications.

B. Intermediate Reinforcement:
1. Galvanized-Steel Ducts: Galvanized steel .
2. Stainless-Steel Ducts:
    a. Not Exposed to Airstream: Galvanized.

C. Liner (where indicated on drawings or in schedules):
1. Supply Air Ducts: Natural fiber, 2 inch thick.
2. Return Air Ducts: Natural fiber, 1 inch thick.
3. Exhaust Air Ducts: Natural fiber, 1 inch thick.
4. Supply Fan Plenums: Natural fiber, 2 inch thick.
5. Return- and Exhaust-Fan Plenums: Natural fiber, 2 inches thick.
6. Transfer Ducts: Natural fiber, 1 inch thick.

D. 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 or Lower:
         i. Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
         ii. Mitered Type RE 4 without vanes.
      b. Velocity 1000 to 1500 fpm:
         i. Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
         ii. Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
         iii. 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 or Higher:
         i. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
         ii. Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
         iii. 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.
         i. Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
         ii. Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
         iii. Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
      b. Radius-to Diameter Ratio: 1.5.
      c. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
      d. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

E. 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.
   2. Rectangular Main to Round Branch: 45-degree entry.
   3. 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 or Lower: 90-degree tap.
      b. Velocity 1000 to 1500 fpm: Conical tap.
      c. Velocity 1500 fpm or Higher: 45-degree lateral.

END OF SECTION 233113

SECTION 233300

AIR DUCT ACCESSORIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Backdraft and pressure relief dampers
   2. Manual volume dampers
   3. Fire dampers
   4. Combination fire and smoke dampers
   5. Ceiling Radiation Dampers
   6. Flange connectors
   7. Turning vanes
   8. Duct-mounted access doors
   9. Flexible ducts
   10. Duct accessory hardware

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

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

1.04 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.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.06 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.

B. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.01 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.

2.02 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.

B. Galvanized Coating Designation: G60.

C. Exposed-Surface Finish: Mill phosphatized.

D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.

E. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

F. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

G. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

H. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.03 BACKDRAFT AND PRESSURE RELIEF DAMPERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
   1. Air Balance Inc.; a division of Mestek, Inc.

2. American Warming and Ventilating; a division of Mestek, Inc.
3. Greenheck Fan Corporation.
4. Nailor Industries Inc.

B. Description: Gravity balanced.

C. Maximum Air Velocity: 1,000 fpm.

D. Maximum System Pressure: 1-inch wg.

E. Frame: Hat-shaped, 0.05-inch-thick, galvanized sheet steel, with welded corners or mechanically attached and mounting flange.

F. Blades: Multiple single-piece blades, center pivoted, maximum 6-inch width, 0.025-inch-thick, roll-formed aluminum with sealed edges.

G. Blade Action: Parallel.

H. Blade Seals: Felt.

I. Blade Axles:
1. Material: Nonferrous metal.
2. Diameter: 0.20 inch.
3. Tie Bars and Brackets: Aluminum.
4. Return Spring: Adjustable tension.
5. Bearings: Steel ball.

J. Accessories:
1. Counterweights and spring-assist kits for vertical airflow installations.
2. Screen Material: Aluminum.
3. Screen Type: Bird.
4. 90-degree stops.

2.04 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include 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. Nailor Industries Inc.
   e. Pottorff.
   f. Ruskin Company.
2. Standard leakage rating, with linkage outside airstream.
3. Suitable for horizontal or vertical applications.
4. Frames:
   a. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet 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 -steel, 0.064 inch thick.

6. Blade Axles: Galvanized steel.
7. Bearings:
   a. Oil-impregnated bronze.
8. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
9. Tie Bars and Brackets: Galvanized steel.

B. Low-Leakage, Steel, Manual Volume Dampers:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
      a. Air Balance Inc.; a division of Mestek, Inc.
      b. American Warming and Ventilating; a division of Mestek, Inc.
      c. Nailor Industries Inc.
      d. Ruskin Company.
   2. Comply with AMCA 500-D testing for damper rating.
      a. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
      b. Suitable for horizontal or vertical applications.
      c. Frames:
         i. Hat shaped.
         ii. 0.094-inch-thick, galvanized sheet steel.
         iii. Mitered and welded corners.
         iv. Flanges for attaching to walls and flangeless frames for installing in ducts.
      d. Blades:
         i. Multiple or single blade.
         ii. Parallel- or opposed-blade design.
         iii. Stiffen damper blades for stability.
         iv. Galvanized, roll-formed steel, 0.064 inch thick.
      e. Blade Axles: Galvanized steel.
      f. Bearings:
         i. Oil-impregnated bronze.
      g. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
      h. Blade Seals: Felt.
         i. Jamb Seals: Cambered stainless steel.
         ii. Tie Bars and Brackets: Galvanized steel.
         iii. Accessories:
            1.) Include locking device to hold single-blade dampers in a fixed position without vibration.
      i. Jackshaft:
         i. Size: 0.5-inchdiameter.
         ii. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
         iii. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.
      j. Damper Hardware:
         i. Zinc-plated, die-cast core with dial and handle made of 3/32-inch-thick zinc-

plated steel, and a 3/4-inch hexagon locking nut.
ii. Include center hole to suit damper operating-rod size.
iii. Include elevated platform for insulated duct mounting.
k. Dampers shall have locking quadrants.

2.05 FIRE DAMPERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include 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.

B. Type: Type B, static; rated and labeled according to UL 555 by an NRTL.

C. Fire Rating: 1-1/2 and 3 hours (shall meet rating of assembly).

D. Frame: Curtain type with blades outside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.

F. Minimum Thickness: 0.05 thick, as indicated, and of length to suit application.
1. 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.
1. Blades: Roll-formed, interlocking, 0.024-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.
2. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
3. Heat-Responsive Device: Replaceable, 165 degree F rated, fusible links.

2.06 COMBINATION FIRE AND SMOKE DAMPERS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include 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. Ruskin Company.

B. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

C. Fire Rating: 1-1/2 and 3 hours (shall meet rating of assembly).

D. Frame: Hat-shaped, 0.094-inch-thick, galvanized sheet steel, with welded corners and mounting flange.

E. Smoke Detector: Integral, factory wired for single-point connection.

F. Blades: Roll-formed, horizontal, interlocking, 0.063-inch-thick, galvanized sheet steel.

G. Leakage: Class I.

H. Rated pressure and velocity to exceed design airflow conditions.

I. Mounting Sleeve: Factory-installed, 0.039-inch-thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking.

J. Master control panel for use in dynamic smoke-management systems.

K. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."

L. 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.
   1. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Section 23 09 00 "Sequence of Operations for HVAC Controls."
   2. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
   3. 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 and breakaway torque rating of 150 in. x lbf.
   4. 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.
   5. Nonspring-Return Motors: For dampers larger than 25 sq. ft. size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
   6. Electrical Connection: 115 V, single phase, 60 Hz.

2.07 CEILING RADIATION DAMPERS

A. Ratings:
   1. Dampers shall have a UL fire resistance rating to match the application.

B. Fire Closure Temperature:
   1. Each ceiling radiation damper shall be equipped with a factory installed heat responsive device rated to close the damper when the temperature at the damper reaches:
      a. 165 degrees F

C. Construction:
   1. Frame:
      a. Damper frame shall be galvanized steel in gauges required by UL listing R13446 with frame height of:
      b. Standard frame: 2 3/16 inches
      c. Bottom Extension: 4 ¾ inches
      d. Top Extension: up to 6 ¾ inches
      e. Top and Bottom Extension: up to 8 7/8 inches
   2. Blades:
      a. Shall be galvanized steel with one set of blades. Blade insulation not required on ceiling dampers under 115.46 sq. in. Blades insulation is provided on ceiling dampers over 115.46 sq. in. and should be non-asbestos, UL classified material.
      b. Shall be galvanized steel with two set of blades. Blade insulation not required on ceiling dampers under 115.46 sq. in. Blades insulation is provided on ceiling dampers over 115.46 sq. in. and should be non-asbestos, UL classified material.
   3. Blade Stops:
      a. Each blade stop (at top and bottom of damper frame) shall occupy no more than ½" of the damper opening area to allow for maximum free area and to minimize pressure loss across the damper.
   4. Fire Closure Device:
      a. Dampers shall be supplied with fusible link.

D. ACCESSORIES:
   1. Provide with thermal blanket.

E. SOURCE QUALITY CONTROL
   1. Factory Tests: Factory cycle damper and actuator assemblies to assure proper operation.

2.08 FLANGE CONNECTORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include 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, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

C. Material: Galvanized steel.

D. Gauge and Shape: Match connecting ductwork.

2.09 TURNING VANES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
   1. Ductmate Industries, Inc.
   2. Elgen Manufacturing.
   3. ETALAIRE, Inc.
   4. SEMCO Incorporated.

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.

C. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

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 wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.10 DUCT-MOUNTED ACCESS DOORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
   1. Cesco Products; a division of Mestek, Inc.
   2. Flexmaster U.S.A., Inc.
   3. Greenheck Fan Corporation.
   4. Nailor Industries Inc.
   5. Pottorff.
   6. Ventfabrics, Inc.

B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."

C. Door:
   1. Double wall, rectangular.

D. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.

E. Vision panel.

F. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.

G. Fabricate doors airtight and suitable for duct pressure class.

H. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.

I. Number of Hinges and Locks:
   1. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
   2. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
   3. Access Doors up to 24 by 48 Inches Three hinges and two compression latches with

outside and inside handles.

4. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

J. Provide duct-mounted access doors for access to fire and fire/smoke dampers and other accessories requiring periodic inspections.

2.11 FLEXIBLE DUCTS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include 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, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
1. Pressure Rating: 4-inch wg positive and 0.5-inch wg negative.
2. Maximum Air Velocity: 4,000 fpm.
3. Temperature Range: Minus 20 to plus 175 degrees F.
4. Insulation R-Value: Comply with ASHRAE/IESNA 90.1.

C. Flexible Duct Connectors:
1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

D. Flexible Duct shall be constructed of rigid materials.

E. Flexible ductwork shall only be allowed to make the connection from branch ducts to diffusers and shall be a maximum of 3 feet long. Flexible ductwork shall have a maximum flame spread index of 25, a maximum smoke developed index of 50 and conform to UL 181 - Standard for Factory-made air ducts and air connectors. Flexible ductwork shall be vapor barrier jacketed, insulated and have a continuous inner core that shields the fiberglass insulation. Core shall be manufactured from a durable material that will not collect moisture or degrade in the air stream.

2.12 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.

PART 3 - EXECUTION

3.01 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 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.

E. Install steel volume dampers in steel ducts.

F. Set dampers to fully open position before testing, adjusting, and balancing.

G. Install test holes at fan inlets and outlets and elsewhere as indicated.

H. Install fire and smoke dampers according to UL listing.

I. Connect ducts to duct silencers with flexible duct connectors.

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. Upstream and downstream from turning vanes.
   8. Upstream or downstream from duct silencers.
   9. Control devices requiring inspection.
   10. Elsewhere as indicated.

K. Access Door Sizes:

   1. One-Hand or Inspection Access: 8 by 5 inches (unless indicated otherwise on drawings).
   2. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
   3. Install flexible connectors to connect ducts to equipment.
   4. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
   5. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.
   6. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inchlengths of flexible duct clamped or strapped in place.
      a. Connect flexible ducts to metal ducts with adhesive.
      b. Install duct test holes where required for testing and balancing purposes.

L. Maximum length of flexible ducts shall not exceed 5’-0”.

3.02 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.

END OF SECTION 233300

SECTION 233313

LOOSE DAMPERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Loose dampers.
   2. Motorized dampers.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

1.04 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.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For loose dampers to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.01 MATERIALS — GENERAL

A. See schedule for sizes.

B. Dampers shall have galvanized steel frames and blades, with elastomer blade and stainless steel jamb seals for low leakage performance.

   1. Adjustable blades shall be contained within a single 6-inch frame.
   2. Shall be ultra-low leakage with blade and jamb seals. Air leakage rate shall be no greater than 4 CFM/FT^2 of damper surface area at 1.0-inch water gauge and shall be labelled by an approved agency when tested on accordance with AMCA 5000 for such purpose.

2.02 MOTOR OPERATED DAMPERS

A. Dampers shall have 2-position, 120-volt electric actuation with an integral limit switch.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install dampers according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts.

B. Install dampers and 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. Set dampers to fully open position before testing, adjusting, and balancing.

D. Install test holes at fan inlets and outlets and elsewhere as indicated.

3.02 FIELD QUALITY CONTROL

A. Tests and Inspections:
   1. Operate dampers to verify full range of movement.

END OF SECTION 233313

SECTION 233315

LOUVERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
1. Louvers.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

1.04 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.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For loose dampers to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.01 MATERIALS

A. Aluminum Extrusions: ASTM B 221, Alloy 6063-T5 or T-52.

B. Louvers shall be Combination "Stationary Adjustable Drainable" type with a drain gutter in each stationary blade and downspouts in jamb and mullions.

C. Stationary blades and adjustable blades shall be contained within a single 6-inch louver frame. Adjustable section shall include low leakage blade and jamb seals.

D. Louvers shall have a KYNAR finish. Color to be selected by owner.

2.02 FIXED WALL LOUVERS

A. ontinuous Horizontal Fixed Blade Louvers complying with the following requirements:
   1. Drainable blade louver with drip pan
   2. Louver Depth: 4 inches.
   3. Louver Blade and Jamb Thickness: 0.081 inch.
   4. Louver Head and Sill Thickness: 0.100 inch.
   5. Net Free Area: 50%.
   6. Blade Design: 45 degrees.
   7. Blade Spacing: 6" o.c. nominal
   8. All SS Hardware

2.03 LOUVER SCREENS

A. Provide each exterior fixed louver with removable insect screens mounted on interior face of louver. Secure screens to louver frames with stainless steel machine screws.

B. Louver Screen Frames: Fabricate screen frames from aluminum extrusions with mitered corners, in mill finish.

C. Louver Screen Mesh: Fabricate screen mesh from 18 x 16 mesh formed with 0.012 inch diameter aluminum wire in mill finish.

2.04 ALUMINUM FINISHES

A. Comply with NAAMM "Metal Finishes Manual" for recommendations relative to application and designations of finishes.

B. Finish louvers after assembly.

PART 3 - EXECUTION

3.01 PREPARATION

A. Coordinate setting drawings, diagrams, templates, instructions and directions for installation of anchorages which are to be embedded in masonry construction. Coordinate delivery of such items to project site.

3.02 INSTALLATION

A. Locate and place louver components and supports plumb, level, and in proper alignment with adjacent work.

B. Fasten blades to structural supports with aluminum blade braces.

C. Repair finishes damaged by installation. Restore finishes so there is no evidence of corrective work. Return items which cannot be refinished in field.

D. Install concealed gaskets, flashings, joint fillers, and insulation, as louver installation progresses where required to make louver joints weathertight. Caulk all around.

E. Clean and touch-up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory-applied finish coating.

3.03 CLEANING

A. Before final inspection, clean exposed surfaces with water and with a mild soap or detergent not harmful to finishes. Rinse thoroughly and dry surface.

END OF SECTION 233315

SECTION 233423

HVAC POWER VENTILATORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. In-line centrifugal fans.
   2. Ceiling-mounted ventilators.

1.03 PERFORMANCE REQUIREMENTS

A. Operating Limits: Classify according to AMCA 99.

1.04 REFERENCES

A. Performance ratings: Conform to AMCA standard 210, 260 and 300. Fans must be tested in accordance with AMCA 210, 260 and 300 in an AMCA accredited laboratory and certified for air and sound performance. Fan shall be licensed to bear the AMCA ratings seal for air performance (AMCA 210), sound performance (AMCA 300), and induced flow fan for high plume dilution blowers (AMCA 260).
B. Fans shall be UL and CUL listed per UL 705 safety standard.
C. Fans shall meet the criteria of NFPA-45.
D. Classification for Spark Resistant Construction shall conform to AMCA 99.

1.05 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.

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

1.06 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.

1.07 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.08 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.

1.09 COORDINATION

A. Coordinate size and location of structural-steel support members.

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

1.10 WARRANTY

A. Fan manufacturer shall provide a 7 year parts warranty from time of purchase to include fan, plenum, motor and drive mechanisms including pillow blocks, sheaves, shafts, couplings and belts. This warranty shall be held solely by the fan manufacturer. It is unacceptable to extend the warranty of a provided component supplier (i.e. motors, dampers, actuators). All warranty claims shall be the sole responsibility of the fan manufacturer.

PART 2 - PRODUCTS

2.01 IN-LINE CENTRIFUGAL FANS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
   1. Greenheck Fan Corporation.
   2. Loren Cook Company.
   3. Twin City.

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. 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.

D. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.

