SECTION 23 05 04
ELECTRIC WIRING

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services for the complete installation of motor control wiring and temperature control wiring as required in Contract Documents. Provide wiring and conduit, required to connect devices furnished as part of or adjunctive to the automatic temperature control system and for motor control regardless of the source of supply. Control wiring includes 120 volt and lower voltage wiring for control signals directing equipment operation. Control circuits shall be 120 volt maximum. Provide wiring in accordance with requirements specified in Division 26, "Electrical" and the National Electrical Code. Provide devices required for proper system operation, including special electrical switches, transformers, disconnect switches, relays, and circuit breaker protection.

B. Coordinate all work with Division 26, "Electrical".

1.02 WORK NOT INCLUDED

A. Power wiring for motors, motor starters and associated starting and control equipment, as well as the motor starters (except in the case of equipment specified to have packaged control/starters), are included in Division 26, "Electrical", unless otherwise called for.

1.03 QUALIFICATIONS

A. Wiring shall be installed in compliance with all requirements of Division 26, "Electrical".

1.04 SUBMITTALS

A. Provide complete wiring diagrams for equipment systems. Deliver wiring diagrams to proper trades in time for roughing of conduit, equipment connections, and avoid delay in construction schedule. Wiring diagrams and roughing information to be wired as part of the Work of Division 26, "Electrical", shall be clearly indicated.

PART 2 - PRODUCTS

2.01 PRODUCTS

A. Refer to Division 26 specifications for required wiring materials.

PART 3 - EXECUTION

3.01 GENERAL

A. Check electrical wiring pertaining to equipment for completeness and correctness of connections. Correct any misapplied motor and/or motor starter, improper thermal overload device, or device which fails to function and resultant damage, whether due to incorrect connections or improper information on wiring diagrams.

3.02 WIRING FOR CONTROL SYSTEMS

A. Provide motor control and temperature control wiring for equipment. All wiring shall be in conduit, unless otherwise noted. Refer to Section 260501 for type of conduit to be used in specific applications. Provide 18 in. length flexible conduit at motors and devices subject to vibration. Conduit supported on 5 ft. centers. Do not attach directly to hot surfaces, piping, or ductwork. Control wiring shall be in separate conduit from all other wiring. Provide green grounding wire circuited from starter, and run ground wire through conduit to each remote auxiliary relay, pushbutton station, remote panel heating device, thermostat, or device with potentials in excess of 50 volts. Size ground wire as required by NEC.

B. All temperature control wiring shall be plenum rated type, meeting the requirements of NEC Article 300.

C. Provide pushbutton stations, pilot lights, selector switches, auxiliary starter contacts, and other devices required to provide specified functions.

D. Where allowable by Code and contract documents, temperature control wiring may be installed without conduit. Installation and wire insulation types shall be as described by NEC, Article 725. All low voltage wiring circuits 50 volt and under shall:

1. Be adequately supported using bridle rings spaced a maximum of 3 ft. on centers or other approved method when installed horizontally above accessible ceilings or run exposed in unfinished areas.
2. Be installed in conduit when run in wall cavity or surface metal raceway where no access is available to wall cavity, in finished areas.
3. Be installed in conduit when installed vertically in Mechanical/Utility Rooms from panels and devices up to above ceiling, or 10 ft. above finished floor if no ceiling.
4. Be installed in conduit in all cases not specifically covered by the above cases, or where subject to physical damage.

3.03 EQUIPMENT WIRING

A. Provide power and control wiring between sections of electrical radiation units, between shipping splits, and between remote panels, thermostats, disconnect

switches, and their respective units. Provide control wiring from the package control system, to each respective electric heat coil, reheat coil or motor. Properly mount control package. Power wiring to and including disconnect switch shall be by Division 26 "Electrical".

3.04 FIELD WIRING IN STARTERS, CONTROLLERS AND PANELS

A. Wiring within starters, controllers, and temperature control panels, shall be routed neatly in gutter space, away from moving and/or heat producing parts. Provide suitably rated terminal blocks. Do not place more than two wire connections on pilot device or relay terminal. Where more than two circuit connections are required, use terminal blocks. Provide nylon insulated, ring spade terminal for all control wires. Cables and wires shall be neatly bundled and lashed with nylon cable straps.

END OF SECTION

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SECTION 23 05 13
MOTORS AND ADJUSTABLE SPEED DRIVES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.02 SUBMITTALS

A. Submit manufacturer's product data on all motors and adjustable speed drives.

B. Product Data: For each motor, provide dimensions; mounting arrangements; frame type, enclosure type, location for conduit entries; shipping and operating weights; and manufacturer's technical data on features, performance, electrical ratings and characteristics.

C. Motor Performance Data: For each motor, include the following manufacturers' data:

1. Motor Performance: Percent Efficiency, Power Factor, Torque, RPM, Duty Rating and Design Category.

1.03 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Motor manufacturer shall be based and headquartered in the United States of America and shall design and manufacture motors in the United States.
2. Motor manufacturer shall have over fifteen (15) years-experience in the motor industry and shall maintain active company-wide quality assurance program.
3. Motor manufacturer shall maintain an authorized service center within 60 miles of the project site, capable of providing training, parts and emergency maintenance and repairs.

B. Motor performance shall be warranted against material and workmanship defects by manufacturer's limited warranty and service policy.

1. Premium efficiency motors shall be warranted for 36 months.
2. Severe duty motors (as applicable) shall be warranted for 60 months.
3. Extended warranty shall be offered for certain products or as agreed by additional terms and specified elsewhere.

PART 2 - PRODUCTS

2.01 MOTORS

A. General Requirements:

1. Motors built for 60 Hz operation, three phase for 1/2 HP and larger; single phase for 1/3 HP and smaller.

a. In compliance with NEMA Standards, wound specifically for nameplate voltage, and selected for appropriate duty and environment.

b. 1.15 minimum service factor at rated voltage and frequency.

c. Bearings: Bearings shall have a rated fatigue life of L-10 (B-10) of 150,000 hours for direct-coupled applications and 50,000 hours for belted applications minimum. Belted rating shall be based on radial loads and pulley sizes called out in NEMA MG 1-14.43. The calculation will be determined from the pulley centerline being at the end of the motor shaft.

d. V-belt connected motors with adjustable slide rail bases and pulleys.

e. Motors shall have Class F insulation system, with Class B temperature rise, insulation meeting NEMA MG 1 Part 31. Maximum allowable motor temperature rise for open drip-proof or totally enclosed fan cooled (TEFC) type at 1.15 service factor shall be 115°C above 40°C ambient with a total temperature rating of 155°C.

f. NEMA locked rotor kVA code as required to match unit equipment torque characteristics.

g. Single-phase motors shall be capacitor start, induction run, or split phase type.

h. Polyphase motors shall be constant speed, squirrel cage, unless otherwise specified.

i. Nameplates shall have as a minimum, all information as described in NEMA Standard MG-1-20.60. Motor nameplate shall be mounted on enclosure with stainless steel fastening pins.

2. Motors for use with adjustable speed drive applications shall be premium efficiency inverter duty rated in accordance with NEMA and be capable of a 20:1 turndown.

a. These motors shall meet NEMA corona inception voltage requirements, withstanding peak voltages up to 1600 volts, and be manufactured in accordance with NEMA MG 1 Part 30 and 31.

b. All motors controlled by adjustable speed drives shall be equipped with circumferential micro-fiber shaft grounding rings to provide protection from electrical bearing damage, to meet NEMA MG 1,

31.4.4.3. Provide Bearing Protection Ring Kit installed in accordance with the manufacturer's recommendation. For motors controlled by adjustable speed drives and 50hp or greater the motor shall have a ceramic electrically insulating bearing assembly on the opposite end of the grounding brushes

3. Three phase motors rated 1 HP and greater shall be copper winding, re-lubable ball bearings, 1.15 service factor, premium efficiency, energy-saver type with a guaranteed NEMA nominal full-load efficiency, by IEEE Standard 112 Test Method "B". Efficiency rating shall appear on nameplate, and shall be not less than as follows; per NEMA MG 1 Part 12, Table 12-12, nominal minimum efficiencies:

MINIMUM NOMINAL FULL-LOAD MOTOR EFFICIENCY						
HP	**ODP MOTORS (RPM)**			**TEFC MOTORS (RPM)**		
	1200	**1800**	**3600**	**1200**	**1800**	**3600**
1.0	82.5	85.5	77	82.5	85.5	77.0
1.5	86.5	86.5	84	87.5	86.5	84
2.0	87.5	86.5	85.5	88.5	86.5	85.5
3.0	88.5	89.5	85.5	89.5	89.5	86.5
5.0	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10	91.7	91.7	89.5	91.0	91.7	90.2
15	91.7	93.0	90.2	91.7	92.4	91.0
20	92.4	93.0	91.0	91.7	93.0	91.0

4. Nominal Motor Voltage Table:

Nominal System Voltage	**Motor Nameplate**
480V - 3 phase	460 volt
240V - 1 phase and 3 phase	230 volt
208V - 1 phase and 3 phase	200 volt
120V - 1 phase	115 volt

5. Motor Application; Provide the following enclosure types unless noted otherwise:

Environment/Location	Motor Enclosure Type
General Purpose	Open drip-proof, TEFC with cast iron frame, or encapsulated
Outdoors, below grade or high humidity	TEFC with cast iron frame
Hazardous	Explosion-proof
Packaged Refrigeration Compressors	Hermetic or semi-hermetic

6. Acceptable Manufacturers: Motors need not all be of the same manufacturer. Subject to the requirements of this section provide products by the following:
   a. General Electric Energy & Saver NEMA Premium Efficiency/(ODP); General Electric X$D Ultra NEMA Premium Efficiency (TEFC).
   b. Century/A.O. Smith Speed Plus
   c. Baldor-Reliance Super E.
   d. Lincoln Ultimate E CTAC.
   e. Marathon XRI.
   f. Siemens GO100A.
   g. Nidec Motor Co. (U.S. Motors) Premium Efficient.

B. Adjustable Speed Drives (ASD's):
1. The ASD shall be 5 HP minimum size, UL Listed, NEMA standard frame size for horsepower rating indicated including 115% motor service factor. Short circuit rating shall be 42kA minimum. Integral solid state programmable overload relay with selectable time class (10, 20 or 30) shall be provided.
2. Units shall be wall or floor mounted as suitable for the intended location. Units shall be an integral component of a motor control center where indicated. Units shall be in NEMA 1 enclosure.
3. The unit shall be provided with a 120V control power transformer. The control power transformer shall be provided with primary and secondary fusing.
4. Cooling fans shall have removable washable filter.
5. Unit shall be of pulse width modulating design with separate common mode choke on the input and output of the drive, if not already built in the

unit to minimize total harmonic distortion. Provide with 3% input and output line reactor.

6. The allowable conductor length between the unit and the controlled motor shall be at least 300 ft. for a standard rated motor. Ambient temperature range shall be 0 to 40ºC with a 3300 ft. altitude.

7. Door mounted selector switch for Auto-Manual control. In the auto mode, the start command and speed control shall be provided from a remote source. In the manual mode, the start-stop and speed control shall be provided through the door mounted controls. Provide extra contact blocks on the selector switch for monitoring of switch position.

8. Door mounted pushbuttons for start-stop control. Stop pushbuttons shall always be active. Door mounted LED type pilot lights for indication of On (Red) and Off (Green). Door mounted human interface module for programming, display and speed control.

9. Programming shall include:

    a. One isolated, configurable analog input.

    b. Two isolated, configurable analog outputs.

    c. Alarm digital input for automatic shutdown, field configurable for ramped deceleration, full stop and manual/auto reset. Digital input to force unit to a preprogrammed speed for smoke control or other need.

    d. Four field programmable digital outputs.

10. Field selectable isolated process control interface to enable the ASD to follow 0-5 mA, 1-5 mA, 4-20 mA, 10-50 mA, 0-8 VDC, 1-4 VDC, or 0-10 VDC grounded or ungrounded signal from a process controller. Provide RS232 or RS485 communication module board.

11. Network connection shall be suitable for unit on/off and speed control. Communication to the building control system shall include actual motor speed verification, amperage, voltage, kW, and kWh. All unit programming functions shall be accessible through network communication. Communication shall be selectable for BACnet, Metasys, Modbus, Lonworks, Profibus and the project building control system.