E. Accessories:
   1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
   2. Companion Flanges: For inlet and outlet duct connections.
   3. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
   4. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.02 CEILING-MOUNTED VENTILATORS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. American Coolair Corporation.
   2. Ammerman; Millennium Equipment.
   3. Carnes Company.
   4. FloAire.
   5. Greenheck Fan Corporation.
   6. Loren Cook Company.
   7. PennBarry.
   8. or equal

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: 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. Isolation: Rubber-in-shear vibration isolators.

G. Provide with integral radiation damper for installations penetrating the membrane of a rated ceiling assembly.

2.03 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

3.01 INSTALLATION

A. Install fans level and plumb.

B. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

C. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch.

D. Install units with clearances for service and maintenance.

E. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.02 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."

3.03 FIELD QUALITY CONTROL

A. Perform tests and inspections.

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

C. 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.
   12. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   13. Prepare test and inspection reports.

3.04 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 233426

INDUSTRIAL CEILING FANS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes
   1. Ceiling-mounted circulation fan is the model scheduled with the capacities indicated. The fan shall be furnished with standard mounting hardware and variable speed control to provide cooling and destratification.

B. Summary of Work
   1. Installation of the fan, miscellaneous or structural metal work (if required), field electrical wiring, cable, conduit, fuses and disconnect switches, other than those addressed in the installation scope of work, shall be provided by others. Factory installation services are available through Big Ass Fans. Consult the appropriate installation scope of work for information on the available factory installation options, overview of customer and installer responsibilities, and details on installation site requirements.

1.02 RELATED SECTIONS

A. 21 00 00 Fire Suppression

B. 23 00 00 Heating, Ventilating, and Air Conditioning (HVAC)

C. 26 00 00 Electrical

1.03 REFERENCES

A. National Fire Protection Association (NFPA)

B. Underwriters Laboratories (UL)

C. Restriction of Hazardous Substances (RoHS)

D. Canadian Standards Association (CSA)

E. National Electrical Manufacturers Association (NEMA)

F. National Electrical Code (NEC)

G. International Organization for Standardization (ISO)

H. Nationally Recognized Testing Laboratory (NRTL)

1.04 SUBMITTALS

A. Shop Drawings: Drawings detailing product dimensions, weight, and attachment methods.

B. Product Data: Specification sheets on the ceiling-mounted fan, specifying electrical and installation requirements, features and benefits, and controller information.

C. Revit Files: Files provided for architectural design

D. Installation Guide: The manufacturer shall furnish a copy of all operating and maintenance instructions for the fan. All data is subject to change without notice.

E. Schedule

F. Ceiling fan sizing, placement, and performance shall be verified using computational fluid dynamics (CFD) analysis. At a minimum, the input data for the CFD analysis shall include the ceiling fan(s), significant obstructions to airflow at the floor level, and the actual space dimensions. As verification of performance, the submittal shall include results of the CFD analysis including, at a minimum, the following performance metrics determined in accordance with ANSI/ASHRAE Standard 55-2017: average air speed, minimum, maximum and average cooling effect from elevated air speed, Predicted Mean Vote, and Predicted Percentage Dissatisfied for seated and standing occupants in each occupied zone.

1.05 QUALITY ASSURANCE

A. Certifications
   1. The fan assembly, as a system, shall be Nationally Recognized Testing Laboratory (NRTL)-certified and built pursuant to the guidelines set forth by UL standard 507 and CSA standards 22.2 No. 60335-1 and 22.2 No. 113.
   2. The fan shall be compliant with NFPA 13—Standard for the Installation of Sprinkler Systems, NFPA 72—National Fire Alarm and Signaling Code, and NFPA 70—National Electrical Code (NEC).
   3. Controllers shall comply with National Electrical Code (NEC) and Underwriters Laboratories (UL) standards and shall be labeled where required by code.

B. Manufacturer Qualifications
   1. The fan and any accessories shall be supplied by Big Ass Fans, which has a minimum of twenty (20) years of product experience.
   2. ISO 9001 compliant
   3. The manufacturer shall not be listed on the Air Movement and Control Association International Inc. (AMCA) Certified Ratings Program (CRP) Non-Licensed Products report in the previous 36 months.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver product in original, undamaged packaging with identification labels intact. The fan shall be new, free from defects, and factory tested.

B. The fan and its components shall be stored in a safe, dry location until installation.

1.07 WARRANTY

A. The manufacturer shall replace any products or components defective in material or workmanship for the customer free of charge (including transportation charges within the USA, FOB Lexington, KY), pursuant to the complete terms and conditions of the Big Ass Fans Warranty in accordance to the following schedule:

Mechanical†	7 years
Electrical††	3 years
Labor	1 year

a. "Mechanical" is defined as mechanical components of the fan, including, the gearbox, fan hub, motor frame, mounting, airfoils, and winglets.
b. "Electrical" is defined as electrical and electronic components of the fan, including the motor, motor drive, variable frequency drive, and any standard controller or accessories.
c. All reasonable costs of repair or replacement will be paid or reimbursed provided customer obtains pre-approval.
d. The Warranty period for any manufacturer defects or flaws to surface finishes is limited to 1 year.
e. All products are considered for indoor use only unless specifically specified on the product label.
f. See the complete warranty for more details.

B. The warranty shall not require the submission of a post installation form or photographs of the installed fan(s) to the manufacturer for the warranty to be in effect.

C. The warranty shall not require the periodic submission of maintenance records for the warranty to remain in effect.

PART 2 - PRODUCTS

2.01 MANUFACTURER

A. Delta T LLC, dba Big Ass Fans, PO Box 11307, Lexington, Kentucky 40575.
Phone (877) 244-3267. Fax (859) 233-0139. Website: www.bigassfans.com

2.02 HIGH VOLUME, LOW SPEED FANS – BIG ASS FANS POWERFOIL®8 & POWERFOIL®8 PLUS

A. Complete Unit
   1. Regulatory Requirements: The entire fan assembly shall be NRTL-certified and built pursuant to the construction guidelines set forth by UL standard 507 and CSA standards 22.2 No. 60335-1 and 22.2 No. 113.
   2. Sustainability Characteristics: The fan shall be designed to move an effective amount of air for cooling and destratification in industrial applications over an extended life. The fan components shall be designed specifically for high volume, low speed fans to ensure lower operational noise. Sound levels from the fan operating at maximum speed measured in a laboratory setting shall not exceed 55 dBA. Actual results of sound measurements in the field may vary due to sound reflective surfaces and environmental conditions.
   3. Good workmanship shall be evident in all aspects of construction. Field balancing of the airfoils shall not be necessary.

B. Airfoil System
   1. The fan shall be equipped with eight (8) Powerfoil airfoils of precision extruded aluminum alloy. The airfoils shall be connected by means of two (2) high strength locking bolts per airfoil. The airfoils shall be connected to the hub and interlocked with zinc plated steel retainers.
   2. The fan shall be equipped with eight (8) Powerfoil winglets (standard) or eight (8) Powerfoil Plus winglets (optional) on the ends of the airfoils and eight (8) AirFences® positioned on the airfoils at the optimum location for performance. Both the winglets and AirFences shall be molded of a polypropylene blend. The standard color of the winglet and AirFence shall be "BAF Yellow."
   3. Airfoil Restraint System
      a. All 20- to 24-ft (6- to 7.3-m) diameter fans shall be equipped with a patented airfoil restraint system to provide redundant safety between the ends of the airfoils and the fan hub. The airfoil restraint system shall be available as an option on smaller diameter fans.
      b. The airfoil restraint system shall be comprised of durable, lightweight nylon safety straps that shall extend from winglets through the airfoils and secure to the fan hub with 12-gauge stamped steel safety clips.
      c. The straps shall be made of 1 in. (24 mm) wide heavy-duty nylon webbing rated for 825 lb (374 kg). The loops at the ends of the straps shall be secured in a double-stitch pattern for reinforced durability.
      d. The straps shall be precisely matched to each fan's diameter, eliminating the need for a tensioning mechanism and reducing opportunity for noise.
      e. The straps shall run along the inside of the airfoils for an uninterrupted look.
      f. Safety clips shall secure to each winglet to comprise the outer anchor points and provide tension, while clips on the opposite end shall secure to threaded inserts incorporated in the fan hub.

C. Motor
   1. The fan motor shall be an AC induction type inverter rated at 1725 RPM, 200–240/400–480 VAC, 50/60 Hz, three-phase.
   2. The motor shall be totally enclosed, fan cooled (TEFC) with an IP56. A B5 standard frame shall be provided for ease of service. The motor shall be manufactured with a double baked

Class F insulation and be capable of continuous operation in 5° F to 104° F (-15° C to 40° C) ambient conditions.

D. Gearbox
   1. The gearbox shall be a helical gear reducer, precision finished from hardened steel for low noise and long service life with double lip seals to retain oil and prevent contamination. The gearbox shall be lubricated for life. The gear reducer shall have a standard backlash of less than 25 arc minutes and be equipped with a 17-4 stainless steel shaft of 1-1/4" (3.2 cm) diameter.

E. Motor Frame
   1. The motor frame and mount shall be constructed of steel and powder coated for corrosion resistance and appearance.

F. Mounting System
   1. The fan mounting system shall be designed for quick and secure installation on a variety of structural supports. The design of the upper mount shall provide two axes of rotation. This design shall allow for adjustments to be made after the mount is installed to the mounting structure to ensure the fan will hang level from the structure.
   2. The upper mount shall be of ASTM A-36 steel, at least 3/16" thick, and powder coated for appearance and corrosion resistance. No mounting hardware or parts substitutions, including cast aluminum, are acceptable.
   3. All mounting hardware shall be SAE Grade 8 or equivalent.

G. Hub
   1. The fan hub shall be 19" (48 cm) in diameter and shall be made of precision cut aluminum for high strength and light weight. The hub shall consist of two (2) aluminum plates, eight (8) aluminum spars, and one (1) aluminum spacer fastened with a pin and collar rivet system. The overall design shall provide a flexible assembly such that force loads experienced by the hub assembly shall be distributed over a large area to reduce the fatigue experienced at the attachment point for the fan blade.
   2. The hub shall be secured to the output shaft of the gearbox by means of a steel coupling interface. The hub shall incorporate four (4) safety retaining clips made of 1/4" (0.6 cm) thick steel that shall restrain the hub/airfoil assembly.

H. Safety Cables
   1. The fan shall be equipped with an upper safety cable that provides an additional means of securing the fan assembly to the building structure. The upper safety cable shall have a diameter of Ø3/8" (1 cm).
   2. The fan shall be equipped with two lower safety cables pre-attached to the fan hub that shall provide an additional means of securing the fan to the extension tube. The lower safety cables shall have a diameter of 1/4" (0.6 cm).
   3. The safety cables shall be fabricated out of 7 x 19 galvanized steel cable. The end loops shall be secured with swaged Nicopress® sleeves, pre-loaded and tested to 3,200 lbf (13,345 N).
   4. Field construction of safety cables is not permitted.

I. Variable Frequency Drive
   1. The Variable Frequency Drive (VFD) shall be a NEMA 4X VFD that is factory programmed to minimize starting and braking torques. The VFD shall have touchpad controls and an LED display for controlling the fan's direction, operation, speed, and programming. The VFD may be equipped with an EMI/RFI filter to limit interference with other electronic equipment and a rotary switch disconnect for lock-out/tag-out requirements.
   2. Onboard Variable Frequency Drive: The VFD may be mounted on the fan motor frame. A wall-mounted digital variable speed controller shall be provided for such installations, allowing access to all VFD functions.
   3. Wall-Mounted Variable Frequency Drive: The VFD may be wall-mounted for ease of access.

J. Digital Variable Speed Wall Controller
   1. The fan shall be equipped with a digital variable speed wall controller. The user interface shall be an intuitive touchscreen interface.
   2. The controller shall be mounted to a standard rectangular or square outlet box.
   3. A 150-ft (45.7-m) CAT5 cable shall be provided for connecting the controller to the fan's VFD and to provide power to the controller.
   4. The controller mounting location shall meet the requirements of OSHA standard 29 CFR 1910.303(g) for accessibility minimum clearances.
   5. The controller shall have an IP55 rating.
   6. The controller shall provide fan start/stop, speed, and direction control functions.
   7. The controller shall provide diagnostic and fault history information for the connected fan, as well as the ability to configure fan parameters with the assistance of Big Ass Fans Customer Service.
   8. The controller interface shall be able to be secured with a passcode to prevent unauthorized access to fan controls and settings.
   9. The controller shall operate out of the box without setup and upon connection to CAT5 cable.

K. BAFCon Controller (Optional)
   1. The fan shall have the option of operating with the BAFCon controller.
   2. The digital controller user interface shall be a wall-mounted touchscreen with a 5-inch (127-mm) display and an 800 (RGB) x 480 pixel resolution.
   3. The digital controller shall be mounted to a standard rectangular or square outlet box.
   4. The digital controller mounting location shall meet the requirements of OSHA standard 29 CFR 1910.303(g) for accessibility minimum clearances.
   5. The digital controller shall support up to eight Powerfoil 8 or Powerfoil 8 Plus fans controlled as a group or individually.
   6. The digital controller shall provide fan start/stop, speed, and direction control functions.
   7. The digital controller shall provide diagnostic and fault history information for each connected fan as well as the ability to configure fan parameters with the assistance of Big Ass Fans Customer Service.
   8. The digital controller shall include optional SmartSense functionality to maximize energy savings. SmartSense shall provide the capability to automatically control the speed of Big Ass Fans using information from user-determined settings and built-in temperature and humidity sensors.
   9. The digital controller shall include a scheduling feature that shall provide the ability to create up to four fan schedules for turning fans on/off and turning Auto mode on/off. The scheduling feature shall require the date and time to be set on the controller.

10. The digital controller interface shall be able to be secured with user and admin passcodes to prevent unauthorized access to fan controls and settings.
11. The digital controller shall be BACnet-compatible.

L. Fire Control Panel Integration
1. Includes a 10–30 VDC pilot relay for seamless fire control panel integration. The pilot relay can be wired Normally Open or Normally Closed in the field.

M. Guy Wires
1. Included for installations with extension tubes 4 ft (1.2 m) or longer to limit the potential for lateral movement.

PART 3 EXECUTION

3.01 PREPARATION

A. Fan location shall have a typical bar joist or existing I-beam structure from which to mount the fan. Additional mounting options may be available.

B. Mounting structure shall be able to support weight and operational torque of fan. Consult structural engineer if necessary.

C. Fan location shall be free from obstacles such as lights, cables, or other building components.

D. Check fan location for proper electrical requirements. Consult installation guide for appropriate circuit requirements.

E. Each fan requires dedicated branch circuit protection.

3.02 INSTALLATION

A. The fan shall be installed by a factory-certified installer according to the manufacturer's Installation Guide, which includes acceptable structural dimensions and proper sizing and placement of angle irons for bar joist applications. Big Ass Fans recommends consulting a structural engineer for installation methods outside the manufacturer's recommendation and a certification, in the form of a stamped print or letter, submitted prior to installation.

B. Minimum Distances
1. Airfoils must be at least 10 ft (3.05 m) above the floor.
2. Installation area must be free of obstructions such as lights, cables, sprinklers, or other building structures with the airfoils at least 2 ft (0.61 m) clear of all obstructions.

C. The fan shall not be located where it will be continuously subjected to wind gusts or in close proximity to the outputs of HVAC systems or radiant heaters. Additional details are in the Big Ass Fans Installation Manual.

D. In buildings equipped with sprinklers, including ESFR sprinklers, fan installation shall comply with all of the following:
   1. The maximum fan diameter shall be 24 ft (7.3 m).
   2. The HVLS fan shall be centered approximately between four adjacent sprinklers.
   3. The vertical clearance from the HVLS fan to the sprinkler deflector shall be a minimum of 3 ft (0.9 m).
   4. All HVLS fans shall be interlocked to shut down immediately upon receiving a waterflow signal from the alarm system in accordance with the requirements of NFPA 72—National Fire Alarm and Signaling Code.

E. If the SmartSense feature will be used, the BAFCon controller must not be mounted adjacent to or above a radiant heat source, near HVAC ventilation intakes/exhausts, on a poorly insulated exterior wall, or in a different temperature/humidity environment than the fan(s) it will control. Additional mounting guidelines can be found in the controller installation guide.

END OF SECTION 233426

SECTION 233713

DIFFUSERS, REGISTERS AND GRILLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Square ceiling diffusers.
   2. Linear slot diffusers.
   3. Fixed face grilles.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product indicated, include the following:

B. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.

C. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.

1.04 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.

   1. Provide product information submittal.

PART 2 - PRODUCTS

2.01 CEILING DIFFUSERS

A. Rectangular and Square Ceiling Diffusers:
   1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:

a. Nailor Industries Inc.
b. Price Industries.
c. Titus.

2. Devices shall be specifically designed for variable-air-volume flows.
3. Material: Steel.
4. Finish: Baked enamel, white.
5. Face Size: 24 by 24 inches.
6. Mounting: Surface.
7. Pattern: Fixed.
8. Accessories:
   a. Equalizing grid.

2.02 LINEAR SLOT DIFFUSERS

A. Linear Slot Diffuser:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
   a. Nailor Industries Inc.
   b. Price Industries.
   c. Titus.
2. Devices shall be specifically designed for variable-air-volume flows.
3. Material - Shell: Steel, insulated.
4. Material - Pattern Controller and Tees: Aluminum.
5. Finish - Face and Shell: with aluminum face.
6. Finish - Pattern Controller: Baked enamel, black.
7. Finish - Tees: Baked enamel, white.
8. Slot Width: as scheduled.
9. Number of Slots: as scheduled.
10. Length: as scheduled.
11. Accessories: as scheduled. Coordinate frames with ceiling system, see Architectural drawings.
12. Provide with insulated plenum as indicated on the contract drawings.

2.03 REGISTERS AND GRILLES

A. Fixed Face Grille:
1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include the following:
   a. Nailor Industries Inc.
   b. Price Industries.
   c. Titus.
2. Material: Steel.
3. Finish: Baked enamel, white.
4. Core Construction: Integral.
5. Frame: 1-1/4 inches wide.
6. Mounting: Countersunk screw.

2.04 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

3.01 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.

3.02 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.

3.03 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 235216
CONDENSING BOILERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes packaged, factory-fabricated and -assembled, gas-fired, condensing boilers, trim, and accessories for generating hot water.

1.03 QUALITY ASSURANCE

A. The equipment shall, as a minimum, be in strict compliance with the requirements of this specification and shall be the manufacturer's standard commercial product unless specified otherwise. Additional equipment features, details, accessories and appurtenances which are not specifically identified but which are a part of the manufacturer's standard commercial product, shall be included in the equipment being furnished.
B. The equipment shall be of the type, design, and size that the manufacturer currently offers for sale and appears in the manufacturer's current catalogue.
C. The equipment must fit within the allocated space, leaving ample allowance, as may be required by local or state codes, for maintenance and cleaning, and must leave suitable space for easy removal of all equipment appurtenances.
D. The equipment shall be new and fabricated from new materials. The equipment shall be free from defects in materials and workmanship.
E. All units of the same classification shall be identical to the extent necessary to insure interchangeability of parts, assemblies, accessories, and spare parts wherever possible.
F. In order to provide unit responsibility for the specified capacities, efficiencies, and performance, the boiler manufacturer shall certify in writing that the equipment being submitted shall perform as specified. The boiler manufacturer shall be responsible for guarantying that the boiler provides the performance as specified herein.

1.04 SUBMITTALS

A. The contractor shall submit, in a timely manner, all submittals for approval by the engineer. Under no circumstances shall the contractor install any materials until the engineer has made final approval on the submittals.
B. The bidder must submit in writing to the engineer any request for a proposed deviation, omission, modification, or substitution to this specification for evaluation no later than ten (10) days prior to the bid date. A request for any substitution shall be accompanied by technical data, drawings, product samples, and complete data substantiating compliance of proposed substitution with these specifications. No materials shall be deemed acceptable if not in strict and full compliance with these specifications. All bidders must bid solely on the specified materials unless acceptance by the engineer of a deviation, omission, modification, or substitution is granted in writing to all bidders prior to the bid date.

C. Shop Drawings - Shop drawings shall be submitted to the engineer for approval and shall consist of:
D. General assembly drawing of the boiler including product description, model number, dimensions, clearances, weights and service sizes.
E. Schematic flow diagram of gas valve trains.
F. Schematic wiring diagram of boiler control system. Schematic wiring diagram shall be ladder-type showing all components, interlocks, etc. Schematic wiring diagram shall clearly identify factory wiring and field wiring.
G. Installation Instructions: Manufacturer's printed instructions for installation shall be submitted to the engineer for approval.
H. Boiler Inspector's Certifications: As specified hereinafter, shall be submitted in writing prior to final acceptance by the engineer.
I. Factory Test Reports: Factory test reports, as specified hereinafter, shall be submitted prior to final acceptance by the engineer.
J. Field Test Reports: Field test reports, as specified hereinafter, shall be submitted prior to final acceptance by the engineer.
K. Operation and Maintenance Manuals: Manufacturer's printed operation and maintenance manuals shall be submitted prior to final acceptance by the engineer. Operation and maintenance manuals shall contain shop drawings, product data, operating instructions, cleaning procedures, replacement parts list, maintenance and repair data, complete parts list, etc.
L. Manufacturer's Field Service: Manufacturer's printed field service procedures shall be submitted prior to final acceptance by the engineer. Field service procedures shall include the name of boiler manufacturer's field service manager and phone number of boiler manufacturer's field service department.

1.05 CERTIFICATIONS

A. Manufacturer's Certification: The boiler manufacturer shall certify the following:
   1. The products and systems furnished are in strict compliance with the specifications.
   2. The boiler, burner and other associated mechanical and electrical equipment have all been properly coordinated and integrated to provide a complete and operable boiler.
B. ASME certification.
C. CSA (AGA/CGA) certification.
D. The specified factory tests have been satisfactorily performed.
E. The equipment furnished contains inter-changeable parts with the specified equipment so that all major equipment parts can be obtained from the specified manufacturer.
F. Contractor's Certification: The contractor shall certify the following:
   1. The products and systems installed are in strict compliance with the specifications and all applicable local or state codes.
   2. The specified field tests have been satisfactorily performed.
   3. The equipment furnished contains inter-changeable parts with the specified equipment so that all major equipment parts can be obtained from the specified manufacturer.

1.06 DELIVERY, STORAGE, AND HANDLING

A. The contractor shall be responsible for the timely delivery of the equipment to the jobsite. The contractor shall be responsible for unloading and rigging of the equipment. The contractor shall be responsible for protecting the equipment from the weather, humidity and temperature conditions, dirt, dust, other contaminants, as well as jobsite conditions during construction.
B. Equipment shall be unloaded, handled, and stored in accordance with the manufacturer's handling and storage instructions.

1.07 WARRANTY

A. Defects in materials and workmanship shall be warranted for a period of one year from the date of startup.
   1. The heat exchanger and burner shall be warranted for a period of 5-years against defects in material and workmanship; and 10-years against thermal shock.

PART 2 - PRODUCTS

2.1 GENERAL

A. Furnish and install factory "packaged" low pressure hot water. Each factory "packaged" boiler shall be complete with all components, accessories and appurtenances necessary for a complete and operable boiler as hereinafter specified. Each unit shall be furnished factory assembled with required wiring and piping as a self-contained unit. Each unit shall be readily transported and ready for installation.
B. Each factory "packaged" boiler, including pressure vessel, trim, valve trains, burner, control system, and all related components, accessories and appurtenances as herein specified shall all be assembled and furnished by the boiler manufacturer. The boiler manufacturer shall provide unit responsibility for the engineering, coordination, workmanship, performance, warranties, and all field services for each factory "packaged" boiler as specified herein. The boiler manufacturer shall be fully responsible for all components assembled and furnished by him whether or not they are of his own manufacture.

2.2 PERFORMANCE CRITERIA

A. Each boiler shall be capable of operating continuously at rated capacity while maintaining a CSA certified and AHRI listed with a thermal efficiency of not less than as scheduled.
B. Boiler shall comply with ASME Section IV.
C. Ambient air temperature shall be assumed to range from 50F to 90F with an average of 70F.
D. Power voltage shall be 120 VAC, 1-phase, 60 hertz. Control voltage shall be 24 VAC (transformer to be supplied by boiler manufacturer).

2.3 BOILER DESIGN

A. Each hot water boiler shall consist of a horizontal, cast aluminum heat exchanger complete with trim, valve trains, burner, and boiler control system. The boiler manufacturer shall fully coordinate the boiler as to the interaction of its elements with the burner and the boiler control system in order to provide the required capacities, efficiencies, and performance as specified.
B. Each boiler heat exchanger shall be cast aluminum, counter-flow design for maximum heat transfer with the multiple sections arranged in a reverse return configuration to assure balanced flow through each section
C. Contractor must, when filling the system, verify that the pH level is maintained between 6.0 and 8.5.
D. Glycol and other additives must be approved by the glycol manufacturer for use in aluminum boilers and verify that the pH level is maintained between 6.0 and 8.5.
E. All boiler pressure parts shall be constructed in accordance with the latest revision of the ASME Boiler and Pressure Vessel Code, Section IV, and shall be so stamped.
F. Boiler heat exchanger headers shall be fabricated steel and be completely removable for inspection. Seals shall be EPDM, rated for 400F service. Push nipples or gaskets between the sections are not permitted.
G. Boiler shall be enclosed with a single wall outer casing. It shall be fabricated from a minimum 16 gauge carbon steel. The top and side panels shall be secured in place with 1/4-20 NC studs and nuts (sheet metal screws are not acceptable). The front wall shall be hinged to provide access to the burner and control panel. The complete outer casing shall be finished, inside and out, with a powder coat finish. The composite structure of the boiler combustion chamber, insulating air gap and outer casing shall be of such thickness and materials to assure an outer casing temperature of not more than 50F above ambient temperature when the boiler is operated at full rated load without requiring insulation.
H. An observation port shall be located on the boiler to allow for observation of the burner flame.
I. Flue gas outlet shall be located on the rear of the boiler. Boiler to be certified for installation with Category IV venting (stack) as defined in NFPA 54 (ANSI Z221), latest edition. Contractor must provide venting (stack) certified for installation on a Category IV appliance.

2.4 BOILER CONNECTIONS

A. Each boiler shall be provided with all necessary inlet and outlet connections

2.5 BOILER TRIM

A. Each boiler shall be provided with all necessary trim. Boiler trim shall be as follows:
B. Safety relief valve shall be provided in compliance with the ASME code. Contractor to pipe to acceptable drain.
C. Water pressure-temperature gauge.
D. Primary low water flow fuel cutoff (probe type with manual reset).
E. Manual reset high limit water temperature controller.
F. Operating temperature control to control the sequential operation of the burner.
G. Separate inlet and outlet water temperature sensors capable of monitoring flow
H. Exhaust temperature sensor
I. Condensate neutralization kit for each boiler

2.6 LOW NOx BOILER FUEL BURNING SYSTEM

A. The boiler manufacturer shall furnish each boiler with an integral, power type, straight gas, low Nox burner pre-certified to SCAQMD 1146.2, fully automatic fuel burner. The fuel burner shall be an assembly of gas burner, combustion air blower, valve train, and ignition system. The burner manufacturer shall fully coordinate the burner as to the interaction of its elements with the boiler heat exchanger and the boiler control system in order to provide the required capacities, efficiencies, and performance as specified.
B. Each burner shall be provided with an integral gas firing combustion head.
C. Each burner shall provide adequate turbulence and mixing to achieve proper combustion without producing smoke or producing combustibles in the flue gases
D. Each boiler shall be provided with an integral variable speed power blower to premix combustion air and fuel within the blower. The combustion air blower shall have sufficient capacity at the rated firing rate to provide air for stoichiometric combustion plus the necessary excess air. Static and total pressure capability shall comply with the requirements of the boiler. The blower shall operate at 6000 RPM maximum without undue vibration and noise and shall be designed and constructed for exposure to temperatures normal to its location on the boiler. The operating fan speed will be tachometer sensed and be capable of being displayed at the LED display.
E. Each burner shall of the radial-fired type and constructed of steel with a stainless steel inner and stainless steel mesh outer screen.

2.7 OPERATION

A. Each boiler shall be provided with a “Full Modulating” firing control system whereby the firing rate is infinitely proportional at any firing rate between 20% and 100% as determined by the pulse width modulation input control signal. Both fuel input and air input must be sequenced in unison to the appropriate firing rate without the use of mechanical linkage.
B. Each boiler shall include a master/member microprocessor boiler controller to control each boiler’s temperature, lead /lag sequencing of up to 24 hot water boilers in any combination of condensing and non-condensing boilers and flame safeguard functions. Each boiler to be supplied with LCD display/ interface (4.75” X 6.25”) and tactile membrane keypad. Displayed at each boiler shall be complete boiler status, alarm and alarm histories with full text description of each.
C. The control shall have the following capabilities:
    1. Maintain single set point for each boiler or supply temperature multiple boiler applications’.
    2. Reset the set point based on outdoor air temperature.
    3. Sequence condensing/non-condensing hybrid boiler plants to optimize boiler efficiency and protect non-condensing boilers from condensing.
    4. Boiler start rotation
    5. Boiler performance tracking
    6. Boiler/heating plant shutdown based on outdoor air temperature
    7. Internal dual set point program with an external switchover. (e.g. - night setback w/external clock, supplied by others)
    8. Alarm relay for any for any manual reset alarm function.
    9. Programmable Low Fire Delay to prevent short cycling based on a time and temperature factor for release to modulation.
    10. Frost protection
    11. Pump exercising
    12. Flue gas temperature / blocked flue protection
    13. Short cycle protection

14. Local Manual Operation.
15. On board Domestic Hot Water Priority capable of changing from the heating pump to the DHW pump as well as changing the boiler set point from a heating temperature to a higher set point temperature to satisfy the DHW system and then return to the heating mode.
16. Remote Control Building Management Interface. The boilers shall be capable for interface with external control systems. This interface shall be via (RS-485 MODBUS RTU Standard, or Optional LonWorks, BACnet, or MetasysN2,) protocol two way communication to, control boiler on/off and firing rate and read boiler status and error messages. The boiler controls shall also be capable of accepting a 0 -10vdc remote external analog signal to control the firing rate
17. Computer (PC) interface for programming and monitoring all functions

2.8 MAIN GAS VALVE TRAIN – NATURAL GAS

A. Each boiler shall be provided with an integral main gas valve train. The main gas valve trains shall be factory assembled, piped, and wired. Each gas valve train shall include at least the following:
B. Two (2) manual shutoff valves
C. Two (2) safety shutoff valves. Valves equipped with dual solenoids that can independently energized for leak testing.
D. Air - Gas ratio control (maximum inlet pressure 14 IN WC)
E. One (1) low gas pressure switch (manual reset).
F. One (1) high gas pressure switch (manual reset).
G. Two (2) pressure test ports

2.9 IGNITION SYSTEM

A. Each boiler shall be equipped for direct spark ignition

2.10 COMBUSTION AIR CONTROL SYSTEM

A. Each boiler shall be provided with an integral combustion air control system. The combustion air system shall be factory assembled. Each combustion air control system shall include at least the following:
B. The primary control shall vary the speed of the blower based on load demand. The blower shall apply a varying negative pressure on the gas valve which will open or close to maintain zero pressure at the valve orifice, thereby increasing or decreasing the firing rate. Both the air and gas shall be premixed in the blower.
C. One (1) low airflow differential pressure switch to insure that combustion air is supplied.
D. High exhaust back pressure switch

2.11 BURNER CONTROL SYSTEM

A. The control system shall be supplied with a 24 VAC transformer (120 VAC, single phase, 60 hertz primary). The 120/1/60 power supply to each boiler shall be protected by a 15 Amp circuit breaker located in the MCC (supplied by contractor).
B. The boiler shall include an electric spark ignition system. Main flame shall be monitored and controlled by flame rod (rectification) system.
C. Each boiler shall be provided with all necessary controls, all necessary programming sequences, and all safety interlocks. Each boiler control system shall be properly interlocked with all safeties.
D. Each boiler control system shall provide timed sequence pre-ignition air purge of boiler combustion chamber. The combustion airflow sensor shall monitor and prove the airflow purge.

2.12 BOILER CONTROL PANEL

A. The boiler manufacturer shall provide each boiler with an integral factory prewired control panel. The control panel shall contain at least the following components, all prewired to a numbered terminal strip:
   1. One (1) burner "on-off" switch.
   2. One (1) electronic combination temperature control, flame safeguard and system control.
   3. Control circuit breaker.
   4. All necessary control switches, pushbuttons, relays, timers, terminal strips and accessories.

2.13 FACTORY TESTING - HYDROSTATIC

A. Each factory "packaged" boiler shall be hydrostatically tested and bear the ASME “H” stamp.

2.14 FACTORY TESTING - FIRE TESTING

A. Each factory "packaged" boiler shall be fire tested. The boiler manufacturer shall perform this fire test under simulated operating conditions, with the boiler attached to a working chimney system and with water circulating through the boiler. The manufacturer shall provide a fire test report, including fuel and air settings and combustion test results permanently affixed to the boiler.

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.
B. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
C. Examine mechanical spaces for suitable conditions where boilers will be installed.
D. 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) using elastomeric pads. Comply with requirements for equipment bases specified in Section 03 30 00 "Cast-in-Place Concrete." Comply with requirements for vibration isolation devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC Piping and Equipment."
B. Minimum Deflection: 1/4 inch.
C. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
    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. Install gas-fired boilers according to NFPA 54.
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. 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.
D. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service.
E. 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.
F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.
G. Install piping from safety relief valves to nearest floor drain.
H. Boiler Venting:
I. Connect full size to boiler connections. Comply with requirements in Section 23 51 00

"Breechings, Chimneys, and Stacks."

J. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."
K. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
B. Manufacturer's Field Service: Engage a factory-authorized service representative to 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 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.
    5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
    6. Remove and replace malfunctioning units and retest as specified above.
    7. Prepare test and inspection reports.
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 to comply.
    3. Perform field performance tests to determine capacity and efficiency of boilers.
    4. Test for full capacity.
F. 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.
G. Repeat tests until results comply with requirements indicated.
H. Provide analysis equipment required to determine performance.
I. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
J. Notify Owner’s Rep. in advance of test dates.
K. Document test results in a report and submit to Engineer.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Video training sessions.

END OF SECTION 235216

SECTION 237200

ENERGY RECOVERY UNITS – INDOOR

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Energy recovery units (indoor).
   2. Remote condensing units.

1.03 ACTION SUBMITTALS

A. Product Data: Literature shall be provided that indicates dimensions, operating and shipping weights, capacities, ratings, fan performance, filter information, factory supplied accessories, electrical characteristics, and connection requirements. Installation, Operation and Maintenance manual with startup requirements shall be provided. Run test report shall be supplied with the unit in the control compartment's literature packet, and also available electronically after the unit ships.

B. Shop Drawings: Unit drawings shall be provided that indicate assembly, unit dimensions, clearances, and connection details. Computer generated fan curves for each fan shall be submitted with specific design operation point noted. Wiring diagram shall be provided with detail for power and control systems and differentiate between factory installed and field installed wiring.

C. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

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

1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, elevations, 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 equipment or suspension systems will be attached.

B. Seismic Qualification Certificates: For energy recovery and remote condensing unit equipment, accessories, and components, from manufacturer.

C. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

D. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

E. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For energy recovery and remote condensing unit equipment to include in maintenance manuals.

1.06 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.

B. Filters: One set of each type of filter specified.

C. Fan Belts: One set of belts for each belt-driven fan in energy recovery units.

D. Wheel Belts: One set of belts for each heat wheel.

1.07 QUALITY ASSURANCE

A. Energy Recovery Unit (Outdoor):
   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. ARI Compliance:
      a. Capacity ratings for air-to-air energy recovery equipment shall comply with ARI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."
      b. Capacity ratings for air coils shall comply with ARI 410, "Forced-Circulation Air- Cooling and Air-Heating Coils."
   3. ASHRAE Compliance:
      a. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
      b. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."
   4. NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.
   5. UL Compliance: heat recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Nonducted Heat Recovery Ventilators.

B. Energy Recovery Unit (Indoor):
   1. Unit shall be certified in accordance with UL Standard 1995/CSA C22.2 No. 236, Safety Standard for Heating and Cooling Equipment.
   2. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration.
   3. Unit Energy Efficiency Ratio (EER) shall be equal to or greater that prescribed by

ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings.

4. Unit shall be safety certified by ETL and be ETL US and ETL Canada listed. Unit nameplate shall include the ETL label.

C. Remote Condensing Units:
   1. Unit shall be certified in accordance with UL Standard 1995/CSA C22.2 No. 236, Safety Standard for Heating and Cooling Equipment.
   2. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration.
   3. Energy Efficiency Ratio (EER) shall be equal to or greater than prescribed by ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings.
   4. Unit shall be safety certified by ETL and be ETL US and ETL Canada listed. Unit nameplate shall include the ETL label.

1.08 COORDINATION

A. Coordinate layout and installation of energy recovery equipment, remote condensing unit 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 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.

1.09 DELIVERY, STORAGE AND HANDLING:

A. Units shall be on a wooden pallet with skeleton crating prior to shipment to prevent damage during transport and thereafter while in storage awaiting installation.

B. Follow installation, operation and maintenance manual instructions for rigging, moving, and unloading the units at their final locations.

C. Units shall be handled carefully to avoid damage to components, enclosures and finish.

D. Units shall be stored in a clean, dry place protected from weather and construction traffic in accordance with Installation, operation and Maintenance manual instructions.

1.10 WARRANTY

A. Manufacturer shall provide a limited “parts only” warranty for a period of 12 months from the date of equipment start up or 18 months from the date of original equipment shipment from the factory, whichever is less. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided manufacturer’s written instructions for installation, operation, and maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts and air filters.

PART 2 - PRODUCTS

2.01 ENERGY RECOVERY UNITS (INDOOR)

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. McQuay
   2. Semco
   3. Innovent
   4. Air Enterprise
   5. Aaon
   6. or equal.

B. General Construction:
   1. R-410A refrigerant.
   2. ECM driven direct drive backward curved plenum supply fans.
   3. Double wall cabinet construction.
   4. Insulation with a minimum R-value of 6.25.
   5. Double-sloped stainless steel drain pans.
   6. Hinged access doors with lockable handles.
   7. LED service lights in the control panel.

C. Energy Recovery Ventilator Units
   1. General Description:
      a. Indoor air handling units shall include filters, supply fans, and the following:
         i. DX evaporator coil
         ii. Hot gas reheat coil
         iii. Hot water coil
         iv. Exhaust fans & energy recovery wheel
         v. Unit controls
      b. Unit shall have a draw-through supply fan configuration and discharge air vertically.
      c. Unit shall be shipped in two sections and factory tested including leak testing of the coils and run testing of the supply fans and factory wired system. Run test report shall be supplied with the unit in the control compartment's literature packet, and also available electronically after the unit ships.
      d. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
      e. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components.
      f. Installation, Operation and Maintenance manual shall be supplied within the unit.
      g. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's hinged access door.
      h. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's hinged access door.
   2. Construction: All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.
      a. Unit insulation shall have a minimum thermal resistance R-value of 6.25. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D1929-11 for a minimum flash ignition temperature of 610°F. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents

moisture accumulation on the insulation, provides a cleanable interior, prevents heat transfer through the panel and prevents exterior condensation on the panel.

b. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Sealing shall be included between panels and between access doors and openings to reduce air leakage. Piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.
c. Access doors shall be flush mounted to cabinetry.
d. Units with a cooling coil shall include double-sloped 304 stainless steel drain pan. Drain pan connection shall be on the right hand side of unit with a 1" MPT fitting.
e. Cooling coil shall be mechanically supported above the drain pan by multiple supports that allow drain pan cleaning and coil removal.
f. Unit shall include factory wired control panel compartment LED service lights.
g. Unit shall include exterior corrosion protection which shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.

3. Electrical:
   a. Unit shall be provided with an internal control panel with separated low and high voltage control wiring. Access to internal control panel shall be through service access door with removable pin hinges and lockable quarter turn handle.
   b. Unit shall be provided with standard power block for connecting power to the unit.
   c. Unit shall include a factory installed 24V control circuit transformer.
   d. Unit shall have a 5kAIC SCCR.
   e. Unit shall include high and low voltage quick connects for easy wiring at installation.
   f. Unit shall be provided with remote safety shutdown terminals for wiring to a field installed smoke detector, firestat, or building safety automatic shutdown system.
4. Supply Fans:
   a. Unit shall include direct drive, unhoused, backward curved, plenum supply fans.
   b. Blower and motor assembly shall be dynamically balanced.
   c. Motor shall be a high efficiency electronically commutated motor (ECM).
   d. Blower and motor assembly shall be mounted on rubber isolators.
   e. ECM driven supply fan speed shall be controlled with the factory installed AAON controller.
   f. Access to supply fan shall be through removable bolted access panels on the top and bottom of the unit.
5. Exhaust Fans: Unit shall include direct drive, unhoused, backward curved, plenum exhaust fans.
   a. Blower and motor assembly shall be dynamically balanced.
   b. Motor shall be a high efficiency electronically commutated motor (ECM).
   c. Blower and motor assembly shall utilize neoprene gasket.
   d. Access to exhaust fan shall be through an access door with removable pin hinges and lockable quarter turn handles.
   e. ECM driven exhaust fan speed shall be controlled with the factory installed AAON controller.
6. Cooling Coil:
   a. Access to cooling coil shall be through hinged access door with lockable quarter turn handles.
   b. Access to reheat coil shall be through hinged access door with lockable quarter turn handles.
   c. Evaporator Coil:
      i. Coil shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end

casings. Fin design shall be sine wave rippled.
ii. Coil shall have two circuits and interlaced circuitry.
iii. Coil shall be 4 row and 14 fins per inch.
iv. Coil shall be hydrogen leak tested.
v. Coil shall be furnished with factory installed thermostatic expansion valves. The sensing bulbs shall be field installed on the suction line immediately outside the cabinet.
vi. Coil shall have right hand external piping connections. Liquid and suction connections shall be sweat connection. Coil connections shall be labeled, extend beyond the unit casing, and be factory sealed on both the interior and exterior of the unit casing to minimize air leakage.

7. Refrigeration System:
   a. Air handling unit and matching condensing unit shall be capable of operation as an R-410A split system air conditioner.
   b. Each refrigeration circuit shall be equipped with thermostatic expansion valve type refrigerant flow control.
   c. Modulating hot gas reheat shall be provided on the lead refrigeration circuit. Air handling unit shall be provided with hot gas reheat coil, a check valve on the liquid line, and a check valve on the hot gas reheat line. The matching condensing unit must include modulating 3-way reheat valve, liquid line receiver, electronic controller, supply air temperature sensor and a dehumidification control signal terminal. This allows the system to have a dehumidification mode of operation and includes supply air temperature control to prevent supply air temperature swings and overcooling of the space. Reheat line connections shall be labeled, extend beyond the unit casing and be located near the suction and liquid line connections for ease of field connection. Connections shall be factory sealed on both the interior and exterior of the unit casing to minimize air leakage.
8. Heating Coil
   a. Hot Water Heating Coil (Glycol-Water)
      i. Coil shall be certified in accordance with AHRI Standard 410 and be hydrogen or helium leak tested.
      ii. Coil shall be designed and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.
      iii. Coil shall have half serpentine circuitry, 1 row and 12 fins per inch.
      iv. Coil shall have right hand external piping connections. Supply and return connections shall be sweat connection. Coil connections shall be labeled, extend beyond the unit casing, and be factory sealed on both the interior and exterior of the unit casing to minimize air leakage.
      v. Control valves shall be field supplied and field installed.
      vi. Coils shall be located in the preheat position upstream of the cooling coil.
9. Filters
   a. Unit filter access shall be through service access door with piano hinges and lockable quarter turn handles.
   b. Unit shall include four-inch thick, pleated panel filters with MERV rating of 13, in a prefilter box upstream of the cooling coil.
10. Energy Recovery:
   a. Unit shall contain an energy recovery cabinet with back outside air opening, back exhaust air opening, top return air opening, and top supply air opening.
   b. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow

core, airfoil blades with rubber edge and end seals. Damper blades shall be gear driven and designed to have no more than 20 cfm of leakage per sq ft. at 4 in. w.g. air pressure differential across the damper. Low leakage dampers shall be Class 2 AMCA certified, in accordance with AMCA Standard 511. Dampers shall be controlled by a fully modulating actuator.

c. An outdoor air temperature sensor shall be factory provided and wired to control the economizer dampers. The energy recovery wheel shall not operate during economizer mode of operation.
d. Unit shall include on/off exhaust air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge and end seals. Damper blades shall be gear driven and designed to have no more than 20 cfm of leakage per sq ft. at 4 in. w.g. air pressure differential across the damper. Low leakage dampers shall be Class 2 AMCA certified, in accordance with AMCA Standard 511.
e. The exhaust air damper shall open with a 24VDC exhaust fan enable signal, and the exhaust fan shall not be enabled until after the exhaust air damper is fully opened.
f. Unit shall include four-inch thick, pleated panel outside air filters with MERV rating of 13, upstream of the wheel.
g. Unit shall contain a factory mounted and tested energy recovery wheel. The energy recovery wheel shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings.
h. Wheel frame shall slide out for service and removal from the cabinet.
i. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt.
j. Wheels shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow. The layers shall be effectively captured in stainless steel wheel frames or aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix.
k. Wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.
l. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.
m. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the AHRI Certified Products.
n. Energy recovery wheel cassette shall carry a 5 year non-prorated warranty, from the date of original equipment shipment from the factory. The first 12 months from the date of equipment startup, or 18 months from the date of original equipment shipment from the factory, whichever is less, shall be covered under the standard AAON limited parts warranty. The remaining period of the warranty shall be covered by Airxchange. The 5 year warranty applies to all parts and components of the

cassette, with the exception of the motor, which shall carry an 18 month warranty. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided the Airxchange written instructions for installation, operation and maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts. Refer to the Airxchange Energy Recovery Cassette Limited Warranty Certificate.

o. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.
p. Unit shall include energy recovery wheel rotation detection sensors and a set of normally open and normally closed contracts for field indication of wheel rotation.
q. Unit shall include energy recovery wheel defrost control to periodically stop the wheel rotation, which allows the warm exhaust air to defrost the wheel.
r. Unit shall include a clogged filter switch that senses pressure drop across the outside air filters and energy recovery wheel.
s. Unit shall include factory installed magnehelic gauge measuring the pressure drop across the outside air filters and energy recovery wheel.
t. Energy recovery wheel access shall be through service access door with removable pin hinges and lockable quarter turn handles.
u. Outside air dampers, economizer air dampers, exhaust air dampers, and energy recovery wheel control panel access shall be through service access doors with removable pin hinges and lockable quarter turn handles.

11. Controls:
    a. Unit shall be provided with a proof of airflow switch. When airflow is not detected, the supply fans will shut down.
    b. Unit shall be provided with an internal control panel with separated low and high voltage control wiring.
    c. Access to internal control panel shall be through an access door with removable pin hinges and lockable quarter turn handles.
    d. Factory Installed and Factory Provided Controller:
        i. Unit controller shall be capable of controlling all features and options of the unit. Controller shall be factory installed in the unit controls compartment and factory tested.
        ii. Controller shall be capable of stand alone operation with unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling available without dependence on a building management system.
        iii. Controller shall have an onboard clock and calendar functions that allow for occupancy scheduling.
        iv. Controller shall include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.
        v. Make Up Air Controller
            a) Unit shall modulate cooling with constant airflow to meet ventilation outside air loads. Cooling capacity shall modulate based on supply air temperature.
            b) Variable capacity digital scroll compressor is required on the lead circuit.
            c) Unit shall modulate heating with constant airflow to meet ventilation outside air loads. Heating capacity shall modulate based on supply air temperature.

vi. Unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling shall be accomplished with connection to interface module with LCD screen and input keypad. Controller shall be capable of communicating and integrating with a BACnet MSTP network and can be hardwired for a remote enable/disable signal by others.

2.02 REMOTE CONDENSING UNITS

A. General Construction:
1. R-410A refrigerant.
2. Hinged access doors with lockable handles.
3. Variable capacity compressor with 10-100% capacity.
4. 2,500 hour salt spray tested exterior corrosion protection.

B. Remote Condensing Units:
1. General Description:
a. Air-Cooled condensing unit shall include compressors, air-cooled condenser coils, condenser fans, filter driers, and suction and liquid connection valves.
b. Unit shall be factory assembled and tested including leak testing of the coil and run testing of the completed unit. Run test report shall be supplied with the unit in the control compartment.
c. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.
d. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components.
e. Installation, Operation and Maintenance manual shall be supplied within the unit.
f. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's access door.
g. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's access door.
2. Construction:
a. Unit shall be completely factory assembled, piped, and wired and shipped in one section.
b. All cabinet walls, access doors, and roof shall be fabricated of G90 galvanized steel panels.
c. Unit shall be specifically designed for outdoor application.
d. Access to compressors and control components shall be through hinged access doors with quarter turn, lockable handles.
e. Access to condenser coils and fans is through removable access panels.
f. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.

g. Unit shall include lifting lugs.
h. Unit shall include forklift slots.
i. Unit shall include factory installed, painted galvanized steel condenser coil guards on the face of the condenser coil.
3. Electrical:
a. Unit shall be provided with standard power block for connecting power to the unit.
b. Control circuit transformer and wiring shall provide 24 VAC control voltage from the line voltage provided to the unit.

c. Unit shall have a 5kAIC SCCR.
d. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.
e. Unit shall be provided with factory installed and factory wired 115V, 12 amp GFI outlet in the unit control panel.
f. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more than 10% out of balance on voltage, the voltage is more than 10% under design voltage, or on phase reversal.