12. Isolation Disconnect Switch: Provide isolation disconnect switch integral to unit with a provision for padlocking in the "Off" position.

13. Drive shall be a part of a unit with a three contactor isolated manual drive bypass as described below:

    a. The manual isolated drive bypass unit will consist of two units - a bypass starter unit and an adjustable speed drive (ASD) unit. The intent of the manual isolated drive bypass unit is to isolate the adjustable speed AC drive for servicing. The ASD unit door shall be interlocked with the bypass starter unit. When in the bypass mode the motor can be energized and de-energized with the across-

the-line bypass starter. Starter shall meet the requirements of a magnetic starter defined in this section.

b. All power components shall have a normal duty rating suitable for the nominal horsepower of the application.

c. Bypass Starter Unit: The bypass starter unit shall include the fusible disconnect or circuit breaker, the bypass contactor and solid state overload relay, control circuit transformer and terminal blocks. "DRIVE ON" and "BYPASS ON" pilot lights shall be provided to indicate operational status. Shall be three contactor design.

d. ASD Unit: A "DRIVE-OFF-BYPASS" selector switch, a "BYPASS START" push button and a "BYPASS STOP" push button shall be provided. These pilot devices shall be located in the same control station as the "DRIVE ON" and "BYPASS ON" pilot lights on the bypass starter unit.

e. Isolating Disconnect: The isolating disconnect shall be a six-pole device capable of making and breaking the load. Auxiliary isolating disconnect contacts will permit the operation of only one unit at a time either the Bypass Starter or the ASD.

f. Isolation Switch Operation:

1) Bypass Mode: When in bypass mode the "BYPASS ON" pilot light shall be energized when the bypass motor control circuit is energized. When in bypass mode the bypass starter unit and the ASD unit are isolated from one another. In addition, the isolation switch shall have means to be padlocked, to prevent being switched to drive mode. In this mode no power shall be present in the ASD enclosure.

2) Drive Mode: When in drive mode the isolating disconnect shall permit the starter bypass unit to supply power to the ASD unit and connects the ASD unit to the motor. When the isolation switch is in the drive mode the "DRIVE ON" pilot light shall be energized. In addition, the isolation switch shall have means to be padlocked to prevent being switched to bypass mode.

3) Unit shall be of three contactor construction.

14. Design Make: Allen Bradley Powerflex 700 with Drive Bypass.

15. Make: Allen Bradley, Eaton Corporation, Square D, General Electric, ABB, Emerson or approved equal.

PART 3 - EXECUTION

3.01 MOTORS

A. Furnished by equipment manufacturer and especially manufactured and/or selected, mounted, and installed for intended use. Install motors accessible for maintenance and belt adjustment.

3.02 ADJUSTABLE SPEED DRIVES

A. Set controllers in place on wall or freestanding steel frame as required, with 6 in. high concrete base. Completely erect and assemble, including shipping splits and make respective connections from terminal or terminal strips to any miscellaneous control devices.

B. Provide power feed terminations with proper phase connections to provide proper motor rotation. Adjust unit controls in accordance with manufacturer's instructions.

C. Adjust unit controls in accordance with manufacturer's instructions.

D. A factory-trained manufacturer's service representative shall provide complete start-up services at the site during construction plus a separate (after startup on a 100% correctly operating drive) four (4) hour training session for the Owner.

END OF SECTION

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SECTION 23 05 16
VIBRATION ABSORBERS, EXPANSION COMPENSATORS AND EXPANSION JOINTS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Documents.

1.02 SUBMITTALS

A. Submit product data on items provided for each piece of equipment.

B. Submit detailed fabrication drawings for all field fabricated anchors.

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Vibration Isolation for Piping: Section 230548 - Vibration Isolation of Mechanical Systems.

B. Anchors and Guides: Section 232010 - Piping Systems and Accessories.

PART 2 - PRODUCTS

2.01 VIBRATION ISOLATION FOR PIPING

A. Pipe runs connected to mechanical equipment should be mounted on steel spring and/or elastomer isolators as called for in "Vibration Isolation of Mechanical Equipment Specification 230548.

2.02 RADIATION GUIDES AND ANCHORS

A. For use with expansion compensators (see above) within fin radiation enclosures.

B. Two-piece full circumference nylon guide, bolted to "L" bracket. Keflex Model CTG, Tri-State Industries A-Series or equal.

C. Two-piece, bolted copper tube anchor and "L" bracket. Keflex Model CTA, Tri-State Industries C-Series or equal.

2.03 FLEXIBLE EXPANSION LOOPS

A. Provide flexible expansion loops of size and type as shown on the drawings, which will provide a flexible pipe loop that will absorb and compensate multi-plane movements simultaneously as well as reduce piping stress.

B. Materials of construction and end fittings type shall be consistent with pipe material and equipment/pipe connection fittings.

C. Flexible loops shall consist of two (2) flexible sections of hose and braid, two (2) 90° elbows and a 180° return assembled in such a way that the piping does not

change direction, but maintains its course along a single axis. Flexible loops shall have a factory supplied, center support nut located a t the bottom of the 180° return, and a drain/air release plug.

D. Flexible loops shall impart no thrust loads to system support anchors or building structure. Loops shall be installed in a neutral, pre-compressed or pre-extended condition as required for the application.

E. Provide nested construction loops when installed in multiples. For steam service, loops must be installed with flexible legs horizontal to prevent condensate build up.

F. Provide guides and anchors as specified.

G. Loops shall be at 0 in. deflection at time of installation based upon 50°F ambient temperature. If the installation temperature is to be below 50°F, it is the Contractor's responsibility to review the installation with the Engineer before proceeding.

H. Make: Metraflex Co., Flex-Hose Co Inc., Flexi Craft Industries..

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. Equipment installed in accordance with the manufacturer's installation instructions.

B. Piping shall be properly anchored to control the direction of expansion and guided at the entrance to expansion devices.

C. Expansion compensators and joints are sized based upon an ambient temperature of 50°F at the time of installation. If the installation temperature is to be below 50°F, it is the Contractor's responsibility to review the installation with the Engineer before proceeding.

END OF SECTION

SECTION 23 05 19
GAUGES AND THERMOMETERS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Documents.

1.02 SUBMITTAL

A. Submit product data for gauges, thermometers and thermowells.

PART 2 - PRODUCTS

2.01 WATER PRESSURE GAUGES

A. Construction to be Bourdon tube type; 4-1/2 in. diameter minimum, dial face, stamped stainless steel, replaceable glass lens, with snap-on rings. Phosphor bronze tube, bronze bushed rotary movement, silver brazed or soldered to brass socket and brass tip. 1/4 in. bottom connection. Accuracy, one (1.0) percent of included scale range. White dial face with black numerals, graduated in pounds; equipped with bronze pulsation dampener or snubber.

B. Make: American, Ashcroft, Crosby, Duro, Marsh, Moeller, Trerice, Weiss, Weksler, Winters.

2.02 PIPING SYSTEM THERMOMETERS

A. Industrial type, plastic, aluminum or steel case, glass or plastic front, non-toxic organic liquid filled, red reading column, white or silver V-shaped scale, black numerals. Union flange mounted, separable socket with thermowell, extension necks where required; range as called for service. Universal adjustable type, 9 in. scale. For installation in hot water systems, graduations of 2°F., accurate to within 1°F. For installation in water systems where the maximum temperature is less than 120°F, graduations of 1°F, accurate to within 1/2°F.

B. Make: American, Moeller, Trerice, Weiss, Weksler, Winters.

2.03 PRESSURE/TEMPERATURE TEST PLUGS

A. 1/4 in. NPT plug shall be capable of reading either a pressure or temperature. 1/8 in. o.d. dual seal core of Nordel 275°F with zero leakage from vacuum to 500 psig.

B. Test kit consisting of: one 2-1/2 in. test gauge 0-100 psi, one gauge adapter 1/8 in. probe, and two 5 in. stem pocket testing thermometers - one 0° to 220° and one 25° to 125°F.

C. Makes: Peterson Equipment Company, Sisco P/T plugs, IMI Flow Design.

PART 3 - EXECUTION

3.01 GENERAL

A. Provide where called for in the drawings and as noted below.

B. All gauges and thermometers shall be provided with pressure and temperature ranges appropriate for the system in which they are installed. Select to operate in the middle third of the range under normal operating conditions. Gauges and thermometers shall be suitable for the environment of their installed location, and if installed outdoors shall be acceptable for operation down to an ambient temperature of -20°F.

3.02 WATER PRESSURE GAUGES

A. Heating water coils: 0 to 60 psi range.

B. Provide 1/4 in. ball valve in each pump inlet and outlet tapping, or in piping adjacent to same. Range 30 in. vacuum to 100 psi.

C. Each water make-up valve assembly: 0 to 60 psi range.

3.03 THERMOMETERS

A. Provide thermowells mounted in oversize tee, or elbow if necessary, to provide as little restriction as possible to fluid flow. Provide thermometer stems and thermowell depths of proper length to allow accurate reading. Locate adjacent to control sensing equipment. Install and adjust angles so as to be easily read from floor.

B. Boiler: Inlet and outlet; range 30° to 220°F.

C. Hot Water Zone: Supply and return pipe; range 30° to 220°F.

D. Radiant Heat: Supply and return; range 0° to 160°F.

E. Heating Coil: Inlet and outlet; range 0° to 220°F.

3.04 TEST PLUG

A. Provide test plugs at locations as called for. Deliver test kit to Owner and obtain receipt.

END OF SECTION

SECTION 23 05 23
VALVES

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services as required for the complete installation and related Work designed in Contract Documents.

1.02 SUBMITTAL

A. Submit product data for valves and accessories.

PART 2 - PRODUCTS

2.01 VALVES

A. General: Valves shall have following requirements:

1. Working pressure stamped or cast on bodies.
2. Stem packing serviceable without removing valve from line.
3. Valves on insulated services shall have handle extensions so that the handle is fully beyond the insulation jacketing.
4. Where possible, all valves of like type shall be of a single manufacturer.

B. Acceptable Manufacturers:

1. Globe, and Check Valves: Apollo, Hammond, Milwaukee, Nibco, Watts.
2. Ball Valves: Apollo, Hammond, Jamesbury, Milwaukee, Watts, Nibco.
3. Butterfly Valves: Apollo, DeZurik, Jamesbury, Keystone, Milwaukee, Watts, Nibco.
4. High Performance Butterfly Valves: Keystone, Bray, Velan, Milwaukee.
5. To establish a standard of quality and to identify features, certain manufacturer's numbers are given in the following paragraphs.

C. Globe Valves:

1. 2-1/2 in. and Larger: Iron body, renewable seat and disc, 125 SWP, flanged ends, bolted bonnet, Milwaukee F-2981.
2. 2 in. and Smaller: Bronze body, renewable composition or bronze disc, union bonnet, rising stem, threaded ends, 150 SWP, Milwaukee 590.

D. Check Valves:

1. 2-1/2 in. and Larger: Iron body, renewable seat and disc, bolted flange cap, flanged ends, 125 SWP, Milwaukee F-2974.
2. 2 in. and Smaller: Bronze, swing check, threaded ends, 125 SWP, Milwaukee 1509.

3. Silent Check Valves, 2 in. and Smaller: Renewable seat, bronze body with bronze trim and stainless steel spring, 125 lb. SWP. Apollo 61-500 Series.

4. Silent Check Valves, 2-1/2 in. and Larger: Cast iron body, EPDM seat, aluminum bronze disc, 316 stainless steel spring and stem, 125 lb. SWP. Milwaukee 1400.

E. Ball Valves for Water Service:

1. For chilled and hot water systems 3 in. and under: Bronze body with hardened chrome-plated brass ball, glass reinforced or carbon impregnated PTFE seats, full porting, 600 lb., W.O.G., adjustable packing gland, insulated handle, screwed or soldered ends, blowout proof stem. Provide handle extension on insulated services.

2. Provide extended operations handle on non-thermal conductive material and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.

F. Valves for Gauges and Instruments:

1. 1/4 in., bronze body, hardened chrome plated brass ball, glass reinforced carbon impregnated seats, standard porting, 400 lb. W.O.G., adjustable packing gland, screwed ends, tee handle, Watts B6000TH.