4. Refrigeration System:
   a. Unit shall be provided with two independently circuited R-410A scroll compressors with thermal overload protection. Lead compressor shall be a variable capacity scroll capable of modulation from 10-100% of its capacity.
   b. Each compressor shall be furnished with a crankcase heater.
   c. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged access doors shall provide access to the compressors.
   d. Compressors shall be isolated from the base pan with the compressor manufacturer's recommended rubber vibration isolators and mounted on an elevated compressor deck, to reduce any transmission of noise from the compressors into the building area.
   e. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low pressure sides, and service valves for liquid and suction connections. Liquid line filter driers shall be factory provided and installed. Field installed refrigerant circuits shall include the low side cooling components, refrigerant, thermal expansion valve, liquid line, insulated hot gas reheat line, and insulated suction line.
   f. Unit shall include a factory holding charge of R-410A refrigerant and oil. Adjusting the charge of the system will be required during installation.
   g. Lead refrigeration circuit shall be provided with modulating hot gas reheat valve, electronic controller, liquid line receiver, supply air temperature sensor and a dehumidification control signal terminal that enables the dehumidification mode of operation, and includes supply air temperature control to prevent supply air temperature swings and overcooling of the space. The matching indoor air handler must include a hot gas reheat coil, a check valve on the hot gas reheat line, and a check valve on the liquid line.
   h. Each refrigeration circuit shall be equipped with a liquid line sight glass.
   i. Units shall be provided with a suction pressure transducer on each refrigeration circuit.

5. Fans
   a. Condenser fan shall be vertical discharge, axial flow, direct drive fans.
   b. Condensing unit shall be provided with an electrically commutated motor (ECM) condenser fan, condenser head pressure controller, and discharge pressure transducers for modulating head pressure control to allow cooling operation down to 35°F.Fan motor shall be weather protected, single phase, direct drive, and totally enclosed air over (TEAO) with electronic protection.

6. Coils
   a. Coils shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.
   b. Coils shall be designed for a minimum of 10°F of refrigerant sub-cooling.

c. Coils shall be hydrogen leak tested.

7. Controls: Unit shall be provided with factory supplied and factory installed MUA AAON Orion controller in the matching AAON air handling unit.

PART 3 - EXECUTION

3.01 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-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for electrical services to verify actual locations of connections before installation.

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

3.02 INSTALLATION

A. Equipment Mounting: Where shown on drawings (AHU indoors/remote condensing unit outdoors), install air-to-air energy recovery equipment on concrete bases.

1. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor (for indoor unit).
2. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded
3. Pipe drains from drain pans to nearest drain: use ASTM B 88, Type L, drawn-temper copper water tubing with soldered or pressure-seal joints, same size as condensate drain connection.

3.03 CONNECTIONS

A. Install piping adjacent to units to allow service and maintenance.

B. Provide connections to the refrigerant piping systems.

C. Connect piping to units mounted on vibration isolators with flexible connectors.

D. Connect cooling condensate drain pans with air seal trap at connection to drain pan and install cleanouts at changes in pipe direction.

E. Comply with requirements for ductwork specified in Section 233113 "Metal Ducts."

F. Install electrical devices furnished with units but not factory mounted.

3.04 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. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Adjust seals and purge.
   3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   4. Set initial temperature and humidity set points.
   5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Energy recovery and remote condensing equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.05 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain energy recovery and remote condensing units.

END OF SECTION 237200

SECTION 237202

HEAT RECOVERY VENTILATORS

PART 1 - GENERAL

1.01 DESCRIPTION

A. The CONTRACTOR shall furnish all labor, materials, equipment, and services necessary for, and incidental to, the installation of the Energy Recovery Units as shown on the Drawings and/or as specified herein.

1.02 SUBMITTALS

A. Submit product data.

B. Submit manufacturer's installation instructions.

C. Submit point-to-point wiring diagram

D. Factory test balancing reports.

1.03 OPERATION AND MAINTENANCE DATA

A. Submit manufacturer's descriptive literature, operation instructions, and maintenance and repair data.

1.04 WARRANTY

A. Warranty to be for a period of 1-year (parts only) from the date of final acceptance.

PART 2 - PRODUCTS

2.01 GENERAL

A. Suitable for HVAC system energy recovery.

2.02 CASING

A. Standard panels shall be galvanized solid exterior, lined with 1-inch thick insulation.

B. The housing shall be supported by structural base.

C. Lifting holes shall be provided at the unit base.

D. Units shall have a one piece weatherproof sheet metal roof.

E. Also furnish and install insulated motorized dampers on supply and exhaust openings.

F. The exterior of the unit shall standard galvanized.

G. Provide double wall construction with 24-gauge galvanized steel liner.

2.03 ACCESS

A. Access to components shall be provided through a large, tightly sealed, hinged and easily removable access door.

B. Access panels shall be constructed of the same materials as the unit casing.
1. Use manufacturer's standard hardware.

C. The heat recovery cassette shall be easily removable from the unit.

2.04 UNIT CONFIGURATION

A. The supply air inlet and exhaust air outlet shall be oriented at opposite ends of the Energy Recovery Unit to maximize the distance between the two airstreams in order to minimize the risk of short circuiting the exhaust air into the supply air intake.

2.05 S.A. FAN AND E.A. FAN

A. Fan ratings shall be based on tests made in accordance with AMCA Standard 210.

B. Fans shall be DWDI, designed with a scroll type housing with vibration isolators.

C. Fan blades shall be statically and dynamically balanced and tested prior to shipment.

D. Fans shall be driven by fixed speed motors using belts and adjustable sheaves.

E. Motor shall be 1800 rpm, ODP, high efficiency type.

2.06 FILTERS

A. General:
1. Provide Owner with one (1) set of spare filters for each ERU.

B. Outdoor Air Pre-Filters:
1. Shall be cartridge type, 2" thick in beverage board frames of a size to suit unit filter sections and rated 500 fpm maximum filter face velocity.
2. Efficiency shall be minimum 30% average atmospheric dust spot efficiency (as per ASHRAE Std. 52-76).
3. Shall be ULC Class 2 listed.

C. Exhaust Air Filters:
1. Shall be cartridge type, 2" thick in beverage board frames of a size to suit unit filter sections and rated 500 fpm maximum filter face velocity.
2. Efficiency shall be minimum 30% average atmospheric dust spot efficiency (as per ASHRAE Std. 52-76).

2.07 DAMPERS

A. Dampers shall be heavy duty, designed to withstand static pressure specified.

B. Dampers shall have nylon bushings, edge and end seals and thrust washers.

C. Damper motors shall be direct coupled to blades within air stream for ease of access, maintenance and adjustment.

D. Damper blade hardware shall be provided with corrosive resistant material.

E. Damper assemblies and motors shall be properly mounted and fitted for air tight and trouble free operation.

F. Damper motors for outside air and exhaust air closure dampers shall be power open, spring return operation with integral, adjustable auxiliary switches.

G. Unit shall be complete with low leakage motorized shut-off dampers on outside air and exhaust air connections.
   1. Damper actuators shall be complete with integral end switch to prevent main fans from operating until dampers have reached open position.
   2. Damper actuators shall be configured to be normally closed.
   3. Provide all interconnecting control wiring between the damper actuators and the unit control panel.

2.08 ENERGY TRANSFER

A. Unit shall be capable of transferring both sensible and latent energy between airstreams.

B. Latent energy transfer shall be accomplished by direct water vapor transfer from one airstream to the other, without exposing transfer media in succeeding cycles directly to the exhaust air and then to the fresh air.

2.09 PASSIVE FROST CONTROL

A. Unit core shall perform without condensing or frosting under normal operating conditions (defined as outside temperatures above -10°F and inside relative humidity below 40%).
   1. Occasional more extreme conditions shall not affect the usual function, performance or durability of the core. No condensate drains will be allowed.

2.10 CONTINUOUS VENTILATION

A. Unit shall have the capacity to operate continuously without the need for bypass, recirculation, pre-heaters or defrost cycles under normal operating conditions.

2.11 POSITIVE AIRSTREAM SEPARATION

A. Water vapor transfer shall be through molecular transport by hydroscopic resin and shall not be accomplished by “porous plate” mechanisms.

B. Exhaust and fresh airstreams shall travel at all times in separate passages, and airstreams shall not mix.

2.12 LAMINAR FLOW

A. Airflow through the Unit’s core shall be laminar over the products entire operating airflow range, avoiding deposition of particulates on the interior of the energy exchange plate material.

2.13 ELECTRICAL

A. Unit shall be equipped with a factory installed non-fused, disconnect and require a single point power connection with a voltage as listed on the schedule.

2.14 REQUIRED OPTIONS

A. Units shall be provided with passive defrost control.

B. The CONTRACTOR shall furnish all dampers, actuators, thermostats, etc, such that all heat recovery units are completely operational.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Verify that the structural support is ready to receive work.

B. Verify that proper power supply is available.

3.02 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.03 SEQUENCE OF OPERATION

A. Furnish and install Remote Wall Control Box (for each Heat Recovery Ventilator).
   1. Field locate where directed by Owner’s Representative.

B. Control Box timer shall Enable and Disable Heat Recovery Ventilator.
   1. Control Box timer shall communicate with BMS.

C. Heat Recovery Ventilator shall operate according to manufacturer’s logic.

END OF SECTION 237202

SECTION 23 72 30
DEDICATED MAKE-UP AIR UNITS - INDOOR

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. Indoor, hot water, make-up air units.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For make-up air equipment. 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.

1.4 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For make-up air equipment to include in 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. Filters: One set(s) of each type of filter specified.

2. Fan Belts: One set(s) of belts for each belt-driven fan in make-up air units.

3. Wheel Belts: One set(s) of belts for each heat wheel.

1.6 QUALITY ASSURANCE

A. NFPA 90 A & B - Installation of Air Conditioning and Ventilation Systems and Installation of Warm Air Heating and Air Conditioning Systems.

B. ARI 360 - Commercial and Industrial Unitary Air Conditioning Equipment testing and rating standard.

C. ANSI/ASHRAE 37 - Testing Unitary Air Conditioning and Heat Pump Equipment.

D. ANSI/ASHRAE/IES 90 A - Energy Conservation in New Building Design Standard.

E. Energy Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

F. ANSI/NFPA 70 - National Electric Code (latest edition).

1.7 SUBMITTALS

A. Submit unit performance data including: capacity, nominal and operating performance.

B. Submit Mechanical Specifications for unit and accessories describing construction, components and options.

C. Submit shop drawings indicating overall dimensions as well as installation, operation and services clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.

D. Submit data on electrical requirements and connection points. Include recommended wire and fuse sizes or Minimum Circuit Ampacity (MCA), sequence of operation, safety and start-up instructions.

1.8 DELIVERY, STORAGE and HANDLING

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

B. Protect units from physical damage. Leave factory shipping covers in place until installation.

1.9 WARRANTY

A. Provide a full parts and labor warranty for a period of two (2) years.

1. Warranty shall commence on date balance report is submitted.

PART 2 - PRODUCTS

2.1 GENERAL UNIT DESCRIPTION

A. Air Handler (Indoor) - Factory assembled and tested, designed for roof installation, and consisting of, but not limited to:

1. supply fan
2. heating section
3. filters
4. dampers
5. outdoor air hood

B. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.

C. Units shall have outlet airflow as indicated on contract drawings.
D. Wiring internal to the unit shall be colored and numbered for identification.

2.2 CONSTRUCTION

A. All units shall be completely factory assembled, piped and wired and shipped in one section. Indoor units shall be modular and shall be disassembled on site as required to enter the building.

B. Outdoor units shall be specifically designed for outdoor rooftop application with a fully weatherproof cabinet.

C. Cabinet shall be constructed entirely of G90 galvanized steel, structural members of 16-gauge or heavier material, and removable panels of 20-gauge or heavier material.

D. Paint finish shall be capable of withstanding at least 2500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.

1. Unit exterior shall be "Gray" in color.

E. The unit roof on outdoor units shall be sloped or cross-broken to assure drainage.

F. Unit specific color coded wiring diagrams shall match the unit color coded wiring and will be provided in both point-to-point and ladder form.

G. Diagrams shall also be laminated in plastic and permanently affixed inside the control compartment.

H. Access to filters, blowers, heating section, and other items needing periodic checking or

maintenance shall be through hinged access doors with quarter turn handles.

1. Door fastening screws are not acceptable.

I. Access doors shall have full-length stainless steel hinges and full perimeter gasketing.

J. All openings through the base pan of the unit shall have upturned flanges of at least 1/2-inches in height around the opening through the base pan.

K. Air side service access doors on outdoor units shall have rain break overhangs.

L. Unit shall have decals and tags to indicate unit lifting and rigging, service areas and caution areas. Installation and maintenance manuals shall be supplied with each unit.

M. Unit shall be furnished with double wall insulation liners.

1. The interior air side of the unit shall be 1-inch thick high performance composite panel constructed with G90 galvanized steel on both sides and a closed cell polyurethane foam interior core with a minimum R value of 6.25.

2.3 SUPPLY FANS

A. Supply blower shall be entirely self-contained on a slide deck for service and removal from the cabinet.

B. All belt drive blowers shall have backward inclined blades.

C. All direct drive blowers shall have forward curved blades.

D. Adjustable V-belt drive shall be provided with a minimum rating of 140% of the motor nameplate brake horsepower when the adjustable pulley is at the minimum RPM.

E. Blowers, drives and motors shall be dynamically balanced.

F. Motors shall be premium efficiency.

1. Motors shall have ball bearings rated for 200,000 hours service and external lubrication connections.

2.4 VARIABLE FREQUENCY DRIVES (VFD):

A. Shall be furnished by manufacturer, integral to unit.

1. Supply fan motor shall be equipped with VFD.

2.5 OUTSIDE AIR

A. Units shall designed for 100-percent outdoor supply air.

1. Damper blades shall be gear driven and designed to have no more than 15 CFM of leakage per sq. ft. of damper area when subjected to 2" w.g. air pressure differential across the damper.

2. Damper motor shall be spring return to ensure closing of outdoor air damper during periods of unit shut down or power failure.
   a. Barometric relief dampers shall also be provided.

2.6 FILTERS

A. 4-inch thick fiberglass pleated filters with an ASHRAE efficiency of 30% and a MERV rating of 7.

1. Provide:

   a. Clogged filter switch
   b. Direct dial reading Magnehelic gauge mounted in the controls compartment.

2.7 HOT WATER HEATING COIL (GLYCOL WATER)

A. Coil shall be certified in accordance with AHRI Standard 410 and be hydrogen or helium leak tested.

B. Coil shall be designed and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.

C. Coil shall have half serpentine circuitry, 1 row and 12 fins per inch.

D. Coil shall have right hand external piping connections. Supply and return connections shall be sweat connection. Coil connections shall be labeled, extend beyond the unit casing, and be factory sealed on both the interior and exterior of the unit casing to minimize air leakage.

E. Control valves shall be field supplied and field installed.

F. Coils shall be located in the preheat position upstream of the cooling coil.

2.8 ELECTRICAL POWER

A. Unit shall be factory wired for a single-point electrical connection.

1. EC shall make connection, and extend power to building system.

B. Unit shall be provided with a factory installed and wired internal disconnect.

C. Outdoor units shall come equipped with a factory mounted convenience outlet.

1. Provide necessary transformers and accessories for 120-volt power.

2. Shall be a GFI type receptacle suitable for outdoor use.

3. Provide weather proof cover.

2.9 CONTROLS

A. Unit shall come equipped with factory-mounted DDC actuators on outdoor air damper.

1. Damper shall be 2 position-type.

B. See Section 23 09 00.

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 roughing-in for electrical services to verify actual locations of connections before installation.

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

3.2 INSTALLATION

A. Outdoor Unit Support: Where shown on drawings: Install unit level on structural curbs. Coordinate roof penetrations and flashing with roof construction. Secure equipment to structural support with anchor bolts.

1. Install units with clearances for service and maintenance.

2. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

B. Indoor Unit Support: Where shown on drawings: Install unit level on concrete pad. Secure equipment pad with anchor bolts.

1. Install units with clearances for service and maintenance.

2. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

3.3 CONNECTIONS

A. Comply with requirements for piping specified in Section 23 21 13 "Hydronic Piping and Accessories." Drawings indicate general arrangement of piping, fittings, and specialties.

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

C. Connect piping to units mounted on vibration isolators with flexible connectors.

D. Comply with requirements for ductwork specified in Section 23 31 13 "Metal Ducts."

E. Install electrical devices furnished with units but not factory mounted.

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. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Adjust seals and purge.

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

4. Set initial temperature set points.

5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Equipment will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.5 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units according to Section 01 79 00 “Training of Campus Personnel.”

END OF SECTION

SECTION 237419

VARIABLE REFRIGERANT FLOW (VRF) SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:
   1. Variable Refrigerant Flow (VRF) system

1.03 PERFORMANCE REQUIREMENTS

A. Structural Performance: Hangers, supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in Section 23.

1.04 ACTION SUBMITTALS

A. Product Data: For all outdoor units, indoor units, control systems, piping, etc. Include certified performances and rated capacities, operating characteristics, furnished specialties, dimensions, and accessories for each type of product indicated

B. Shop Drawings: For each unit:
   1. Show unit, layout and connections.
   2. Include support details.
   3. Include diagrams for power, signal and control wiring.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data.

1.06 WARRANTY

A. The manufacturer shall provide 2-year parts only warranty and an extended 5-year parts only warranty on all hermetic compressor assemblies. Warranty period shall commence on the date the balance report is submitted.

PART 2 - PRODUCTS

2.01 HEAT PUMP AND HEAT RECOVERY SYSTEM(S) – (3 TONS NOMINAL)

A. Product Design
   1. Variable Refrigerant Flow (VRF) HVAC outdoor unit shall be a variable capacity, direct expansion (DX), Heat Pump or Heat Recovery engineered system. The VRF system shall consist of a single frame outdoor unit, interconnecting piping, multiple indoor units

(ducted, non-ducted or mixed combinations), onboard, self-contained, stand-alone communication and controls. Heat recovery systems also include intermediary heat recovery units.

2. Outdoor unit shall be manufactured as either a Heat Pump or a Heat Recovery model capable of heating and/or cooling. Heat pump models shall be able to heat OR cool separate thermal zones.
3. Heat pump systems shall require two pipes, between the outdoor unit and indoor units. Simultaneous heating and cooling is not supported. One pipe shall support bidirectional flow single state liquid refrigerant. The other pipe shall support bidirectional flow of single state refrigerant gas. In heating mode the gas shall be super-heated high pressure. In cooling mode the gas shall be low pressure, low temperature.
4. Heat pump and Heat recovery outdoor units shall be designed to communicate directly with all VRF indoor units manufactured by the same supplier over a field supplied stranded, twisted and shielded pair wire. Systems requiring intermediary protocol translators, signal boosters, integration with a third party building management systems (BMS) or any other device required for communication possible shall not be accepted.
5. Indoor unit connectivity: The system shall be designed to accept connection up to 12 indoor units of various configurations and capacity. Number of 3-ton indoor units allowed: six (6).
6. Combination Ratio (CR) is defined as sum of nominal cooling capacity of proposed indoor units/nominal cooling capacity of the outdoor unit. The maximum allowable system combination ratio shall be 130%. Systems designed with combination ratio above 130% are not acceptable. The total nominal capacity of all indoor units shall be no less than 50%.

B. Operating Conditions
   1. The VRF systems shall be capable of providing continuous compressor operation over the required ambient operating range. Submittal or technical performance data that indicates the required operating ambient range includes data points that do not guarantee continuous compressor operation, noted or footnoted as reference data, shall not be accepted.

C. Electrical
   1. ALL air source heat pump and heat recovery frame(s) shall be designed and electrically protected to maintain stable continuous compressor operation when provided with 208-230/60/1 power and can withstand:
      a. 208-230/60/1 power and can withstand a voltage fluctuation of ± 10%
         i. Voltage tolerance between 187V to 253V
      b. Power surge of up to 5kA RMS Symmetrical.

D. General Features
   1. The unit shall be shipped from the factory fully assembled including internal refrigerant piping, inverter driven compressor, controls, contacts, relay(s), fan(s), power and communication wiring.
   2. The refrigerant shall be R410A. The factory shall supply the following charge of refrigerant R410a: 6.6 lbs.
   3. All outdoor units, regardless of the Heat Pump or Heat Recovery models, shall be the same generation and provide with most up to date firmware version at the time of delivery. Manufacturers commissioning agents shall assure the owner in the commissioning report that the latest software version.
   4. If the specifications include both heat pump and heat recovery outdoor models, the manufacturer shall provide the most recent generation equipment only. Old stock or obsolete models will not be accepted. Products purchased over the internet and not from the manufacturer's authorized local mechanical representative or authorized distributer will not be accepted.

5. The outdoor unit refrigeration circuit at a minimum shall include the following components:
   a. Refrigerant strainer(s)
   b. Check valve(s)
   c. Inverter driven, high pressure shell compressor
   d. Oil separator
   e. Accumulator/receiver
   f. 4-way reversing valve
   g. Electronic expansion valve(s)
   h. Double spiral tube sub-cooler and EEV
   i. High/low Schrader valve service ports with caps
   j. High/low service valves
   k. Threaded fusible plug
   l. High pressure switch
6. The VRF outdoor unit shall use the sub-cooler while operating in cooling mode to sub-cool liquid refrigerant coming from the condenser coil well below saturation temperature to ensure that refrigerant remains in 100% liquid state when it reaches the farthest indoor unit's EEV valve. The amount of sub-cooling shall be modified by the microprocessor controller and minimized at all times to maximize efficiency by not overcooling the liquid.
7. Third Party Controls platform Integration
   a. The VRF system manufacturer's central controls platform shall be able to communicate with third party building management systems (BMS) via BACnet IP, Modbus TCP, or LonWorks™ protocol allowing third party BMS system control and/or monitoring of the LG air conditioning and heating system. See controls specification for more detailed description of integration and points to be controlled and monitored.
   b. The VRF system manufacturer shall have available off-the shelf devices that allows on/off binary interfaces between third party ancillary devices such as fans, door locks, photo eyes, key card switches, motion sensors, exhaust fans, dampers, and a single (or group of) VRF indoor units. Indoor units shall have the ability to start/stop the third party device, receive a contact closure signal from the third party device, or have the third party device change the operating conditions of the VRF indoor unit. Operating conditions shall include one or more of the following indoor unit functions: fan speed, fan on/off, thermal on/off cooling or heating, or indoor unit start/stop.
8. Wi-Fi communication:
   a. The outdoor unit shall be Wi-Fi capable. Wi-Fi shall allow service or maintenance personal access to the operating system diagnostics and monitoring functions, via the manufacturer's provided maintenance and diagnostic software over a mobile device or personal computer. Communication between devices shall include: 1) Real-time system operation monitoring with the ability to capture all system operating data for a field determined period of time into a downloadable csv file format to a wireless connected device; 2) Collection of point in time (snapshot) information including all current outdoor unit operating conditions and each indoor unit, system EEV and solenoid valves, sensors, compressor speed, and refrigerant operating pressures. Systems that require computers with a hard wire only connection or other devices to collect, review or record operating conditions shall not be allowed.

9. Microprocessor Control
    a. Factory installed microprocessor control in the outdoor unit, heat recovery unit(s), and indoor unit(s) shall communicate using the same protocol. Translators of any kind are not allowed. Communication between VRF system components shall be via field supplied stranded, shielded and twisted wire pair in a RS 485 network configuration. Integrated control system shall perform functions to optimize the operation of the VRF system.
    b. Power and communication interruption: The system shall be capable of performing continuous operation when an individual or several indoor units are being serviced; communication wire cut or power to indoor unit is disconnected. Systems that alarm and/or shut down because of a lack of power to any number of indoor units shall not be acceptable or allowed.
    c. Main microprocessor shall include human interface capability that provides a visual code that reports systems operation status. If any malfunction occurs, or system is operating with an unstable refrigerant cycle sensors shall report the malfunction to the visual display.
    d. Main processor shall provide the commissioning agent the ability to customize the VRF systems operation based on the environment in which it is installed. Customization function to include defrost operation, modifying target superheat, sub-cooling, low pressure and high pressure values , and invoke other algorithms such as smart load control to optimize system operating efficiency. The main processor board shall include the following features:
        i. Service tool connection
        ii. DIP switches
        iii. Auto addressing
        iv. Error codes
        v. Main microprocessor
        vi. Inverter PCB
10. Outdoor unit microprocessor shall have the capability of reporting malfunction and diagnostic codes to remote control devices such as the VRF manufacturer's central controller, Zone controllers, and Building Management System (BMS).
11. Refrigerant Flow Control
    a. The refrigerant cycle operation core logic shall establish and maintain target evaporating temperature (Te) to be constant in cooling mode and condensing temperature (Tc) constant in heating mode and maintain system stable operation while operating compressors across the range of environmental conditions guaranteeing continuous compressor operation. VRF system core logic shall be able to dynamically modify the target evaporator and condenser temperatures to maximize energy savings when system is operating at part load conditions.
    b. Smart Load Control (SLC): Smart load control operation shall enhance energy savings and increase indoor comfort by monitoring the real time ambient temperature, real time weighted mean average building load, and the outdoor relativity humidity (if enabled).
        i. Smart load control shall be field selectable to optimize system operation for project location and building use. Smart Load Control field setting shall select one of three operating algorithms. The commissioning agent shall select at the time of commissioning and can be changed at any other time:

ii. The Smart Load Control available settings shall:
  a) The system shall be influenced by any one of the chosen algorithm
  b) Off mode: Smart load control algorithm shall be in off mode
  c) Smooth mode: Smart Load control shall maximize energy savings. The rate of temperature change shall be insignificant.
  d) Normal Mode: Smart Load Control shall balance the rate of temperature change with energy consumed.
  e) Peak Mode: Smart Load shall quickly cool/heat the building. The energy consumption shall not be the priority in this mode.

iii. For the first 20 minutes after the initial startup, the Smart Load Control will influence the outdoor unit operation for the chosen algorithm. This operation will be available at every start up.

iv. After 20 minutes of compressor operation
  a) Smart Load control will maintain the chosen logic and system will operate with the same core logic.

v. Smart Load Control monitors two or three inputs:
  a) Weighted mean average building load
  f) Outdoor ambient dry bulb temperature
  g) Outdoor ambient relative humidity or indoor relative humidity (when enabled)

c. Enhance energy savings
  i. Cooling Mode:
    a) Smart Load Control raises the system target low pressure during off-peak operation.
    b) Raising the operating low pressure shall reduce the compressor lift, reduce compressor's speed and power consumption.
  ii. Heating Mode
    a) Smart Load control shall lower the system target high pressure during off-peak heating operation.
    b) Lowering the operating high pressure target shall reduce compressor lift, reduce compressor speed and power consumption.
    c) Energy saved is in addition to the energy savings basic VRF load control provides.

d. Increased indoor comfort
  i. Smart Load control shall use one (or two) sensors to measure changing outdoor weather conditions and shall prepare the VRF system to operate under the revised weather conditions. This operation shall be activated before the changed ambient conditions have an impact on indoor units.

E. Field Supplied Refrigerant Piping Design Parameters
1. The outdoor unit shall be capable of operating at an elevation difference of up to of 164 feet above or 131 feet below the lowest or highest indoor unit respectively without the requirement of field installed sub cooler or other forms of performance enhancing booster devices.
2. The outdoor unit shall be capable of operating with up to 984 equivalent length feet of interconnecting liquid line refrigerant pipe in the network.
3. The outdoor unit shall be capable of operating with up to 492 actual feet or 574 equivalent length feet of liquid line refrigerant pipe spanning between outdoor unit and farthest indoor unit.
4. The elevation difference between the highest and lowest indoor units shall not exceed 49

feet.

5. The piping system shall be designed with pipe expansion and contraction possibilities in mind. Required expansion devices shall be field designed, supplied and installed based on proper evaluation of the proposed piping design. In addition to these requirements, the piping system installation must conform to the VRF equipment manufacturer's published guidelines.
6. The installation of pipe hangers, supports, insulation, and in general the methods chosen to attach the pipe system to the structure must allow for expansion and contraction of the piping system and shall not interfere with that movement.

F. Defrost Operations
   1. Heat Pump
      a. The outdoor unit(s) shall be capable of auto defrost operation to melt accumulated frost off the outdoor unit heat exchanger. The defrost cycle control shall monitor the outdoor ambient temperature and outdoor unit heat exchanger surface temperature.
      b. The frequency of operating the defrost cycle shall be determined by the system's ability to maintain sufficient system head pressure to deliver comfortable warm air to the building.
   2. Heat Recovery
      a. The outdoor unit(s) shall be capable of intelligent defrost operation to melt accumulated frost off the outdoor unit heat exchanger. The defrost cycle control shall monitor the outdoor ambient temperature, humidity (if enabled), building load, and outdoor unit heat exchanger surface temperature in real time.
      b. The frequency of operating the defrost cycle shall be determined by the system's ability to maintain sufficient system head pressure to deliver comfortable warm air to the building.
      c. The intelligent defrost algorithm shall be field selectable at the time of commissioning of the outdoor unit based on anticipated winter weather conditions. Intelligent defrost continuously calculates the dew point of the ambient air using the outdoor unit's temperature and humidity sensors (if enabled) and maintains the outdoor unit's coil surface temperature above the dew point delaying defrost operation while maintaining indoor space temperature.
      d. The intelligent defrost algorithm shall provide smart heating that will extend the system's heating operation and reduce the frequency of defrost cycles.

G. Oil Management
   1. The system shall have an oil injection mechanism to ensure a consistent film of oil on all moving compressor parts.
   2. The system shall be provided with a factory installed oil separator at the discharge port of the compressor and designed to separate, condense, and collect oil vapor from the discharge refrigerant gas and return oil to the sump of the compressor. The oil separator shall have no moving parts in the separation chamber.
   3. The system oil return control algorithm shall operate every 8 hours at a minimum, for a 3-minute period. When activated, the algorithm shall operate the system with the reversing valve in the cooling position, open all electronic expansion valves at the indoor unit(s) and raise the compressor speed to flush oil back to the compressor.

H. Fan and Motor Assembly
   1. Heat Pump shall be equipped with two direct drive variable speed axial flow fan(s) with a horizontal air discharge. Each fan shall be provided with an independent dedicated Brushless Digitally Controlled (BLDC), variable speed, inverter driven motors

2. The fan(s) blades shall be made of Acrylonitrile Butadiene Styrene (ABS) material.
3. The fan motor(s) shall be equipped with permanently lubricated bearings.
4. The fan assembly(s) shall have a minimum operating speed range from 0 RPM to 850 RPM in cooling mode and heating mode.
5. The fan(s) shall have a polymer fan guard(s) to help prevent contact with moving parts.
6. The fan control shall have a function setting to remove accumulated powder snow from outdoor fan blades and discharge fan guard

I. Cabinet
1. The cabinet shall have piping knockouts to allow refrigerant piping to be connected at the front, right side, or through the bottom of the unit.
2. The cabinet shall have a factory installed coil guard and shall have a baked enamel finish.
3. A removable service panel, shall be provided to access the following internal components:
   a. Service tool connection
   b. DIP switches
   c. Main microprocessor
   d. Inverter PCB
   e. Outdoor unit coil EEV valve
   f. Subcooling heat exchanger and EEV valve.
   g. Reversing valve.

J. Outdoor Unit Coil
1. Outdoor unit coil shall be comprised of aluminum fins mechanically bonded to copper tubing with inner surfaces having a riffling treatment to expand the total surface of the tube interior
4. The aluminum fin heat transfer surfaces shall have factory applied corrosion resistant GoldFin™ coating. The coils coating shall be tested per ASTM B-117 standard. The test shall be performed for a minimum of 1000 hours. The outdoor unit coil shall have a minimum of 2 rows.
5. The outdoor unit coil shall have a minimum of 14 Fins per Inch (FPI).
6. The outdoor unit coil, all indoor units and the interconnecting field provided pipe network shall be field tested to a minimum pressure of 550 psig. Manufacturers that do not specify and/or specify field testing pressures at less than 550 psig shall not be acceptable.

K. Compressor
1. Heat Pump models<ARUN024GSS4 ~ ARUN053GSS4>:
   a. The compressor shall be a high efficiency high-side shell rotary hermetic design. Bearing shall be manufactured using high lubricity material. Compressor shall be factory charged with Polyvinyl Ether (PVE) oil. Single or dual speed compressors charged with Polyolester oil (POE) shall not be acceptable. Compressor inverter drive shall allow modulation from 20Hz to 90Hz with control in 1.0 Hz increments depending on the nominal capacity. <ARUN060GSS4> The compressor shall be a high-side shell hermetic scroll design. Oil sump area and chamber housing the motor shall be operated at the same temperature and pressure of the gas leaving the compressor chamber to ensure that the low temperature low pressure refrigerant returning to the compressor does not mix with the oil in the sump. Bearing shall be manufactured using high lubricity material. Compressor shall be factory charged with Polyvinyl Ether (PVE) oil. Single or dual speed compressors charged with Polyolester oil (POE) oil shall not be acceptable. Compressor motor shall be designed to operate at a frequency range of 0Hz to 160Hz. Compressor inverter drive shall allow modulation from 12Hz to 110Hz.