G. Lug Type Butterfly Valves for Water Service:

1. Rated for working pressure 200 psi, bi-directional dead end service, bubble-tight.

2. Body: Lug type, cast iron ASTM A126.

3. Disc: Aluminized bronze.

4. Seat: EPDM, resilient seat. Rated to 250^{o}F.

5. Stem: 316 or 416 stainless steel.

6. Operator: Lockable Lever for sizes through 6 in. Manual hand wheel gear actuator for sizes 8 in. and larger.

7. Milwaukee CL223E (2 in. - 6 in.), CL323E (8 in. and larger).

H. Gas Valves:

1. 2-1/2 in. and Larger: Manual actuated with level actuators bolted gland type, short pattern, lubricated plug type, 175 lb. WOG, flanged, Nordstrom, Fig. #143, UL listed.

2. 2 in. and Smaller: AGA/CGA and UL/FM listed for natural and LP gas, forged brass full port, threaded ends, Watts FBV Series.

I. Hose Thread Drain Valves:

1. Ball valve, bronze body, hardened chrome ball with hose thread end, cap and chain.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General:

1. Provide valves of type called for and where required to service equipment.
2. Provide at major building and systems sections.
3. Provide chain wheels, guides, and chain loops for valves, where called for or in Mechanical Rooms where valves are mounted higher than 8'-0" AFF.
4. Isolating valves for individual fan convectors, room units, terminal units, or other similar apparatus may be inside cabinet or at connection to branch mains where accessible.
5. Locate valves with handles at horizontal position when 5 ft. or more above the floor, for greater visibility and easier use. Otherwise, locate valves with handles at or above horizontal position. Swing check valves in upright position only.
6. Butterfly valves may be used for water service over 2 in. unless otherwise noted.
7. Ball valves may be used for water service through 3 in., unless otherwise noted.
8. Provide hose threaded valves at low points, strainers, equipment, and as called for.

END OF SECTION

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SECTION 23 05 25
HYDRONIC COIL PIPING PACKAGE

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide Hydronic Coil Piping Packages as shown on drawings and as specified herein.

B. Type, size, and rating compatible with intended service.

C. Suitable for use in Chilled Water and Hot Water Systems.

1.02 SUBMITTALS

A. Submittals shall include the following:

1. Drawing of coil package showing product arrangement with end connection type and size listed. Components shall be clearly labeled.
2. Written description of all components provided in package.
3. Manufacturer's system component specifications.
4. Computer generated, job specific package schedule indicating package part number, end connection size and types, control valve Cv, flow cartridge spring range, design flow rate, and location tag for each coil package.

1.03 DELIVERY, STORAGE, AND HANDLING

A. All equipment provided under this specification shall be shipped to the job site clearly labeled for intended use and in shrink-wrapped plastic per coil assembly. Manufacturer shall factory mount actuators (supplied by others) to actuated ball valve prior to shrink-wrap and shipment.

B. Manufacturer's representative shall coordinate with valve actuator supplier to develop common schedule of actuator type, size, and location. This schedule will be used by coil piping package factory to mount actuators prior to shrink-wrap and shipping.

1.04 WARRANTY

A. Manufacturer shall warrant all components for eighteen (18) months from date of final acceptance. The flow limiting cartridge shall be warranted by manufacturer for no less than five (5) years from date of final acceptance.

B. Manufacturer shall provide replacement flow limiting cartridges at no charge for up to 10% of total quantity of purchased packages in the event that flow conditions (gpm) are modified by Engineer after packages have shipped to the jobsite.

1.05 ACCEPTABLE MANUFACTURER

A. Griswold "Automizer" CPP-2A (Basis of Design).

B. Griswold PIC-V.

C. Delta Controls "Auto Touch".

D. FCI - Delta P Valve.

E. Danfoss/Nexus Coil Pak

F. Flow Design/IMI

PART 2 - PRODUCTS

2.01 COMBINATION VALVES (RETURN SIDE) 10 GPM AND BELOW

A. Combination valve shall include a flow limiting cartridge, actuated ball valve, and manual isolation ball in a single valve housing to prevent opportunity for leakage with union end connection. Separate assembled components shall not be acceptable.

B. Valve housing shall consist of forged brass, rated at no less than 360 psi at 250°F.

C. Valve shall have a union end connection that includes a factory installed manual air vent to allow for venting of the coil or heat pump.

D. Automatic Flow Limiting Cartridge (FLC):

1. FLC shall automatically control flow rates with ±5% accuracy over an operating pressure differential range of at least 14 times the minimum required for control. Three (3) operating pressure ranges shall be available with the minimum range requiring no more than 2 PSID to actuate the mechanism.
2. Valve internal control mechanism shall consist of a stainless steel one-piece cartridge with segmented port design and full travel linear coil spring. Plated steel cartridges shall not be acceptable.
3. Dual pressure/temperature test valves for verifying the pressure differential across the cartridge and system shall be standard.
4. Manufacturer shall be able to provide certified independent laboratory tests verifying accuracy of performance.

E. Actuated Ball Valve:

1. Valve ball shall consist of chemically plated nickel brass.
2. Actuator stem shall be removable/replaceable without removing valve from line.

3. Manufacturer shall be able to provide ball insert to make flow control equal percentage. Insert shall be constructed of a glass-filled polymer.
4. Valve shall have EPDM O-rings behind Reinforced Teflon (PTFE) ball seals to allow for a minimum close-off pressure of 100 psi with 35 in.-lbs. of torque for 1/2 in. to 2 in. sizes.
5. Actuator shall provide minimum torque required for full valve shutoff position.
6. Coordinate specific details of actuator with BMS provider. BMS provider shall ship valve actuator to hydronic coil piping package manufacturer to be factory mounted or mount and wire actuators in the field.

F. Control Valves: All pressure independent valves for individual coil control shall be provided as part of Hydronic Coil Piping/Hose Kit Packages as specified herein. Control valve actuators will be supplied and installed by the Contractor or supplied by the Contractor and shipped to the pressure independent valve manufacturer for factory installation. The Contractor is responsible for wiring and testing the valve actuators.

G. Isolation Ball Valve:
1. Valve shall include a 600 WOG manual isolation ball valve.

2.02 COMBINATION VALVES (RETURN SIDE) LARGER THAN 10 GPM

A. The modulating control valves shall be pressure independent.

B. The pressure independent modulating control valve shall include a pressure compensating cartridge, actuated ball valve, and manual isolation ball in a single valve housing.

C. Valve housing shall consist of forged brass, rated at no less than 360 psi at 250°F.

D. Valve shall have a fixed end or union end connection with factory installed air vent to allow for venting of the coil or heat pump.

E. The control valve shall accurately control the flow from 0 to 100% full rated flow.

F. A flow tag shall be furnished with each valve.

G. A universal mounting plate shall allow installation of actuators meeting the system electrical requirements and valve torque requirements as provided by Belimo, ELO Drive, Honeywell, Invensys, Johnson Controls, KMC, Neptronics, or Siemens.

H. The actuator and plate can be rotated after mounting.

I. Pressure Compensating Cartridge (PCC):

1. PCC shall automatically compensate for pressure changes in valve and shall maintain a constant pressure drop across the flow limiting actuated ball.
2. The operating pressure range shall be available with the minimum range requiring 5.8 PSID to actuate the mechanism.
3. Valve internal control mechanism includes a diaphragm and full travel linear coil spring.
4. Valves shall include an accessible/replaceable cartridge.
5. Dual pressure/temperature test valves for verifying the pressure differential across the cartridge and flow limiting ball shall be standard.

J. Actuated Ball Valve:

1. Valve ball shall consist of chemically plated nickel brass or stainless steel.
2. Actuator stem shall be removable/replaceable without removing valve from line.
3. Manufacturer shall be able to provide ball insert to limit flow to maximum flow rate with ±5% accuracy.
4. Valve shall have EPDM O-rings behind the seals to allow for a minimum close-off pressure of 100 psi with 35 in.-lbs. of torque for 1/2 in. to 2 in. sizes.
5. Actuator shall provide minimum torque required for full valve shutoff position.

K. Isolation Ball Valve:

1. Valve shall include a 600 WOG manual isolation ball valve.

2.03 COMBINATION VALVE (SUPPLY SIDE)

A. Combination valve shall include a manual isolation ball and integrated strainer, including drain valve with 3/4 in. hose connection with cap, in a single valve housing to prevent opportunity for leakage. Separate assembled components shall not be acceptable. Dual pressure/temperature test valve shall be standard.

B. Valve housing shall consist of forged brass rated at no less than 360 psi at 250°F.

C. Valve shall have one (1) fixed end and one (1) union end connection.

D. Integrated Strainer:

1. Shall be 20 mesh stainless steel and can be removed from housing without disturbing pipe connections for inspection or replacement.
2. Drain valve shall consist of nickel-plated ball in a brass housing rated for 275 psi at 250°F.

E. Isolation Ball Valve:

1. Valve shall include a 600 WOG manual isolation ball valve.

2.04 SUPPLY/RETURN HOSES (AS REQUIRED)

A. All hoses shall be equipped with swivel end connections at terminal unit. All end connections shall be crimped to meet standard pressure ratings. Serrated/slip fit connections shall not be acceptable.

B. Flame Retardant Hoses:

1. Hose material shall be stainless steel braided over a synthetic polymer liner.
2. Hoses shall meet or exceed the ASTM D380-00 standard.
3. Hoses shall meet or exceed flame retardant testing per standards per ANSI/UL 723, NFPA 255, UBC 42-1, and ASTM E84-00.

C. Insulated Hoses:

1. Hose materials shall be high quality polyethylene pipe insulation over a stainless steel braided inner core.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install per manufacturer's recommendations and instructions.

END OF SECTION

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SECTION 23 05 30
ROOF CURBS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation of roof curbs as shown in Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 230550 - Wind Restraint for HVAC Systems.

1.03 SUBMITTALS

A. Typical detail and schedule for equipment. Details shall include cross-sectional view illustrating clearly the type of curb being submitted, i.e. double wall insulated, with or without cant.

PART 2 - PRODUCTS

2.01 ROOF CURBS AND PIPE/DUCT/EQUIPMENT SUPPORTS

A. Basis of Design: Subject to compliance with requirements of this section, provide Roof Products and Systems Corp. (RPS) or comparable product by one of the following:

1. RPI (Roof Products Inc.)
2. ThyCurb
3. Greenheck

B. Configuration: Coordinate curb type with roof deck construction and insulation thickness.

1. Self-flashing without cant strip, with mounting flange (RPS Series 2A).
2. Built-in cant and mounting flange (RPS Series 3A).
3. Built-in raised cant and mounting flange (RPS Series 4A).

C. Provide wind restraint as called for in Item 1.2 above.

2.02 FAN CURBS/DUCT CURBS

A. Double wall, 1-1/2 in. minimum thickness, fully insulated in the interior cavity with rigid insulation. Curb constructed of galvanized steel, 1-1/2 in. 3# density insulation with continuous welded corner seams and painted at all welds. 20 gauge up to 36 in., 18 gauge 38 to 72 in., 16 gauge over 72 in. in any dimension.

B. Kitchen exhaust fan curbs shall be 24 in. high with hinges and service hold-open chain or cable; all other fan curbs shall be 18 in. high or as otherwise noted on the drawings.

C. Provide curb with adhesive backed closed cell foam gasket on the top edge to make airtight seal between curb and ventilator, fan, or air handling unit. Gasketing for kitchen exhaust fan curbs shall be woven ceramic gasket tape rated for the operating temperature.

D. Options:

1. Pitch Mounting: Manufacture curb for roof slopes.

E. Basis of Design: RPS - RC Roof Curbs.

2.03 EQUIPMENT RAILS

A. Double wall, minimum 18 in. high. Constructed of 18 gauge galvanized steel with continuous welded corner seams and painted at all welds. Constructed of heavier gauge steel where standard rail cannot support unit weight. Provide with top cap counter flashing.

B. Basis of Design: RPS - Equipment Rail ER2.

2.04 DUCT MOUNTING PEDESTAL

A. Double wall, minimum 18 in. high. Constructed of 18 gauge galvanized steel with continuous welded corner seams and painted at all welds. Constructed of heavier gauge steel where standard curb cannot support unit weight. Provide with top cap counter flashing.

B. Duct mounting pedestal shall consist of a support rail 12 in. longer than the duct width for single duct support, with a single galvanized steel slide channel equal in length to the equipment rail attached to galvanized steel "U" shaped mounting brackets secured to the side of the equipment rail with lag bolts. The duct mounting slide assembly shall be sized to suit the duct supported and fabricated of galvanized steel and shall have galvanized 18 in. long continuous threaded rods to allow 12 in. vertical adjustment, and lateral adjust spacer bracket for 12 in. horizontal adjustment.

C. Basis of Design: RPS - Duct Mounting Pedestal.

2.05 PIPE MOUNTING PEDESTAL

A. Same construction as "Equipment Rails". Provide with full length steel bracket, U bolts and accessories as required to secure piping to the pipe support as detailed on Contract Drawings.

B. Basis of Design: RPS - Pipe Mounting Pedestal Model ER.

2.06 PIPE CURB ASSEMBLY - PIPE PORTAL

A. Fully insulated with rigid 1-1/2 in. 3# density insulation. Minimum 18 in. high. Constructed of 18-gauge galvanized steel with welded at all contact points. Painted at all welds.

B. Acrylic coated ABS rib reinforced curb cover and integral counter flashing, size and number of pipe and conduit openings as required to suit job conditions.

C. EPDM protective rubber pipe boots and stainless steel clamps secured around each pipe individually. Curb provided with raised cant, flanged or recessed. Curb flange shall suit roof construction and type of insulation being applied.

D. Basis of Design: RPS - Pipe Portal Flashing System.

PART 3 - EXECUTION

3.01 GENERAL

A. Height as recommended by equipment manufacturer, not less than described in this specification. This Contractor shall be responsible for exact size, length, and location and shall set and secure each curb to the roof. Shim and level curb as required. Provide curb and supports for all roof-mounted equipment. All roof penetrations shall be made through an appropriate curb. All roof mounted equipment including fans, air handling units, etc, shall be set on an equipment support unless otherwise noted. Refer to Contract Drawings for details on plenums extending from curbs.

END OF SECTION

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SECTION 23 05 48
VIBRATION ISOLATION OF MECHANICAL SYSTEMS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Furnish and install vibration control devices, materials, and related items. Perform all work as shown on the Drawings and as specified herein to provide complete vibration isolation systems in proper working order.

1.02 RELATED SECTIONS

A. See Specification Section 230550 - Wind Restraint for Mechanical Systems.

1.03 MATERIAL AND EQUIPMENT

A. All vibration isolation mounts shall be supplied by one of the following approved manufacturers:

1. Mason Industries Inc. (Hauppauge, NY) M.I.
2. Kinetics Noise Control Inc. (Dublin, OH) K.N.C.
3. Vibration Mountings & Controls Group. (Butler, NJ) VMC Group
4. Vibration Eliminator Co. (Long Island City, NY) V.E.C.

1.04 QUALITY ASSURANCE

A. Coordinate the size, location and special requirements of vibration isolation equipment and systems with other trades. Coordinate plan dimensions with size of housekeeping pads.

B. Provide vibration isolators of the appropriate sizes, with the proper loading to meet the specified deflection requirements.

C. Supply and install any incidental materials such as mounting brackets, attachments and other accessories as may be needed to meet the requirements stated herein even if not expressly specified or shown on the Drawings, without claim for additional payment.

D. Verify correctness of equipment model numbers and conformance of each component with manufacturer's specification.

E. Should any rotating equipment cause excessive noise or vibration when properly installed on the specified isolators, the Contractor shall be responsible for re-balancing, realignment, or other remedial work required to reduce noise and vibration levels. Excessive is defined as exceeding the manufacturer's specifications for the unit in question.

F. Upon completion of work, the Architect or the Architect's Representative shall inspect the installation and shall inform the contractor of any further work that

must be completed. Make all adjustments as directed by the Architect that result from the final inspection. This work shall be done before vibration isolation systems are accepted.

1.05 SUBMITTALS

A. Refer to related sections elsewhere for procedural instruction for submittals.

B. Before ordering any products, submit shop drawings of the items listed below. The shop drawings must be completed when submitted and must be presented in a clear, easily understood form. Incomplete or unclear presentation of shop drawings may be reason for rejection of the submittal.

C. A complete description of products to be supplied, including product data, dimensions, specifications, and installation instructions.

D. Detailed selection data for each vibration isolator supporting equipment, including:

1. The equipment identification mark.
2. The isolator type.
3. The actual load.
4. The static deflection expected under the actual load.
5. The specified minimum static deflection.
6. Steel rails, steel base frames, and concrete inertia bases showing all steel work, reinforcing, vibration isolator mounting attachment method, and location of equipment attachment bolts.
7. Special details necessary to convey complete understanding of the work to be performed.

E. Submission of samples may be requested for each type of vibration isolation device. After approval, samples will be returned for installation at the job if requested. All costs associated with submission of samples shall be borne by the Contractor.

PART 2 - PRODUCTS

2.01 VIBRATION ISOLATOR TYPES

A. General:

1. All springs installed out-of-doors shall be zinc electroplated or powder-coated after fabrication. Hardware and other metal parts shall be cadmium-plated or galvanized. Galvanizing shall meet ASTM Salt Spray Test Standards and Federal Test Standard No. 14.
2. All isolators installed out-of-doors shall have base plates with bolt holes for fastening the isolators to the support members.

3. Isolator types are scheduled to establish minimum standards. At the Contractor's option, labor-saving accessories can be an integral part of isolators supplied to provide initial lift of equipment to operating height, hold piping at fixed elevations during installation and initial system filling operations, and similar installation advantages. Accessories and seismic restraint features must not degrade the isolation performance of the isolators.

4. Static deflection of isolators shall be as provided in the EXECUTION section and as shown on the Drawings. All static deflections stated are the minimum acceptable deflection for the mounts under actual load. Isolators selected solely on the basis of rated deflections are not acceptable and will be disapproved.

B. Type FSN (Floor Spring and Neoprene):

1. Spring isolators shall be freestanding and laterally stable without any housing. Spring diameter shall be not less than 0.8 of the compressed height of the spring at the rated load. Springs shall have a minimum additional travel-to-solid equal to 50% of the rated deflection. Springs shall be so designed that the ratio of horizontal stiffness to vertical stiffness is approximately 1 (one). All mounts shall have leveling bolts. The spring element in the isolator shall be set in a neoprene cup and have a steel washer or a flat surface in contact with the neoprene to distribute the load evenly over the bearing surface of the neoprene. Alternatively, each isolator shall be mounted on a Type NP isolator. If the NP isolator is used, a rectangular bearing plate of appropriate size shall be provided to load the pad uniformly within the manufacturer's recommended range. If the isolator is to be fastened to the building and the NP isolator is used, grommets shall be provided for each bolt hole in the base plate. If the basic spring isolator has a neoprene friction pad on its base and a NP isolator is to be added to the base, a galvanized steel, stainless steel or aluminum bearing plate shall be used between the friction pad and the NO isolator. If the isolator is outdoors, bearing plates shall not be made of galvanized steel. The NP isolator, beating plate and friction pad shall be permanently adhered to one another and to the bottom of the isolator base plate.

2. Type FSN isolators shall be one of the following products with the appropriate neoprene pad (if used) selected from Type NP or approved equal:

a.	Type SLF	M.I.
b.	Type FDS	K.N.C.
c.	Series A	VMC Group

C. Type FSNTL (Floor Spring and Neoprene Travel Limited):

1. Spring isolators shall be freestanding and laterally stable. Spring diameter shall not be less than 0.8 of the compression height of the spring at the

rated load. Spring shall have a minimum additional travel-to-solid equal to 50% of the rated deflection. Springs shall be so designed that the ratio of horizontal stiffness to vertical stiffness is approximately one (1). All mounts shall have leveling bolts. All mounts shall have vertical travel limit stops to control extension when weight is removed. The travel limit stops shall be capable of serving as blocking during erection of the equipment. A minimum clearance of 1/4 in. shall be maintained around restraining bolts and between the limit stops and the spring to avoid interference with the spring action.

2. The spring element in the isolator shall be set in a neoprene cup and have a steel washer or a flat surface in contact with the neoprene to distribute the load evenly over the bearing surface of the neoprene. Alternatively, each isolator shall be mounted on a Type NP isolator. If the NP isolator is used, a rectangular bearing plate of appropriate size shall be provided to load the pad uniformly within the manufacturer's recommended range. If the isolator is to be fastened to the building and the NP isolator is use, grommets shall be provided for each bolt hole in the base plate.

3. If the basic spring isolator has a neoprene friction pad on its base and a NP isolator is to be added to the base, a galvanized steel, stainless steel or aluminum bearing plate shall be used between the friction pad and the NP isolator. If the isolator is outdoors, bearing plates shall not be made of galvanized steel. The NP isolator, bearing plate and friction pad shall be permanently adhered to one another and to the bottom of the isolator base plate.

4. Type FSNTL isolators shall be one of the following products, with the appropriate neoprene pad (if used) selected from Type NP or approved equal:

a.	Type SLR	M.I.
b.	Type FLS	K.N.C.
c.	Series AWR	VMC Group

D. Type FN (Floor Neoprene):

1. Neoprene isolators shall be neoprene-in-shear type with steel reinforced top and base. All metal surfaces shall be covered with neoprene. The top and bottom surfaces shall be ribbed. Bolt holes shall be provided in the base and the top shall have a threaded fastener. The mounts shall include leveling bolts that may be rigidly connected to the equipment.

2. Type FN isolators shall be one of the following products or approved equal:

a.	Type ND	M.I.
b.	Type RD	K.N.C.
c.	Series RD	VMC Group

E. Type NP (Neoprene Pad):

1. Neoprene pad isolators shall be one layer of 1/4 in. to 3/8 in. thick ribbed or waffled neoprene. The pads shall be sized so that they will be loaded within the manufacturer's recommended range.

2. Type NP isolators shall be one of the following products or approved equal:

   a. Type W M.I.

   b. Type NPS K.N.C.

   c. Series Shear Flex VMC Group

F. Type DNP (Double Neoprene Pad):

1. Neoprene pad isolators shall be formed by two layers of 1/4 in. to 3/8 in. thick ribbed or waffled neoprene, separated by a galvanized steel, stainless steel or aluminum plate. If the isolator is outdoors, the plate shall not be made of galvanized steel. These layers shall be permanently adhered together. The pads shall be sized so that they will be loaded within the manufacturer's recommended range.

2. Type DNP isolators shall be formed from one of the following products or approved equal:

   a. Type WSW M.I.

   b. Type NPS K.N.C.

   c. Series Shear Flex VMC Group

G. Type HSN (Hanger Spring and Neoprene):

1. Vibration isolator hangers shall consist of a free standing and laterally stable steel spring and a neoprene element in series, contained within a steel housing. Spring diameters and hanger housing lower hole size shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the housing. Alternatively, other provisions shall be made to allow for a 30° arc of movement of the bottom hanger rod without contacting the isolator housing. Spring diameter shall not be less than 0.8 of the compressed height of the spring at the rated load. Spring elements shall have a minimum additional travel-to-solid equal to 50% of the rated deflection. The neoprene element shall be designed to have a 0.3 in. minimum static deflection. The deflection of both the spring element and the neoprene element shall be included in determining the overall deflection of Type HSN isolators.

2. Type HSN isolators shall be one of the following products or approved equal:

   a. Type 30N M.I.

   b. Type SRH or SFH K.N.C.

c. Type RSH or RFH VMC Group

H. Type HN (Hanger Neoprene):

1. Vibration isolator hangers shall consist of a neoprene-in-shear element contained within a steel housing. A neoprene neck brushing shall be provided where the hanger rod passes through the hanger housing to prevent the rod from contacting the hanger housing. The diameter of the hole in the housing shall be sufficient to permit the hanger rod to swing through a 30° arc before contacting the hanger housing.

2. Type HN isolators shall be one of the following products or approved equal:

a. Type HD M.I.

b. Type RH or FH K.N.C.

c. Type RHD or RFD VMC Group

2.02 EQUIPMENT BASES

A. Type BSF (Base-Steel Frame):

1. Steel base frames shall consist of structural steel section sized, spaced, and connected to form a rigid base which will not twist, rack, deform, or deflect in any manner which will negatively affect the operation of the supported equipment or the vibration isolation mounts. Frames shall be adequately sized to support basic equipment units and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure. The depth of steel frame shall be at least 1/10 the longest dimension of the base and not less than 6 in. The base footprint shall be large enough to provide stability for supported equipment.