L. Operational Sound Levels
1. The compressor(s) shall be wrapped with heat resistant foil faced, sound deadening blanket that covers all exposed surfaces of the compressor. Sound deadening blankets shall be secured in place by use of a Velcro™ tool-less joint sealing system with a minimum of ½" of overlap along all seams. The sound deadening compressor blanket shall be engineered to leave no direct sound path between the outer surface of the body of the compressor and the surrounding environment.
2. The compressor(s) shall be mounted on rubber isolation grommets. Compressor shall ship with removable clamps that secure the compressor in place while transported. The installing contractor shall remove and discard (or optionally adjust the clamps to allow the isolator to properly function) the clamps prior to commissioning the water source unit.
3. Manufacturers' published data shall include sound pressure and sound power levels.
   a. Sound pressure level shall not exceed 57 dB(A) during cooling operation for Heat Pump and Heat Recovery outdoor units when tested in an anechoic chamber under ISO3745 standard. Other testing conditions shall not be allowed.
   b. Sound power level shall not exceed 69 dB(A) when tested in an anechoic chamber under ISO3745 standard. Other testing conditions shall not be allowed.

M. Sensors
1. The outdoor unit shall have
   c. Suction temperature sensor
   d. Discharge temperature sensor
   e. High Pressure sensor
   f. Low Pressure sensor
   g. Outdoor temperature sensor
   h. Outdoor unit heat exchanger temperature sensors

N. Wind Load Installations for Outdoor Units
1. LG FL Wind load Installation Drawings meet the requirements of the 2017 Florida Building Code, 6th Edition and ASCE Standard 7-2010

P. Indoor Units (All)
1. General
   a. Indoor units shall be made by the same manufacturer as the outdoor unit. The indoor unit shall be factory assembled, wired, piped, and provided with an internal electronic expansion device, control circuit board, fan and motor. The indoor unit electrical power shall be 208/230V, 1-phase, 60 Hz. The unit shall be capable of satisfactory operation within voltage limits of +/-10%.
   b. Indoor unit refrigeration circuit shall be pressure tested at the factory and shipped with a holding charge of dry nitrogen gas.
   c. All internal refrigerant lines are factory insulated. All refrigerant lines external to the indoor unit case shall be field insulated. The entire unit shall be run tested at the factory.
   d. The unit shall be provided with a factory installed non-metallic condensate drain pan. An insulated flexible condensate drain hose shall be provided to connect the unit drain pan to the field provided condensate drain system.
2. Indoor Unit Coil
   a. Indoor unit coils shall be a minimum of two rows and manufactured using non-ferrous materials. Tubes shall be copper with inner grooves. Fin material shall be aluminum with a stamped louvered configuration. Coils shall be factory pressure tested to 600 psig air pressure.

b. The unit shall be provided with 45º flare refrigerant pipe connections.

3. Ceiling Concealed Ducted Models
   a. Ducted High Static
      i. Casing
         1.) The case shall be designed to mount concealed inside a ceiling cavity. Discharge shall be front horizontal with a dedicated rear horizontal return. The unit shall be manufactured using heavy-gauge galvanized steel. The cold surface areas of the case shall be covered with sheet insulation made of high density ethylene propylene diene M-class rubber (EPDM) manufactured per ASTM standard D-1418. The case shall be provided with metal hangers designed to support the unit weight on four corners. Hangers shall have pre-punched holes designed to accept field supplied all thread rod hangers.
         2.) The casing shall be designed to provide front side discharge and rear side return
      ii. Fan Assembly/Fan Controls
         1.) The indoor unit shall be equipped with two sirocco fan wheels made of high strength ABS GP-2200 polymer resin. Both fans wheels shall be directly driven and mounted on a common shaft. The fan assembly shall be statically and dynamically balanced across the entire operating speed range.
         2.) The fan motor shall be high efficiency, brushless, digitally controlled (DC), having permanently lubricated ball bearings tested for a minimum life cycle of 30,000 hours designed and made by the unit manufacturer.
         3.) The fan assembly speed shall be adjustable from zero to full speed using a microprocessor based direct digital control algorithm that provides a minimum of three pre-programmed fan speeds.
      iii. Air Filter
         1.) Return air shall be filtered with a removable, washable filter designed to capture airborne dust particles. Filter media shall be treated with an anti-fungal agent to restrict the growth of bacteria on the media.
      iv. Microprocessor Controls
         1.) Unit shall be provided with a microprocessor based controller made by the unit manufacturer designed to perform all functions necessary to operate the system and shall interface with the outdoor unit and other indoor connected devices via a RS485 daisy chain communications link.
         2.) The microprocessor control algorithms shall provide self-diagnostics, auto restart following power restoration, and test run functions.
         3.) The microprocessor control algorithm shall provide five operation modes: Auto Operation, Heating, Cooling, Dehumidification, and Fan Only. Auto Operation mode shall automatically switch between cooling, dehumidification, and heating based on room temperature conditions.
         4.) In the heating mode, the microprocessor control shall not begin fan operation until the coil has reached 78ºF.

5.) The microprocessor control shall provide a method for the service technician to adjust the delivered air volume at each preset fan speed to compensate for restrictions to airflow (ESP).

6.) The unit shall be equipped with a room temperature thermistor mounted in the return air stream. Wall mounted and hand-held local controllers shall be equipped with a temperature thermistor. In addition, the unit shall be designed to work with an optional auxiliary wall mounted remote temperature sensor. The unit shall be capable of controlling operations using any of the three sensors individually or any two of the three concurrently.

7.) A single indoor unit shall have the capability of being controlled by up to two local wired controllers.

8.) The microprocessor control shall provide malfunction diagnostic codes at the local controller upon unit malfunction. Displayed diagnostic codes shall be specific and provide the service technician with the source of the malfunction.

v. Condensate Lift/Pump

1.) The indoor unit shall be provided with a factory installed and wired condensate lift pump capable of providing a minimum 27-1/2" lift from the bottom exterior surface of the unit casing.

2.) The unit drain pan shall have an auxiliary drain pan connection provided with a rubber stopper that when removed allows the pan to be drained for service via gravity.

PART 3 - EXECUTION

3.01 FIELD SUPPLIED ITEMS

A. Field Provided Refrigerant Piping
1. All refrigerant lines from the outdoor unit to the heat recovery unit and from the heat recovery unit to the indoor units shall be field insulated.
2. All refrigerant piping runs shall not exceed the specifications set forth by LG for each model. All field provided piping shall be installed in accordance with the restrictions and guidelines provided by the manufacturer.

B. Field Provided Isolation valves
1. Provide field supplied full port isolation ball valves (optionally) on the inlet and the outlet piping connections.

C. Field Provided Refrigerant Piping Insulation
1. All refrigerant piping, liquid and suction lines, including ball valves, Y-Branches, headers and other refrigerant fittings external to the indoor or outdoor unit case(s) shall be field insulated.

D. Field Provided Power Wiring
1. Field provided power wiring and components shall be sized in accordance with the unit manufacturer's recommendations, NEC code, local code - whichever is most restrictive. Indoor unit power may be sourced from terminals provided by the manufacturer in the outdoor unit, or optionally, from a separate electrical panel.

E. Field Provided Control Wiring
   1. Field provided control wiring shall be sized in accordance with the unit manufacturer's recommendations, NEC code, or local code - whichever is most restrictive. Control wiring shall be 24-volt RS485 two conductor stranded shielded twisted pair wire routed in a daisy chain configuration between the outdoor unit(s), heat recovery units, indoor units, and central control devices. No star or home run configurations allowed.

3.02 INSTALLATION

A. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure Outdoor Units to structural support with anchor bolts.

3.03 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. Perform tests and inspections and prepare test reports.
   2. Tests and Inspections:
   3. After installing VRF Units and after electrical circuitry has been energized, test units for compliance with requirements.
   4. Inspect for and remove shipping bolts, blocks, and tie-down straps.
   5. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
   7. Remove and replace malfunctioning units and retest as specified above.

3.04 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:

C. Inspect for visible damage to VRF Units' casing.

D. Inspect for visible damage to compressor, coils, and fans.

E. Inspect internal insulation.

F. Verify that labels are clearly visible.

G. Verify that clearances have been provided for servicing.

H. Verify that controls are connected and operable.

I. Verify that filters are installed.

J. Clean condenser coil and inspect for construction debris.

K. Start refrigeration system.

L. Complete startup sheets and attach copy with Contractor's startup report.

M. Operate unit for an initial period as recommended or required by manufacturer.

N. Low-temperature safety operation.

3.05 DEMONSTRATION

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

B. Commission system in accordance with project commissioning requirements.

END OF SECTION 237419

SECTION 238233
CONVECTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes hydronic convectors:

1. Hydronic Finned-Tube Radiators

2. Flat-Pipe Steel Radiators (Radiant Heat Panels)

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Include rated capacities, operating characteristics, furnished specialties, and accessories.

C. Shop Drawings:

1. Include plans, elevations, sections, and 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 details and dimensions of custom-fabricated enclosures.

4. Indicate location and size of each field connection.

5. Indicate location and arrangement of piping valves and specialties.

6. Indicate location and arrangement of integral controls.

7. Include enclosure joints, corner pieces, access doors, and other accessories.

D. Samples: For each exposed product and for each color and texture specified.

1. Color Samples for Initial Selection: For units with factory-applied color finishes.

2. Color Samples for Verification: For each type of exposed finish.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor 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. Structural members, including wall construction, to which convectors will be attached.

2. Method of attaching convectors to building structure.

3. Penetrations of fire-rated wall and floor assemblies.

PART 2 - PRODUCTS

2.1 HOT-WATER FINNED-TUBE RADIATORS

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

1. Rittling
2. Slant/Fin Corporation.
3. Sterling
4. or equal

B. Performance Ratings: Rate finned-tube radiators according to Hydronics Institute's "I=B=R Testing and Rating Standards for Finned-Tube (Commercial) Radiation."

C. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on element supports. One tube end shall be belled.

D. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.

E. Front Panel: Minimum 0.0528 inch thick steel.

F. Wall-Mounted Back Panels: Minimum 0.0428-inch-thick steel, full height, with full-length channel support for front panel without exposed fasteners.

G. Floor-Mounted Pedestals: Conceal conduit for power and control wiring at maximum 36-inchspacing. Pedestal-mounted back panel shall be solid panel matching front panel.

H. Support Brackets: Locate at maximum 36-inch spacing to support front panel and element.

I. Finish: Baked-enamel finish in manufacturer's custom color as selected by Architect.

J. Damper: Knob-operated internal damper at enclosure outlet.

K. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size 6 by
7 inches integral with enclosure.

L. Enclosure Style: Sloped top.

M. Top Outlet Grille: Punched louver; painted to match enclosure.

2.2 FLAT-PIPE STEEL RADIATORS (RADIANT HEAT PANELS)

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

1. Embassy Industries, Inc.
2. Panel Radiator, Inc.
3. Sterling
4. Runtal

5. or equal

B. Heating Elements: Steel, welded and formed into flat, square, steel header with minimum thickness of 0.109 inches. Include threaded piping and air vent connections.

C. Working pressure: 128-psig

D. Mounting: Wall brackets on maximum spacing of 36 inches.

E. Finish: Baked-enamel finish in manufacturer's custom color as selected by Architect.

F. Accessories:

1. Steel piping covers, finished to match radiator finish.

2. Panel covers, finished to match radiator finish.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive convectors for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for hydronic-piping connections to verify actual locations before installation of convector.

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

3.2 FINNED-TUBE RADIATION INSTALLATION

A. Install units level and plumb.

B. Install enclosure continuously around corners, using outside and inside corner fittings.

C. Join sections with splice plates and filler pieces to provide continuous enclosure.

D. Install access doors for access to valves.

E. Install enclosure continuous from wall to wall.

F. Terminate enclosures with manufacturer's end caps, except where enclosures are indicated to extend to adjoining walls.

G. Install valves within reach of access door provided in enclosure.

H. Install air-seal gasket between wall and recessed flanges or front cover of fully recessed unit.

I. Install piping within pedestals for freestanding units.

3.3 FLAT-PIPE STEEL RADIATOR INSTALLATION:

A. Install units level and plumb.

B. Install piping covers.

C. Install panel covers.

3.4 CONNECTIONS

A. Piping installation requirements are specified in Section 23 21 13 "Hydronic Piping and Accessories." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect hot-water convectors and components to piping according to Section 23 21 13 "Hydronic Piping and Accessories."

C. Install shutoff valves on inlet and outlet, and balancing valve on outlet.

D. Install control valves as required by Section 23 09 00 "Instrumentation and Control for HVAC."

E. Install piping adjacent to convectors to allow service and maintenance.

3.5 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections:

B. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Convectors will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION

SECTION 238239
CABINET AND 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 heaters.
   2. Unit heaters.

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. 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.

C. Plans, elevations, sections, and details.

D. Location and size of each field connection.

E. Details of anchorages and attachments to structure and to supported equipment.

F. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.

G. Location and arrangement of piping valves and specialties.

H. Location and arrangement of integral controls.

I. Wiring Diagrams: Power, signal, and control wiring.

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.
      f. Perimeter moldings for exposed or partially exposed cabinets.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For cabinet unit heaters 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. 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 HEATERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Carrier Corporation.
   2. Dunham-Bush, Inc.
   3. McQuay International.
   4. Trane.
   5. or equal

B. Description: A factory-assembled and -tested unit complying with ARI 440.

C. 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.

D. Thickness: 3/8 inch.

E. Thermal Conductivity (k-Value): 0.24 Btu x in./h x sq. ft. at 75 deg F mean temperature.

F. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.

G. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

H. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

I. Cabinet: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect.

J. Vertical Unit, Exposed Front Panels: Minimum 0.0677-inch-thick, galvanized, sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.

K. Recessing Flanges: Steel, finished to match cabinet.

L. Control Access Door: Key operated.

M. Extended Piping Compartment: 8-inch-wide piping end pocket.

N. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.

O. Pleated: 90 percent arrestance and 7 MERV.

P. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-

water temperature of 220 deg F. Include manual air vent and drain. Shall be compatible with 40% Propylene Glycol.

Q. Fan and Motor Board: Removable.

R. 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.

S. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."

T. Wiring Terminations: Connect motor to chassis wiring with plug connection.

U. Control devices are specified in Section 23 09 00 "Instrumentation and Control for HVAC."

V. Electrical Connection: Factory wire motors and controls for a single field connection.

2.2 UNIT HEATERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Airtherm; a Mestek Company.
2. Engineered Air Ltd.
3. McQuay International.
4. Trane.
5. or equal

B. Description: An assembly including casing, coil, fan, and motor in vertical discharge configuration with adjustable discharge louvers.

C. Cabinet: Removable panels for maintenance access to controls.

D. Cabinet Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heater before shipping.

E. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

F. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

G. General Coil Requirements: Test and rate hot-water propeller unit heater coils according to ASHRAE 33.

H. Hot-Water Coil: Copper tube, minimum 0.025-inchwall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 325 deg F, with manual air vent. Test for leaks to 350 psig underwater. Shall be compatible with 40% Propylene Glycol.

I. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.

J. Fan Motors: Comply with requirements in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."

K. Motor Type: Permanently lubricated, multispeed.

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 propeller unit heaters from structure with all-thread hanger rods and elastomeric hangers. Hanger rods and attachments to structure are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

E. 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.

F. 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 Accessories." 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 and Accessories."

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

B. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

C. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

D. 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 Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters. Refer to Section 017900 "Demonstration and Training."

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SECTION 238316

IN-FLOOR RADIANT HEATING HYDRONIC SYSTEM

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Radiant floor heating systems for various applications and control strategies, using cross-linked polyethylene (PEX) tubing and appropriate fittings.

1.02 REFERENCES

A. General: Standards listed by reference, including revisions by issuing authority, form a part of this specification section to the extent indicated. Standards listed are identified by issuing authority, authority abbreviation, designation number, title or other designation established by issuing authority. Standards subsequently referenced herein are referred to by issuing authority abbreviation and standard designation.

B. Certified to ASTM International by NSF:
1. ASTM F876 Standard Specification for Cross-linked Polyethylene (PEX) Tubing.
2. ASTM F877 Standard Specification for Cross-linked Polyethylene (PEX) Plastic Hot-and Cold-Water Distribution Systems.

C. Certified to ASTM International, UL, NFPA and ULC by Intertek:
1. ASTM E84, Standard Test Method for Surface Burning Characteristics of Test Materials.
2. ASTM E119, UL 263 and NFPA 251 Fire Tests of Building Construction and Materials.
3. CAN/ULC S101-04, Standard Test Methods for Fire Tests of Building Construction and Materials.

D. Certified to Canadian Standards Association (CSA) by NSF:
1. CAN/CSA B137.5 Cross-linked Polyethylene (PEX) Tubing Systems for Pressure Applications.