2. Frame bases shall include side mounting brackets for attachment to vibration isolators. Mounting brackets shall be located on the sides of the base that are parallel to the axis of rotation of the supported equipment.

3. Type BSF bases shall be supplied by the isolator manufacturer and shall be one of the following products or approved equal:

a. Type WFSL M.I.

b. Type SFB or SRB K.N.C.

c. Series WFB VMC Group

B. Type BIB (Base-Inertia Base):

1. Concrete inertia bases shall be formed of stone-aggregate concrete (150 lb./cu. ft.) and appropriate steel reinforcing cast between welded or bolted perimeter structural steel channels. Inertia bases shall be built to form a rigid base that will not twist, rack, deform, deflect, or crack in any manner that would negatively affect the operation of the supported equipment or

the vibration isolation mounts. Inertia bases shall be adequately sized to support basic equipment units and motors plus any associated pipe elbow supports, duct elbow supports, electrical control elements, or other components closely related and requiring resilient support in order to prevent vibration transfer to the building structure. Inertia base depth shall be at least 1/12 the longest dimension of the inertia base and not less than 6 in. The base footprint shall be large enough to provide stability for supported equipment. Inertia bases shall include side mounting brackets for attachment to vibration isolators. Mounting brackets shall be located on the sides of the base that are parallel to the axis of rotation of the supported equipment.

2. The steel frame and reinforcement shall be supplied by the vibration isolator manufacturer.

3. Frame and reinforcement for Type BIB bases shall be one of the following products or approved equal:

   a. Type KSL M.I.

   b. Type CIB-L or CIB-H K.N.C.

   c. Series WPF VMC Group

2.03 RESILIENT PENETRATION SLEEVE/SEAL

A. Resilient penetration sleeve/seals shall be field-fabricated from a pipe or sheet metal section that is 1/2 in. to 3/4 in. larger than the penetrating element in all directions around the element, and shall be used to provide a sleeve through the construction penetrated. The sleeve shall extend 1 in. beyond the penetrated construction on each side. The space between the sleeve and the penetrating element shall be packed with glass fiber or mineral wool to within 1/4 in. of the ends of the sleeve. The remaining 1/4 in. space on each end shall be filled with acoustical sealant to form an airtight seal. The penetrating element shall be able to pass through the sleeve without contacting the sleeve. Refer to details on Drawings.

2.04 RESILIENT LATERAL SUPPORTS

A. These units shall either be a standard product of the vibration isolation mounting manufacturer, or be custom fabricated from standard components. These units shall incorporate neoprene isolation elements similar to Type FN that are specifically designed to provide resilient lateral bracing of ducts or pipe.

B. Resilient lateral supports shall be one of the following products or approved equal:

   1. Type ADA M.I.

   2. Type RGN K.N.C.

   3. Type MDPA VMC Group

2.05 FLEXIBLE DUCT CONNECTIONS

A. Flexible duct connections shall be heavy glass fabric, double neoprene coated, approximately 30 oz. per sq. yd. The clear space between connected parts shall be a minimum of 3 in. and the connection shall have a minimum of 1.5 in. of slack material. Materials for flex connection shall be fire retardant, water and milder resistant, and comply with UL standard 214.

B. Flexible duct connections shall be one of the following products or approved equal:

1. Ventfabrics, Inc. "Ventglass".
2. Ductmate Dyne Corp. "DDFDC".
3. Ductmate "Pro Flex".

2.06 FLEXIBLE PIPE AND PUMP CONNECTIONS (BRAIDED STAINLESS STEEL)

A. Braided stainless steel pump and pipe connector(s) shall be constructed of annular corrugated stainless steel close-pitch hose with stainless steel overbraid. The corrugated metal hose, braid(s) and a stainless steel ring-ferrule/band (material gauge not less than .048 in.) shall be integrally seal-welded using a 100% circumferential, full-penetration TIG weld. Fittings shall be attached using a 100% circumferential TIG weld.

B. Braided stainless steel pump and pipe connector(s) must be suitable for operating temperatures up to 850°F. The rated working pressure of the braided metal hose must have a minimum 4:1 safety factor.

C. Each braided stainless steel connector shall be individually leak tested by the manufacturer using air-under-water or hydrostatic pressure.

D. Braided stainless steel connectors shall carry a three (3) year warranty when installed in accordance with all specifications and installation instructions as described by the manufacturer.

E. End fittings shall be flat-faceplate steel flanges with 150# ANSI drilling, and outside diameter, carbon steel MPT ends, flanged by Schedule 40 grooved ends or increasing ends.

F. Acceptable Manufacturers: Flexhose Pumpsaver or equivalent Keflex, Metraflex, Mason-Mercer.

2.07 THRUST RESTRAINTS

A. Thrust restraints shall consist of a spring element in series with a neoprene pad. The unit shall be designed to have the same deflection due to thrust-generated loads as specified for the isolators supporting the equipment. The spring element shall be contained within a steel frame and be designed so it can be pre-compressed at the factory to allow for a maximum of 1/4 in. movement during starting or stopping of the equipment. Allowable movement shall be field-

adjustable. The assembly shall be furnished complete with rods and angle brackets for attachment to both equipment and the adjacent fixed structural anchor. The thrust restraints shall be installed on the discharge of the fan so that the restraint rods are in tension. Assemblies that place the rods in compression are not acceptable. The holes in the spring restraint brackets through which the restraint rods pass must be oversized to prevent contact between the brackets and rods.

B. Thrust restraints shall be one of the following products or an approved equal:

1. Type WB M.I.
2. Type HSR K.N.C.
3. Type HTR VMC Group

2.08 GROMMETS

A. Grommets shall be specially formed to prevent bolts from directly contacting the isolator base plate, and shall be sized so that they will be loaded within the manufacturer's recommended load range.

B. Grommets shall either be custom made by combining a neoprene washer and sleeve, or be one of the following products or an approved equal:

1. Type Isogrommets MBIS, Inc. (Bedford Heights, OH)
2. Type WB Barry Controls (Brighton, MA)
3. Type HG Mason Industries Inc., (Hauppauge, NY)

2.09 ACOUSTICAL SEALANT

A. Sealants for acoustical purposes as described in this specification shall be silicone or one of the non-setting sealants indicated below:

1.	Acoustical sealant	D.A.P.
2.	BR-96	Pecora
3.	Acoustical sealant	Tremco
4.	Acoustical sealant	U.S.G.

PART 3 - EXECUTION

3.01 APPLICATION

A. General:

1. Refer to the PRODUCTS section of this specification for vibration isolation devices identified on the Drawings or specified herein.
2. The static deflection of all isolators specified herein are the minimum acceptable deflections for the mounts under actual load. Isolators selected solely on the basis of rated deflection are not acceptable and will be disapproved.

B. Major Equipment:

1. Unless otherwise shown or specified on Drawings, all floor-mounted major equipment shall be set on 6 in. high concrete housekeeping pads.
2. Types and minimum static deflections of vibration isolation devices for major equipment items shall be as specified hereunder.
3. Flexible duct connections shall be installed at all fan unit intakes, fan unit discharges, and wherever else shown on the Drawings.
4. Flexible pipe connections shall be installed at all pipe connections to vibration-isolated equipment and as indicated on Drawings in the positions shown on the Drawings.
5. Electrical connections to vibration-isolated equipment shall be flexible, as called for in the electrical portion of the specification.
6. Thrust restraints shall be installed on all suspended fans and on all floor-mounted fans developing 4 in. or more of static pressure, unless the horizontal component of the thrust force can be demonstrated to be less than 10% of the equipment weight.

C. Equipment Vibration Isolation Schedule:

TYPE	VIBRATION ISOLATOR TYPE	MINIMUM STATIC DEFLECTION (In.)	EQUIPMENT BASE
Air Handling Units	FSN	2.5	BSF
Inline Pumps	HSN	.75	----
Boilers	DNP	NA	----
Inline Fans	HSN	1.5	----

NOTE 1: Equipment base and vibration isolators can be deleted where pumps are provided on slabs on grade and if pumps are placed on concrete inertia slab isolated from surrounding floor slab.

D. Miscellaneous Mechanical Equipment:

1. Miscellaneous pieces of mechanical equipment such as converters, pressure reducing stations, dryers, strainers, storage tanks, condensate receiver tanks and expansion tanks which are connected to isolated piping systems shall be vibration-isolated from the building structure by Type NP or Type HN isolators (selected for .01 in. static deflection) unless their position in the piping system requires a higher degree of isolation as called for under "Pipe Isolation".

E. Pipes:

1. All chilled water, condenser water, hot water, steam main and engine exhaust piping shall be isolated from the building structure within the following limits:

   a. Within mechanical rooms.

   b. Within 50 ft. total pipe length of connected vibration-isolated equipment (chillers, pumps, air handling units, pressure reducing stations, etc.).

   c. Piping shall be isolated from the building structure by means of vibration isolators, resilient lateral supports, and resilient penetration sleeve/seals.

   d. Isolators for the first three support points adjacent to connected equipment shall achieve one half the specified static deflection of the isolators supporting the connected equipment. When the required static deflection of these isolators is greater than 1/2 in., Type FSN or Type HSN isolators shall be used. When the required static deflection is less than or equal to 1/2 in., Type FN or Type HN isolators shall be used. All other pipe support isolators within the specified limits shall be either Type FN or Type HN achieving at least 1/4 in. static deflection.

   e. Where lateral support of pipes is required within the specified limits, this shall be accomplished by use of resilient lateral supports.

   f. Pipes penetrating the building construction shall be isolated from the building structure by use of resilient penetration sleeve/seals.

   g. Provide flexible pipe connections as called for under "Major Equipment" above and wherever shown on the Drawings.

3.02 INSTALLATION OF VIBRATION ISOLATION EQUIPMENT

A. General:

1. Locations of all vibration isolation devices shall be selected for ease of inspection and adjustment as well as for proper operation.

2. Installation of vibration isolation equipment shall be in accordance with the manufacturer's instructions.

B. Isolators:

1. All vibration isolators shall be aligned squarely above or below mounting points of the supported equipment.

2. Isolators for equipment with bases shall be located on the sides of the bases which are parallel to the equipment shaft unless this is not possible because of physical constraints.

3. Locate isolators to provide stable support for equipment, without excess rocking. Consideration shall be given to the location of the center of

gravity of the system and the location and spacing of the isolators. If necessary, a base with suitable footprint shall be provided to maintain stability of supported equipment, whether or not such a base is specifically called for herein.

4. If a housekeeping pad is provided, the isolators shall bear on the housekeeping pad and the isolator base plates shall rest entirely on the pad.
5. Hanger rods for vibration-isolated support shall be connected to structural beams or joists, not the floor slab between beams and joists. Provide suitable intermediate support members as necessary.
6. Vibration isolation hanger elements shall be positioned as high as possible in the hanger rod assembly, but not in contact with the building structure, and so that the hanger housing may rotate a full 360° about the rod axis without contacting any object.
7. Parallel running pipes may be hung together on a trapeze that is isolated from the building. Isolator deflections must be the greatest required by the provisions for pipe isolation for any single pipe on the trapeze. Do not mix isolated and un-isolated pipes on the same trapeze.
8. Pipes, ducts and equipment shall not be supported from other pipes, ducts and equipment.
9. Resiliently isolated pipes, ducts and equipment shall not come in rigid contact with the building construction or rigidly supported equipment.
10. The installed and operating heights of equipment vibration-isolated with Type FSNTL isolators shall be identical. Limit stops shall be out of contact during normal operation. Adjust isolators to provide 1/4 in. clearance between the limit stop brackets and the isolator top plate, and between the travel limit nuts and travel limit brackets.
11. Adjust all leveling bolts and hanger rod bolts so that the isolated equipment is level and in proper alignment with connecting ducts or pipes.

C. Bases:

1. No equipment unit shall bear directly on vibration isolators unless its own frame is suitable rigid to span between isolators and such direct support is approved by the equipment manufacturer. This provision shall apply whether or not a base frame is called for on the schedule. In the case that a base frame is required for the unit because of the equipment manufacturer's requirements, and is not specifically called for on the equipment schedule, a base frame recommended by the equipment manufacturer shall be provided at no additional expense.
2. Unless otherwise indicated, there is to be a minimum operating clearance of 1 in. between steel rails, steel frame base or inertia bases and the floor beneath the equipment. The isolator mounting brackets shall be positioned and the isolators adjusted so that the required clearance is maintained. The clearance space shall be checked by the Contractor to

ensure that no construction debris has been left to short circuit or restrict the proper operation of the vibration isolation system.