E. Certified to International Code Council (ICC) by NSF:
1. International Mechanical Code (IMC)
2. International Building Code (IBC)

F. Certified to International Association of Plumbing and Mechanical Officials (IAPMO) by NSF:
1. Uniform Mechanical Code (UMC)

G. International Association of Plumbing and Mechanical Officials (IAPMO):
1. Certificate of Listing

H. National Sanitary Foundation (NSF) International:
1. NSF – PW (Potable Water)
2. NSF – RFH (Radiant Floor Heating)
3. NSF CL – TD and CL – R (as specified in NSF Protocol P – 171)

I. Plastics Pipe Institute (PPI)
1. Technical Report TR – 3 Policies and Procedures for Developing Recommended Hydrostatic Design Stresses for Thermoplastic Pipe Materials

2. Technical Report TR – 4 Recommended Hydrostatic Strengths and Design Stresses for Thermoplastic Piping and Fitting Compounds

1.03 SYSTEM DESCRIPTION

A. Design Requirements:
1. Cross-linked Polyethylene Tubing (PEX): Standard Grade hydrostatic pressure ratings from Plastics Pipe Institute in accordance with TR-3 as listed in TR-4. The following three standard-grade hydrostatic ratings are required:
a. 200 degrees F at 80 psi.
b. 180 degrees F at 100 psi.
c. 73.4 degrees F at 160 psi.

B. Performance requirements: Provide Hydronic system that is manufactured, fabricated and installed to comply with regulatory agencies and authorities with jurisdiction, and maintain performance criteria stated by the tubing manufacturer without defects, damage, or failure.
1. Cross-linked Polyethylene Tubing (PEX):
a. Show compliance with ASTM F877
b. Show compliance with DIN 4726 regarding oxygen diffusion concerns where applicable.
c. Show compliance with NFPA 90A requirements of flame spread/smoke development rating of 25/50 in accordance with ASTM E84 through certification listings with Intertek.
d. Show compliance with ASTM E119, UL 263, NFPA 251, and CAN/ULC S101 through certification listings with Intertek:
i. Intertek Design No. WR/WA 60-01: 1 hour wood or steel stud/gypsum wallboard wall assembly.
ii. Intertek Design No. WR/FCA 60-01: 1 hour wood frame floor/ceiling assembly
iii. Intertek Design No. WR/FCA 120-01: 2 hour concrete floor/ceiling assembly

1.04 SUBMITTALS

A. General: Submit listed submittals in accordance with Conditions of the Contract and Division 01 Submittal Procedures Section.

B. Product Data: Submit manufacturer's product submittal data and installation instructions for each product.

C. Shop Drawings – Hydronic System
1. Provide engineering analysis using manufacturer's proprietary software.
2. Provide installation drawings indicating tubing layout, manifold locations, zoning requirements, and manifold schedules with details required for installation of the system.
3. Provide mechanical schematic indicating heat source, mechanical piping and accessories from heat source to manifolds, circulators, water tempering, and zone controls. Indicate supply water temperatures and flow rates to manifolds.

D. Samples: Submit selection and verification samples of primary materials.

E. Documentation:
1. Provide manufacturer's detailed instructions for site preparation and product installation.
2. Provide manufacturer's electrical power requirements and heat output in watts delivered to the structure.

3. Provide documentation indicating the installer is trained to install the manufacturer's products, as needed.

F. Quality Assurance and Control Submittals:
   1. Upon request, submit test reports from recognized testing laboratories.

G. Closeout Submittals – Submit the following:
   1. Warranty documents specified
   2. Operation and maintenance data
   3. Manufacturer's field reports as specified in this document
   4. Final as-built tubing layout drawing

1.05 QUALITY ASSURANCE

A. Manufacturer Qualifications:
   1. Manufacturer shall have a minimum of ten year's experience in similar systems.
   2. Manufacturer shall provide products of consistent quality in appearance and physical properties.
   3. Manufacturer shall use the highest quality products in the production of systems and components referenced in this document.
   4. Materials shall be from a single manufacturer to ensure consistent quality and compatibility.

B. Installer Qualifications:
   1. Use and installer with demonstrated experience on projects of similar size and complexity and/or documentation proving successful completion of familiarization training hosted/approved in writing by the system manufacturer.
   2. Electrical rough-in and connections shall be done by a licensed electrician.

C. Certifications: Provide letters of certification as follows:
   1. Installer employs skilled workers holding a trade qualification license or equivalent, or apprentices under the supervision of a licensed trades person.

D. Pre-installation meetings
   1. Verify project requirements, substrate conditions, excavation conditions, system performance requirements, coverings, manufacturer's installation instructions, and warranty requirements.
   2. Review project construction timeline to ensure compliance or discuss modifications as required.
   3. Coordinate with other trade representatives to verify areas of responsibility.
   4. Establish the frequency (during construction phase of the project) the engineer intends for site visits and inspections by the manufacturer's representative.

E. Mock-up: Provide a mock-up for evaluation of surface preparation techniques and application workmanship.
   1. Finish areas designated by Architect
   2. Do not proceed with remaining work until workmanship, color, and sheen are approved by Architect.
   3. Refinish mock-up area to produce acceptable work

1.06 DELIVERY, STORAGE, AND HANDLING

A. General: Comply with Division 01 Product Requirements Section.

B. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.

C. Deliver materials in manufacturer's original, unopened, undamaged containers with identification labels intact.

D. Store materials protected from exposure to harmful environmental conditions and at temperature and humidity conditions recommended by the manufacturer:
   1. Store tubing in cartons or under cover to avoid dirt or foreign material from entering the tubing.
   2. Do not expose tubing to direct sunlight for more than 30 days. If construction delays are encountered, cover the tubing that is exposed to direct sunlight.

1.07 PROJECT CONDITIONS

A. Maintain environmental conditions (temperature, humidity, and ventilation) within limits recommended by manufacturer for optimum results. Do not install products under environmental conditions outside manufacturer's absolute limits.

B. Morter-set Systems: Mortar shall cure for 25 days (or time specified by mortar manufacturer) prior to starting heating systems.

1.08 WARRANTY

A. Project Warranty: Refer to Conditions of the Contract for project warranty provisions.

B. Manufacturer's Warranty – Hydronic Systems
   1. Submit, for Owner's acceptance, manufacturer's standard warranty document executed by authorized company official.
   2. Manufacturer's warranty is in addition to, and not a limitation of, other rights Owner may have under contract documents.
      a. Warranty covers the repair or replacement of any tubing or fittings proven defective.
      b. Warranty may transfer to subsequent owners.
      c. Warranty Period for Tubing is 25-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of substantial completion.
      d. Warranty Period for Manifolds and Fittings is 2-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of substantial completion.
      e. Warranty period for Controls and Electrical components is a 2-year, non-prorated warranty against failure due to defect in material or workmanship, beginning with date of substantial completion.

1.09 SYSTEM START-UP

A. Do not start the system for a minimum of 25 days or as specified by mortar, concrete and/or covering manufacturer as applicable.

B. Verify all electrical components are installed per local and National Electrical Code (NEC) prior to start-up.

1.10 OWNER'S INSTRUCTIONS

A. Instruct Owner about operation and maintenance of installed system.

B. Provide Owner with manufacturer's installation instructions for installed components within the system.

C. Provide Owner with all operating instructions/documents for sensors and controls.

D. Provide Owner with copies of any detailed layout drawings and photos of installed product before coverings are installed.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Watts Radiant, inc.
2. Uponor,
3. Viega
4. or equal

2.02 PRODUCT CHARACTERISTICS

A. Material:
1. Cross-linked polyethylene (PEX) with the highest level of oxidation protection.

B. Material Standard:
1. Manufactured in accordance with ASTM F876 and ASTM F877
2. Tested for compliance by an independent third-party agency.

C. Pressure Ratings:
1. Standard Grade hydrostatic design
2. Pressure ratings as issued by the Plastics Pipe Institute (PPI), a division of the Society of the Plastics Industry (SPI).

D. Temperature/Pressure Ratings: shall be capable of withstanding temperatures of:
1. 73.4°F at 160 psi.
2. 180°F at 100 psi.
3. 200°F at 80 psi.

E. Minimum Bend Radius (Cold Bending):
1. No less than six times the outside diameter.
2. Use the tubing manufacturer's bend supports if radius is less than stated.

F. Barrier Tubing Type: Watts Radiant RadiantPEX+ (or equal):
1. Oxygen Diffusion Barrier

a. Tubing has an oxygen diffusion barrier that shall not exceed an oxygen diffusion rate of 0.000062 lb/cu. ft. per day at 104 degrees F water temperature in accordance with German DIN 4726.
b. Tubing also adds a protective polypropylene layer to the outside of the EVOH barrier.

2.03 MANIFOLDS AND FITTINGS

A. Manifolds – Stainless Steel
1. For system compatibility, use 1½" Stainless Steel manifolds offered by the respective tubing manufacturer.
2. Manifolds shall provide individual flow control for each loop of the manifold through valve actuators available from the manifold supplier.
3. Manifolds shall feature manual flow balancing capability within the manifold body for balancing unequal loop lengths across the manifold. Balance valves shall not be ball valves.
4. Manifolds accommodate ⅜ - ¾" RadiantPEX+ tubing (or equal).
5. Each manifold location shall have the ability to vent air manually from the system.
6. Stainless Steel 1½" Manifolds
   a. Heavy-duty, DIN Standard, 304 stainless steel
   b. Matching fittings and accessories are made of solid brass and are heavily plated with nickel to match the appearance of the manifold trunk.
   c. Internal balancing valves
   d. 0 - 4 gpm flow meters
   e. Manifold brackets
   f. All connections are BSP (British Standard Pipe) or straight thread and require the use of the included gasket.
   g. 2⅛" OC circuit spacing
   h. 22 gpm maximum flow rate
   i. 194°F maximum operating temperature
   j. 87 psi maximum operating pressure
   k. 4 gpm per circuit maximum flow rate

B. Manifold Mounting Boxes
1. Each box shall be designed to be installed recessed into a 4" or 6" stud wall, or installed surface mounted.
2. Included elevators can raise the box from 1½" to 4½" off of the floor.
3. Each manifold box shall be constructed of powder-coated sheet metal.
4. Inside Manifold Mounting Brackets:
   a. Manifold boxes shall be equipped with 2 fixed horizontal attachment rails and 2 adjustable rails.
   b. Each manifold option shall utilize different rail positions, depending on the bracket used.

C. Fittings
1. For system compatibility, use fittings offered by the tubing manufacturer.
   a. The fitting assembly shall comply with ASTM F877 and CAN/CSA B137.5 requirements.
   b. Fittings shall be designed to work with either ASTM F1807 CrimpRings or ASTM F2098 CinchClamps or a Compression ferrule, and are designed to be used with ASTM F876 (SDR-9) rated PEX tubing.

c. Available connections:
   i. Sweat
   ii. NPT
   iii. BSP
d. Material:
   i. UNS 31400 Copper Alloy
   ii. UNS 36000 Copper Alloy
   iii. UNS 37700 Copper Alloy

2.04 ACCESSORIES

A. Provide accessories associated with the installation of the radiant heating system as recommended by or available from the tubing manufacturer.
   1. IsoTherm: The IsoTherm shall provide mixing control and zone pumping all in a compact, unique package that conveniently connects directly to manifolds.
      a. The IsoTherm module includes the following items:
         i. Mix Valve
         ii. 3 speed 1/25 hp Circulator
         iii. Temperature Gauge
         iv. Maximum Temperature Sensor
         v. Trunk Isolation Valves
         vi. BSP to NPT Transition Nipple
      b. Mounting:
         i. The IsoTherm shall be wall mounted with standard cush clamps or other copper pipe mounted brackets.
         ii. The IsoTherm shall be integrated into a standard manifold box.
      c. Capacity:
         i. Full heat capacity of 51,000 BTU/h with a minimum boiler temperature of 158°F.
   2. FlowGuard:
      a. FlowGuards shall be of commercial-quality, non-electronic flow indicator and flow setter.
      b. Cast brass construction
      c. Accurate visual flow indication in GPM
      d. Ability to set fluid flow
      e. FlowGuards shall allow zone-by-zone control and optimization.
      f. No special training or electronic instrumentation required,
      g. Sizes:
         i. 1” MNPT ends: 0.5 – 4 gpm flow meter
         ii. 1” FNPT ends: 1 – 13 gpm flow meter

PART 3 - EXECUTION

3.01 EXAMINATION

A. Site Verification of Conditions:
   1. Verify that site conditions are acceptable for installation of the system. Refer to manufacturer’s installation manual for information.
   2. Do not proceed with installation of the system until unacceptable conditions are corrected.

3.02 INSTALLATION OF FLOOR HEATING SYSTEMS

A. Comply with manufacturer's product data, including product technical bulletins, installation instructions and design drawings, including the following:
   1. Installation manuals
   2. Design software engineering and analysis

B. Slab-On-Grade Installation:
   1. Fasten the tubing to the flat mesh or reinforcing bar in accordance with the tubing manufacturer's installation recommendations.
   2. Use closer tubing on-center distances along exterior walls. Increase tubing on-center distances as the installation moves away from the exterior wall as determined by manufacturer analysis.
   3. Staple the tubing to the insulation board.
   4. Install edge insulation where the heated panel directly contacts an exterior wall or panel.
   5. Install tubing at a consistent depth below the surface elevation. Ensure sufficient clearance to avoid control joint saw cutting.
   6. Where tubing crosses metal expansion joints in the concrete, ensure the tubing passes below the joints or is sleeved through the joint.

3.03 FIELD QUALITY CONTROL AND TESTING

A. Site tests:
   1. To ensure system integrity, pressure test the system before covering tubing in concrete or when other trades are working in the vicinity of the tubing.
   2. Test all electrical controls in accordance with respective installation manuals.
   3. System shall be checked after 3 years of operation and every year thereafter. System shall be checked for pH levels to ensure that it is operating within suggested guidelines.

3.04 SYSTEM ADJUSTING

A. Balancing Across Manifold: Balance all loops across each manifold for equal flow resistance based on actual loop lengths and total manifold flow.

B. Balancing between manifolds is accomplished with a flow control device installed on the return piping leg from each manifold when direct return piping is used for the supply and return mains or the circuits deviate by more than 10%.

3.05 CLEANING

A. Remove temporary coverings and protection of adjacent work areas.

B. Repair or replace damaged installed products.

C. Clean installed products in accordance with manufacturer's instructions prior to Owner's acceptance.

D. Remove construction debris from project site and legally dispose of debris.

3.06 DEMONSTRATION

A. Demonstrate operation of system to Owner or Owner's personnel.

B. Instruct the Owner or Owner's personnel about the type, concentration and maintenance of the glycol and water solution.

C. Provide Owner or Owner's personnel with manufacturer's installation, operation, and maintenance instructions for installed components within the system.

3.07 PROTECTION

A. Protect installed work from damage caused by subsequent construction activity on the site. Provide Owner with copy of photos and drawings of product locations to assist.

END OF SECTION 238316

SECTION 239205

VENTING OF GAS-FIRED APPLIANCES

PART 1 - GENERAL

1.01 SUMMARY

A. Furnish all labor, materials, equipment and services necessary for, and incidental to, the installation of vents as specified herein.

B. This Section is applicable for the following:
   1. Natural Gas-Fired Boilers

1.02 SUBMITTALS

A. Submit product data including materials, dimensions, weights, and accessories.

B. Submit shop drawings including required clearances, assembly and installation instructions, and support of components.
   1. Fully detail all components.
      a. One-line drawings are not accepted.
   2. See schedule on drawings for description of fuel burning
   3. Equipment.

C. Quality Control Submittals:
   1. Certificates: Submit certificates of materials compliance with specified ASTM, UL, and ASHRAE requirements.

1.03 QUALITY ASSURANCE

A. Codes and Standards:
   1. Comply with applicable portions of UL safety standards; provide products which have been UL listed and labeled.
   2. Comply with the ASHRAE Equipment Handbook, Chapter 27, for Chimney, Gas Vent, and Fireplace Systems, material requirements and design criteria.

PART 2 - PRODUCTS

2.01 NATURAL GAS-FIRED BOILERS

A. PVC, Schedule 40, pipe and fittings meeting ANSI/ASTM D1785.
   1. PVC Cement and Primer (for Flue Gas Venting) shall be used and shall meet ANSI/ASTM D2564.
      a. Do not mix primers and cements from one manufacturer with a vent system from a different manufacturer.

B. Venting shall follow all Local and State codes for Category IV venting systems.

C. Combustion air and vent pipe, fittings, primers, and solvents must conform to American National Standards Institute (ANSI) standards and American Society for Testing and Materials (ASTM) standards.

D. Direct Vent / 2-Pipe System:
   1. All air for combustion shall be taken directly from outdoor atmosphere, and all flue products shall be discharged to outdoor atmosphere.
   2. Combustion-air and vent pipes must terminate together in the same atmospheric pressure zone through the sidewall.

E. For boilers, furnish and install concentric vent kit for terminations.

F. For ERV, provide roof termination per manufacturer's requirements.

G. Maintain all required clearances per the 2020 Mechanical Code of New York State and the 2020 Fuel Gas Code of New York State.

H. Install per manufacturer's recommendations.

PART 3 - EXECUTION

3.01 ADJUSTING AND CLEANING

A. Clean to remove dust and debris. Clean external surfaces to remove welding slag and mill film.

END OF SECTION 239205