D. Flexible Duct Connections:

1. Sheet metal ducts and plenum openings shall be squarely aligned with the fan discharge, fan intake, or adjacent duct section prior to installation of the flexible connection, so that the clear length is approximately equal all the way around the perimeter. Flexible duct connections shall not be installed until this provision is met. There shall be no metal-to-metal contact between connected sections, and the fabric shall not be stretched taut.

E. Flexible Pipe Connections:

1. Install flexible pipe connections in strict accordance with the manufacturer's instructions.

F. Thrust Restraints:

1. Thrust restraints shall be attached on each side of the fan at the vertical centerline of thrust. The two rods of the thrust restraints shall be parallel to the thrust force. This may require custom brackets or standoffs. The body of the thrust restraint shall not come in contact with the connected elements. Thrust restraints shall be adjusted to constrain equipment movement to the specified limit.

G. Grommets:

1. Where grommets are required at hold down bolts of isolators, bolt holes shall be properly sized to allow for grommets. The hold down bolt assembly shall include washers to distribute load evenly over the grommets. Bolts and washers shall be galvanized.

H. Resilient Penetration Sleeve/Seals:

1. Maintain an airtight seal around the penetrating element and prevent rigid contact between the penetrating element and the building structure. Fit the sleeve tightly to the building construction and seal airtight on both sides of the construction penetrated with acoustical sealant.

END OF SECTION

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SECTION 23 05 50
WIND RESTRAINT FOR HVAC SYSTEMS

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. Support and brace mechanical and electrical systems, as called for, to resist directional wind forces (lateral, longitudinal and vertical).

1.02 APPLICABLE CODES AND STANDARDS

A. Provide work in compliance with the following codes and standards:

B. 2015 International Building Code (Section 1609).

C. 2015 International Mechanical Code (Section 301, Item 301.15).

D. American Society of Civil Engineers (ASCE) Minimum Design Loads for Buildings and Other Structures with Supplement No. 1 - Standard ASCE/SEI 7-10.

1.03 QUALITY ASSURANCE

A. General:

1. The contractor shall provide professional engineer stamped and signed calculations, and details of wind restraint systems to meet total design lateral force requirements for support and restraint of mechanical and electrical systems.
2. Systems requiring wind restraint including, but not limited to:
    a. Exhaust fans.
    b. Hooded intake or relief ventilators.
    c. Condensing units.
    d. Ductwork.
    e. Piping.
    f. Boiler flues.
    g. Roof curbs and pipe/duct/equipment supports associated with any of the equipment listed above.

1.04 SUBMITTALS

A. Submit wind force level (Fp) calculations from applicable building code. Submit pre-approved restraint selections, installation details, and plans indicating locations of restraints.

B. Calculations, plans, restraint selection, and installation details shall be stamped and signed by a professionally licensed engineer experienced in wind restraint design.

C. Submit manufacturer's product data.

D. For each piece of equipment that requires wind restraint as outlined in this section, include the following:

1. Dimensioned Outline Drawings of Equipment Unit: Identify the center of gravity and locate and describe mounting and anchoring provisions.

2. Anchorage: Provide detailed description of equipment anchorage devices on which the calculations are based and their installation requirements. Identify anchor bolts, studs and other mounting devices. Provide information on the size, type and spacing of mounting brackets, holes and other provisions.

E. The Contractor shall provide photographs of the installed roof mounted equipment, showing the fully installed wind restraint anchoring, prior to the roofing material installation, as a formal submittal for verification that the work has been completed.

PART 2 - PRODUCTS

2.01 CODE INFORMATION

A. This project is subject to the wind bracing requirements of the 2015 International Building Code (Section 1609) and American Society of Civil Engineers ASCE/SEI 7-10. The following criteria are applicable to this project:

1. Nominal Design Wind Speed (V) (Per ASCE 7-10): 115 mph.

2. Risk Category (Per ASCE 7-10): II

3. Exposure Category (Per ASCE 7-10): C

4. Height and Exposure Adjustment Coefficient (Per ASCE 7-10): N/A - Building height is less than 60 ft.

2.02 WIND BRACING AND SUPPORT OF SYSTEMS AND COMPONENTS

A. General:

1. Design analysis shall include calculated dead loads, wind loads, and capacity of materials utilized for the connection of the equipment or system to the structure.

2. Analysis shall detail anchoring methods, bolt diameter, and embedment depth.

3. All wind restraint devices shall be designed to accept without failure the forces calculated per the applicable building code and as summarized in Section 2.1.

B. Friction from gravity loads shall not be considered resistance to wind forces.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Wind Restraint of Piping:

1. All restraint systems shall be installed in strict accordance with the manufacturer's restraint guidelines and all certified data.
2. Installation of restraints shall not cause any change in position of equipment or piping, resulting in stresses or misalignment.
3. Transverse piping restraints shall be at 40 ft. maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
4. Longitudinal restraints shall be at 80 ft. maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
5. Transverse restraint for one pipe section may also act as a longitudinal restraint for a pipe section of the same size connected perpendicular to it if the restraint is installed within 24 in. of the elbow or tee or combined stresses are within allowable limits at longer distances.
6. Hold down clamps must be used to attach pipe to all trapeze members before applying restraints.
7. Branch lines may not be used to restrain main lines.
8. Provide reinforced clevis bolts when required.
9. Piping crossing building seismic or expansion joints, passing from building to building, or supported from different portions of the building shall be installed to allow differential support displacements without damaging the pipe, equipment connections, or support connections. Pipe offsets, loops, anchors, and guides shall be installed as required to provide specified motion capability and limit motion of adjacent piping.
10. Do not brace a system to two independent structures such as roof and wall.

B. Wind Restraint of Electrical Services:

1. All restraint systems shall be installed in strict accordance with the manufacturer's restraint guidelines manual and all certified data.
2. Installation of restraints shall not cause any change in position of equipment or piping, resulting in stresses or misalignment.
3. No rigid connections between equipment and the building structure shall be made that degrade the noise and vibration-isolation system specified.
4. Do not install any equipment, piping, duct, or conduit that makes rigid connections with the building unless isolation is not specified.

5. Prior to installation, bring to the Architect's/Engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.
6. Bracing may occur from flanges of structural beams, upper truss cords of bar joists, cast in place inserts, or wedge-type concrete anchors. Consult Structural Engineer of record.
7. Overstressing of the building structure shall not occur from overhead support of equipment. Bracing attached to structural members may present additional stresses. The Contractor shall submit loads to the structural engineer of record for approval in this event.
8. Brace support rods when necessary to accept compressive loads. Welding of compressive braces to the vertical support rods is not acceptable.
9. Provide reinforced clevis bolts where required.
10. Do not brace a system to two independent structures such as a roof and wall.

C. Wind Restraint of Ductwork and Equipment:

1. All restraint systems shall be installed in strict accordance with the manufacturer's restraint guidelines and all certified submittal data.
2. The interaction between mechanical and electrical equipment and the supporting structures shall be designed into the restraint systems.
3. Friction clips shall not be used for anchorage attachments.
4. Expansion anchors shall not be used for non-vibration isolated equipment rated over 10 HP.
5. Components mounted on vibration isolation systems shall have a bumper restraint or snubber in each horizontal direction and vertical restraints shall be provided to resist overturning.
6. Installation of restraints shall not cause any change in position of equipment or ductwork, resulting in stresses or misalignment.
7. Exhaust fans with hinge kits shall have wind restraint fasteners installed on the hinged side, same as the three (3) non-hinged sides.
8. No rigid connections between equipment and the building structure shall be made that degrade the noise and vibration-isolation system specified.
9. Do not install any equipment or duct that makes rigid connections with the building unless isolation is not specified.
10. Prior to installation, bring to the Architect's/Engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.
11. Bracing may occur from flanges of structural beams, upper truss cords of bar joists, cast in place inserts, or wedge-type concrete anchors. Consult Structural Engineer of record.

12. Overstressing of the building structure shall not occur from overhead support of equipment. Bracing attached to structural members may present additional stresses. The Contractor shall submit loads to the Structural Engineer of record for approval in this event.
13. Brace support rods when necessary to accept compressive loads. Welding of compressive braces to the vertical support rods is not acceptable.
14. Provide reinforced clevis bolts where required.
15. Do not brace a system to two independent structures such as a roof and wall.

END OF SECTION

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SECTION 23 05 53
MECHANICAL IDENTIFICATION

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.02 QUALIFICATION

A. All identification devices shall comply with ANSI/ASME A13.1 for lettering size, length of color field, colors and viewing angles.

1.03 SUBMITTALS

A. Submit manufacturer's technical product data and installation instructions for each identification material and device. Submit valve schedule for each piping system typewritten on an 8-1/2 in. x 11 in. (minimum) indicating valve number, location, and valve function. Submit schedule of pipe, equipment and name identification for review before stenciling or labeling.

1.04 MAKES

A. Allen Systems, Inc.; Brady (W.H.) Co.; Signmark Div.; Industrial Safety Supply Co., Inc.; Seton Name Plate Corp.

PART 2 - PRODUCTS

2.01 GENERAL

A. Provide manufacturer's standard products of categories and types required for each application. In cases where this is more than one type specified for an application, selection is installer's option, but provide single selection for each product category.

B. All adhesives used for labels in the interior of the building shall comply with the maximum Volatile Organic Compound (VOC) limits as called for in the current version of U.S. Green Building Council LEED Credits EQ 4.1 and EQ 4.2.

2.02 PIPING IDENTIFICATION

A. Identification Types:

1. Pressure Sensitive Type: Provide manufacturer's standard pre-printed, permanent adhesive, color coded, pressure sensitive vinyl pipe markers complying with ANSI/ASME A13.1. Provide a 360° wrap of flow arrow tape at each end of pipe label.

O.D. Pipe or Covering	Letter Size
3/4 in., 1 in., 1-1/4 in.	1/2 in.
1-1/2 in., 2 in.	3/4 in.
2-1/2 in. and over	1 in.

B. Lettering:

1. Piping labeling shall conform to the following list:

Pipe Function	Identification
Cold Water	CW
Refrigerant Suction	RS
Refrigerant Liquid	RL
Glycol Supply	GS
Glycol Return	GR

2.03 VALVE IDENTIFICATION

A. Valve Tags:

1. Standard brass valve tags, 2 in. diameter with 1/2 in. high numerals. Identify between heating and plumbing services with 1/4 in. letters above the valve number. Lettering to be stamped and in-filled black. Seton, or equal.

a. Valve-tag Fasteners: Brass wire-link or beaded chain; or S-hook.

B. Valve Chart:

1. Provide valve chart for all valves tagged as a part of this project. Frame and place under clear glass. Hang in Mechanical Room.
2. Valve chart to include as a minimum, valve #, valve size, valve type, valve service description, valve location.

2.04 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, phenolic (micarta) labels for mechanical engraving, 1/16 in. thick, and having predrilled holes for attachment hardware.
2. Letter Color: White.

3. Background Color: Black.
4. Maximum Temperature: Able to withstand temperatures up to 160 F.
5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 in. by 3/4 in.
6. Minimum Letter Size: 1/4 in. for name of units if viewing distance is less than 24 in., 1/2 in. for viewing distances up to 72 in., and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
7. Fasteners: Stainless-steel rivets or self-tapping screws.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Label Content: Include equipment's Drawing designation or unique equipment number.

C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2 in. x 11 in. 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.

D. Provide for the following equipment:
1. Air handling units
2. Pumps
3. Air Cooled Condenser
4. Boilers
5. H&V units
6. Energy recovery coil
7. Fans

2.05 ABOVE CEILING EQUIPMENT LOCATOR

A. 3/4 in. diameter adhesive stickers placed on ceiling grid. Color coded. Provide for the following:
1. Fire dampers/smoke dampers - RED
2. Plumbing valves - BLUE
3. HVAC valves - ORANGE
4. VAV boxes or reheat coils - GREEN
5. Fans - YELLOW
6. Pumps - BLACK

PART 3 - EXECUTION

3.01 GENERAL

A. Provide valve tags for all valves provided on project, except for service valves at terminal equipment.

B. Provide equipment tags for all equipment listed above.

C. Provide above ceiling equipment locator stickers on ceiling grid for all equipment listed above.

D. Provide piping identification with directional flow arrows for all piping on project, at maximum intervals of 20 ft. For piping installed through rooms, provide at least one pipe label in each room, for each pipe function.

END OF SECTION

SECTION 23 05 93
TESTING, ADJUSTING AND BALANCING

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for complete adjusting and balancing Work as required in Contract Documents.

B. This Section specifies the requirements and procedures of, mechanical systems testing, adjusting, and balancing. Requirements include measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results.

C. Test, adjust, and balance the following mechanical systems:

1. Supply air systems, all pressure ranges; including constant volume and variable volume systems.
2. Return air systems.
3. Exhaust air systems; including kitchen exhaust systems.
4. Hydronic systems; including constant flow and variable flow systems.
5. Laboratory Fume Hoods.

D. This Section does not include:

1. Testing boilers and pressure vessels for compliance with safety codes;
2. Specifications for materials for patching mechanical systems;
3. Specifications for materials and installation of adjusting and balancing devices. If devices must be added to achieve proper adjusting and balancing, refer to the respective system sections for materials and installation requirements.
4. Requirements and procedures for piping and ductwork systems leakage tests.

1.02 SUBMITTALS

A. Provide information in report form listing items required by specifications. Results shall be guaranteed. Contractor shall be subject to recall to site to verify report information before acceptance of the report by the Owner's Representative.

B. Strategies and Procedures Plan: Within thirty (30) days of Contractor's Notice to Proceed, submit testing and balancing strategies and step-by-step procedures as specified in Section 3.1.B, "Preparation", and consistent with those listed in Part 3 of this specification.

C. System Readiness Checklists: Within thirty (30) days of Contractor's Notice to Proceed, AABC agency shall provide system readiness checklists as specified in

Section 3.1.C, "Preparation", to be used and filled out by the installing contractors verifying that systems are ready for Testing and Balancing.

D. Examination Report: Provide a summary report of the examination review required in Section 3.1.D to the Engineer, documenting issues that may preclude the proper testing and balancing of the systems.

E. Certified report format shall consist of the following:

1. Title sheet with job name, contractor, engineer, date, balance contractor's name, address, telephone number and contact person's name and the balancing technician's name.
2. Individual test sheets for air handlers, terminal units, air distribution, exhaust fans, duct traverses, pumps, air handling coils, reheat coils, radiation, convectors, cabinet unit heaters and unit ventilators.
3. Manufacturer's pump and fan curves for equipment installed with design and actual operating conditions indicated.
4. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems".

1.03 DEFINITIONS

A. System testing, adjusting and balancing is the process of checking and adjusting all the building environmental systems to produce the design objectives. It includes:

1. The balance of air and water distribution;
2. Adjustment of total system to provide design quantities;
3. Electrical measurement;
4. Verification of performance of all equipment and automatic controls.

B. Test: To determine quantitative performance of equipment.

C. Adjust: To regulate the specified fluid flow rate and air patterns at the terminal equipment (e.g., reduce fan speed, throttling).

D. Balance: To proportion flows within the distribution system (submains, branches, and terminals) according to specified design quantities.

E. Procedure: Standardized approach and execution of sequence of work operations to yield reproducible results.

F. Report Forms: Test data sheets arranged for collecting test data in logical order for submission and review. This data should also form the permanent record to be used as the basis for required future testing, adjusting, and balancing.

G. Terminal: The point where the controlled fluid enters or leaves the distribution system. There are supply inlets on water terminals, supply outlets on air terminals, return outlets on water terminals, and exhaust or return supply or outside air inlets or outlets on terminals such as registers, grilles, diffusers, and louvers.

H. Main: Duct or pipe containing the system's major or entire fluid flow.

I. Submain: Duct or pipe containing part of the systems' capacity and serving two or more branch mains.

J. Branch Main: Duct or pipe serving two or more terminals.

K. Branch: Duct or pipe serving a single terminal.

1.04 QUALIFICATIONS

A. Follow procedures and methods published by one or more of the following:

1. Associated Air Balance Council (AABC) or National Environmental Balancing Bureau (NEBB).
2. Individual manufacturer requirements and recommendations.

B. Maintain qualified personnel at project for system operation and trouble shooting. Contractor shall change sheaves and perform mechanical adjustments in conjunction with balancing procedure.

C. Contractor shall be current member of AABC or NEBB.

D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in the *AABC National Standards for Total System Balance.*

1.05 GENERAL REQUIREMENTS

A. Before concealment of systems visit the job site to verify and advise on type and location of balancing devices and test points. Make changes as required to balance facilities.

B. Place systems in satisfactory operating condition.

1. Adjusting and balancing shall be accomplished as soon as the systems are complete and before Owner takes possession.
2. Prior to balancing, adjust balancing devices for full flow; fill, vent and clean hydronic systems, replace temporary filters and strainers.
3. Initial adjustment and balancing to quantities as called for or as directed by the engineer, to satisfy job conditions.
4. All outdoor conditions (Db, Wb, and a description of the weather conditions) at the time of testing shall be documented in the report.
5. Provide sheaves and belts as required to meet system performance requirements for all belt-driven fan motors 10 HP and greater. Adjust and

align sheaves to obtain proper settings and operation. Verify motors are not overloading.

6. Contractor shall replace balancing cocks, flow balancers and dampers in new systems that cannot be manipulated to satisfy balancing requirements.
7. Identify flow balancers, balancing cocks and dampers in existing systems that cannot be manipulated to satisfy balancing requirements.
8. Traverse main ducts to determine total system air quantities after all outlets have been set prior to final adjustment if the system does not meet design requirements. A sum of room CFM's is not acceptable.
9. If duct construction and/or installation prohibits proper traverse readings, provide coil measurements at main coils and/or fresh air intake traverse with units operating in 100% outside air mode (where applicable).

1.06 CONTRACTOR RESPONSIBILITIES

A. Provide Testing and Balancing agency one complete set of contract documents, change orders, and approved submittals in digital and hard copy formats.

B. Contractor shall provide required BAS hardware, software, personnel and assistance to Testing and Balancing agency as required to balance the systems. Contractor shall also provide trending report to demonstrate that systems are complete.

C. Coordinate meetings and assistance from suppliers and contractors as required by Testing and Balancing agency.

D. Provide additional valves, dampers, sheaves and belts as required by Testing and Balancing agency.

E. Flag all manual volume dampers with fluorescent or other high-visibility tape.

F. Provide access to all dampers, valves, test ports, nameplates and other appurtenances as required by Testing and Balancing agency.

G. Contractor shall replace or repair insulation as required by Testing and Balancing agency.

H. Have the HVAC systems at complete operational readiness for Testing and Balancing to begin. As a minimum verify the following:
   1. Airside:
      a. All ductwork is complete with all terminals installed.
      b. All volume, smoke and fire dampers are open and functional.
      c. Clean filters are installed.
      d. All fans are operating, free of vibration, and rotating in correct direction.
      e. ASD start-up is complete and all safeties are verified.

f. System readiness checklists are completed and returned to Testing and Balancing agency.

2. Hydronics:

a. Piping is complete with all terminals installed.

b. Water treatment is complete.

c. Systems are flushed, filled and air purged.

d. Strainers are pulled and cleaned.

e. Control valves are functioning per the sequence of operation.

f. All shutoff and balance valves have been verified to be 100% open.

g. Pumps are started, and proper rotation is verified.

h. Pump gauge connections are installed directly at the pump inlet and outlet flange or in discharge and suction pipe prior to any valves or strainers.

i. ASD start-up is complete and all safeties have been verified.

j. System readiness checklists are completed and returned to Testing and Balancing agency.

I. Promptly correct deficiencies identified during Testing and Balancing.

J. Maintain a construction schedule that allows the Testing and Balancing agency to complete work prior to occupancy.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Provide tools, ladders, recording meters, gauges, thermometers, velometers, anemometers, Pitot tubes, inclined gauge manometers, magnehelic gauges, amprobes, voltmeters, psychrometers and tachometers required.

B. Instrumentation Calibration: Calibrate instruments at least every six (6) months or more frequently if required by instrument manufacturer.

1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

PART 3 - EXECUTION

3.01 PREPARATION

A. Examine Bid Documents and submittals and notify Owner's Representative and Engineer of any questions regarding balancing.

1. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper Testing and Balancing of systems and equipment.

2. Examine the approved submittals for HVAC systems and equipment.
3. Examine equipment performance data including fan and pump curves.

B. Prepare a Testing and Balancing Strategies and Procedures Plan that includes:
1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.
3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

C. Prepare system-readiness checklists, as described in the *AABC National Standards for Total System Balance*, for use by contractor in verifying system readiness for Testing and Balancing. These shall include, at a minimum:
1. Airside:
a. All ductwork is complete with all terminals installed.
b. All volume, smoke and fire dampers are open and functional.
c. Clean filters are installed.
d. All fans are operating, free of vibration, and rotating in correct direction.
e. Permanent electrical power wiring and ASD start-up is complete and all safeties are verified.
f. Automatic temperature-control systems are operational.
g. Ceilings are installed.
h. Windows and doors are installed.
i. Suitable access to balancing devices and equipment is provided.
j. Equipment and duct access doors are securely closed.
2. Hydronics:
a. Piping is complete with all terminals installed.
b. Water treatment is complete.
c. Systems are flushed, filled and air purged.
d. Strainers are pulled and cleaned.
e. Control valves are functioning per the sequence of operation.
f. All shutoff and balance valves have been verified to be 100% open.
g. Pumps are started and proper rotation is verified.
h. Pump gauge connections are installed directly at the pump inlet and outlet flange or in discharge and suction pipe prior to any valves or strainers.
i. Permanent electrical power wiring and ASD start-up is complete and all safeties are verified.

j. Suitable access to balancing devices and equipment is provided.

D. Examine construction and notify Owner's Representative and Engineer of outstanding issues related to balancing, as part of "Examination Report" submittal.

1. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they are properly separated from adjacent areas.
2. Examine HVAC equipment and verify that bearings are greased, belts are aligned and tight, clean permanent filters are installed, and controls are ready for operation.
3. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected, configured by the contractor and functioning.
4. Examine strainers to verify that Contractor has replaced startup screens with permanent screens and that all strainers have been cleaned.
5. Examine two-way valves for proper installation and function.
6. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
7. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
8. Examine air vents to verify that contractor has removed all air from all hydronic systems.
9. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, weld-o-lets, and manual volume dampers prior to pressure testing. Note the locations of devices that are not accessible for testing and balancing.

3.02 GENERAL PROCEDURES FOR TESTING AND BALANCING

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

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve

position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.

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

3.03 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. 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 outside-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 function.

K. Check for proper sealing of air-handling unit components.

L. Check for proper sealing of air duct system.

3.04 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:

a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.

b. Measure static pressure directly at the fan outlet or through the flexible connection.

c. Measure inlet static pressure of single-inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.

d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and treating equipment.

a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.

4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.

5. Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to sheaves sizes, motor sizes, and electrical connections to accommodate fan-speed changes.

6. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved.

a. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

2. Re-measure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure terminal outlets and inlets without making adjustments.

1. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.05 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

1. Set outside-air dampers at minimum, and return-and exhaust-air dampers at a position that simulates full-cooling load.
2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
3. Measure total system airflow. Adjust to within indicated airflow.
4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
    a. If air outlets are out of balance at minimum airflow, report the conditions but leave outlets balanced for maximum airflow.
6. Re-measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that the adequate static pressure is maintained at the most critical unit.
8. Record the final fan performance data.

3.06 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils and heat exchangers. Obtain approved submittals and any manufacturer-recommended testing procedures. Cross check the summation of required coil and heat exchanger gpms with pump design flow rate.

B. Verify that hydronic systems are ready for testing and balancing:

1. Check liquid level in expansion tank and verify that tank is set to specified pressure for system fill and expansion.
2. Check that makeup water has adequate pressure to highest vent.
3. Check that control valves are in their proper positions.
4. Check that air has been purged from the system.
5. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
6. Verify that motor starters are equipped with properly sized thermal protection.

3.07 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design gpm.

1. Measure total water flow.
    a. Position valves for full flow through coils.
    b. Measure flow by main flow meter, if installed.
    c. If main flow meter is not installed, determine flow by pump total dynamic head (TDH) or exchanger pressure drop.
2. Measure pump TDH as follows:
    a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves or fittings.
    b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
    c. Convert pressure to head and correct for differences in gauge heights.
    d. On single stage centrifugal pumps, verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
    e. With all valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.
3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

B. Adjust flow measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted

C. Adjust flow measuring devices installed at terminals for each space to design water flows.

1. Measure flow at all terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after all have been adjusted,.
4. Position control valves to bypass the coil and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after all flows have been balanced,.

D. For systems with pressure-independent valves at the terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.
2. Perform temperature tests after all flows have been verified.

E. For systems without pressure-independent valves or flow measuring devices at the terminals:

1. Measure and balance coils by either coil pressure drop or temperature method.
2. If balanced by coil pressure drop, perform temperature tests after all flows have been verified, if requested by Engineer.

F. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure all final pump operating data, TDH, volts, amps, static profile.
3. Mark all final settings.

G. Verify that all memory stops have been set.

3.08 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Adjust the variable-flow hydronic system as follows:

1. Verify that the differential pressure (DP) sensor is located per the Contract Documents.
2. Determine if there is diversity in the system.

B. For systems with no diversity:

1. Follow procedures outlined for constant-flow hydronic systems.

2. Prior to verifying final system conditions, determine the system DP setpoint.

3. If the pump discharge valve was used to set total system flow with ASD at 60 Hz, at completion open discharge valve 100% and allow ASD to control system DP setpoint. Record pump data under both conditions.

4. Mark all final settings and verify that all memory stops have been set.

C. For systems with diversity:

1. Determine diversity factor.

2. Simulate system diversity by closing required number of control valves, as approved by the design Engineer.

3. Follow procedures outlined for constant flow hydronic systems.

4. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance the terminals that were just opened.

5. Prior to verifying final system conditions, determine the system DP setpoint.

6. If the pump discharge valve was used to set total system flow with ASD at 60 Hz, at completion open discharge valve 100% and allow ASD to control system DP setpoint. Record pump data under both conditions.

7. Mark all final settings and verify that all memory stops have been set.

D. For systems with pressure-independent valves at the terminals:

1. Measure differential pressure and verify that it is within manufacturer's specified range.

2. Perform temperature tests after all flows have been verified.

3.09 PROCEDURES FOR LABORATORY FUME HOODS

A. Before performing laboratory fume hood testing, measure, adjust and record the supply airflow and airflow patterns of each supply air outlet that is located in the same room as the hood. Adjust the air outlet flow pattern to minimize turbulence and to achieve the desired airflow patterns at the face and inside the hood. Verify that adequate make-up air is available to achieve the indicated flow of the hood.

B. Measure, adjust and record the airflow of each laboratory fume hood by duct Pitot-tube traverse with the laboratory fume hood sash in the design open position.

1. For laboratory fume hoods installed in variable exhaust systems, measure adjust, and record the hood exhaust airflow at maximum and at minimum airflow conditions.

2. For laboratory fume hoods designed with integral make-up air, measure, adjust, and record the exhaust and make-up airflow.

C. For laboratory fume hoods that are connected to centralized exhaust systems using automatic dampers, adjust the damper controller to obtain the indicated exhaust airflow.

D. After balancing is complete, do the following:

1. Measure and record the static pressure at the hood duct connection with the hood operating at indicated airflow.

2. Measure and record the face velocity across the open sash face area. Measure the face velocity at each point in a grid pattern. Perform measurements at a maximum of 12 in. between points and between any point and the perimeter of the opening.

   a. For laboratory fume hoods designed to maintain a constant face velocity at varying sash positions, also measure and record the face velocity at 50 and 25 percent of the design open sash position.

   b. Calculate and report the average face velocity by averaging all velocity measurements.

   c. Calculate and report the exhaust airflow by multiplying the calculated average face velocity by the sash open area. Compare this quantity with the exhaust airflow measured by duct Pitot-tube traverse. Report differences.

   d. If the average face velocity is less than the indicated face velocity, retest the average face velocity and adjust hood baffles, fan drives, and other parts of the system to provide the indicated average face velocity.

3. Check each laboratory fume hood for the capture and containment of smoke by using a hand-held emitting device. Observe the capture and containment of smoke flow pattern across the open face and inside the hood. Make adjustments necessary to achieve the desired results.

E. With the room and laboratory fume hoods operating at indicated conditions all fume hoods installed shall be tested to current ASHRAE 110 Standard. Field test reports must be performed and prepared by an independent third party organization having no affiliation with the manufacturer. Results must indicate tracer gas performance ratings of 4.0 AI 0.05 or better for all tests. Manufacturer must have a representative on-site for all tests and must assist in trouble-shooting and correcting all non-conforming hoods.

F. Person-as-Mannequin Test: This test is intended to simulate real-world laboratory conditions in which a real person manipulates real objects in the hood. This test is performed with the investigator standing in front of the ejector while repeatedly moving five (5) objects from one side of the ejector to the other, then rotating the body away from the hood with the elbows next to the body and the arms horizontal in front. This series of movements is repeated for the duration of the tracer gas test. The air sampling is performed with a sampling probe at the same

height as the breathing zone of the mannequin. Results must indicate tracer gas performance ratings of 4.0 AI 0.10 or better for all tests.

G. Contractor to provide a complete report of the results of the testing program including an executive summary, an outline of the test procedures and equipment used, a table of the results of each test conducted on each hood and a conclusion and recommendation section discussing the results and (if necessary) recommendations to improve fume hood performance.

3.10 TOLERANCES

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

1. Supply, Return, and Exhaust Fans: Zero to plus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Minimum Outside Air: Zero to plus 10 percent.
4. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.
5. Heating-Water Flow Rate: Plus or minus 10 percent.
6. Cooling-Water Flow Rate: Plus or minus 10 percent.

3.11 FINAL TEST AND BALANCE REPORT

A. The report shall be a complete record of the HVAC system performance, including conditions of operation, items outstanding, and any deviations found during the Testing and Balancing process. The final report also provides a reference of actual operating conditions for the owner and/or operations personnel. All measurements and test results that appear in the reports must be made on site and dated by the technicians or Test and Balance Engineers.

B. The report must be organized by systems and shall include the following information as a minimum:

1. Title Page:
    a. AABC or NEBB Certified Company Name.
    b. Company Address.
    c. Company Telephone Number.
    d. Project Identification Number.
    e. Location.
    f. Project Architect.
    g. Project Engineer.
    h. Project Contractor.
    i. Project Number.
    j. Date of Report.

k. Certification Statement.

l. Name, Signature, and Certification Number.

2. Table of Contents.

3. National Performance Guaranty.

4. Report Summary:

a. The summary shall include a list of items that do not meet design tolerances, with information that may be considered in resolving deficiencies.

5. Instrument List:

a. Type

b. Manufacturer

c. Model

d. Serial Number

e. Calibration Date

C. Required air side data - Test, adjust and record the following:

1. Motors:

a. RPM

b. BHP

c. Full load amps

d. Sheave sizes, number and size of belts

e. Shaft diameter

f. Complete nameplate data

2. Fans:

a. Cfm

b. RPM

c. Suction static pressure

d. Discharge static pressure

e. Sheave sizes, number and size of belts, key sizes, shaft, diameter

f. Complete nameplate data

g. Sketch of system's inlet and outlet connections

h. Location of test port

3. Duct: Traverse Zones

a. Cfm

b. Static Pressure

4. AHU - Fan coil units (In both minimum O.A. and economizer modes):

a. Minimum outdoor air Cfm

b. Total discharge and return Cfm
c. Static profile thru unit
d. Complete nameplate data

5. Coil:
   a. Entering air temperature (DB/WB)
   b. Leaving air temperature (DB/WB)
   c. Static differential
   d. Face velocity and area
   e. Cfm
   f. Complete nameplate data
6. VAV Boxes:
   a. Minimum Cfm
   b. Maximum Cfm
7. Registers/Grilles/Diffusers:
   a. Cfm
   b. Set, adjust and record air flow pattern
8. Filter Banks:
   a. Nameplate data
   b. Static pressure drop

D. Required Fluid Data: Test, adjust and record the following:
   1. Heat Transfer Devices: Including, but not limited to air handlers, convectors, fin tube radiation sections, unit ventilators, fan coils, cabinet heaters, unit heaters, heat pumps, heat exchangers.
      a. GPM (coil and bypass)
      b. Entering water temperature
      c. Leaving water temperature
      d. Water pressure drop
      e. Complete nameplate data
      f. Refrigerant suction pressure and temperature
   2. Pumps:
      a. Check rotation
      b. GPM
      c. Pump off pressures (suction and discharge)
      d. Running suction pressure
      e. Running discharge pressure
      f. Running load amps

g. RPM - motor

h. Complete nameplate motor and pump

i. Marked up pump curve illustrating final operating conditions

3. Boilers:

a. GPM

b. Entering water temperature and pressure

c. Leaving water temperature and pressure

d. Complete nameplate data

E. The final test and balance report shall be provided as a formal project submittal for review by the Engineer of Record.

END OF SECTION

SECTION 23 07 10
INSULATION

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services to perform operations required for the complete installation and related Work as required in Contract Documents.

1.02 SUBMITTAL

A. Submit product data, product description, manufacturer's installation instructions, types and recommended thicknesses for each application, and location of materials.

1.03 RELATED WORK SPECIFIED ELSEWHERE

A. Section 232010 - Piping Systems and Accessories.

B. Section 233100 - Sheet Metal and Ductwork Accessories Construction.

PART 2 - PRODUCTS

2.01 GENERAL

A. Insulation, jackets, adhesive, and coatings shall comply with the following:

1. Treatment of jackets or facing for flame and smoke safety must be permanent. Water-soluble treatments not permitted.
2. Insulation, including finishes and adhesives on the exterior surfaces of ducts, pipes, and equipment, shall have a flame spread rating of 25 or less and a smoke developed rating of 50 or less, when tested in accordance with ASTM E84.
3. Asbestos or asbestos bearing materials are prohibited.
4. Comply with 2015 International Energy Conservation Code as amended by Part 1 of the 2017 Supplement to the New York State Energy Conservation Code.
5. All adhesives, coatings and sealants used for insulation in the interior of the building shall comply with the maximum Volatile Organic Compound (VOC) limits as called for in the current version of U.S. Green Building Council LEED Credits EQ 4.1 and EQ 4.2.
6. Provide materials which are the standard products of manufacturers regularly engaged in the manufacture of such products and that essentially duplicate items that have been in satisfactory use for at least two (2) years prior to bid opening. Provide insulation systems in accordance with the approved MICA or NAIMA Insulation Standards.

7. Insulation shall be clearly marked with manufacturer's name, identification of installed thermal resistance (R) value, out-of-package R value, flame spread and smoke developed indexes in accordance with Energy Code requirements.

2.02 ACCEPTABLE MANUFACTURERS

A. Fiberglass: Knauf/Manson, Johns Manville, Owen-Corning, Certainteed. (Board, Blanket and Liner).

B. Polyisocyanurate: Dow Trymer 2000XP, HyTherm.

C. Flexible Elastomeric: Armacell, K-Flex.

D. Adhesives, Coatings, Mastics, Sealants: Childers, Foster.

2.03 PIPE INSULATION (RIGID FIBERGLASS TYPE)

A. Product meeting ASTM C 547, ASTM C 585, and ASTM C 795; rigid, molded, noncombustible.

B. 'K' Value: ASTM C 335, 0.23 at 75°F mean temperature installed value. Maximum Service Temperature: 1000°F.

C. Vapor Retarder Jacket: ASJ/SSL conforming to ASTM C 1136 Type I, secured with self-sealing longitudinal laps and butt strips.

D. Field-Applied PVC Fitting Covers with Flexible Fiberglass Insulation: Johns Manville Zeston 2000, speedline Proto Corporation 25/50 or Indoor/Outdoor, UV-resistant fittings, jacketing and accessories, white or colored. Fitting cover system consists of pre-molded, high-impact 20 mil. thick PVC materials with blanket type fiberglass wrap inserts. Blanket fiberglass wrap inserts shall have a thermal conductivity ('K') of 0.26 at 75°F mean temperature. Closures to be stainless steel tacks, matching PVC tape, or PVC adhesive per manufacturer's recommendations.

E. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in pre-forming insulation to cover valves, elbows, tees, and flanges.

2.04 PIPE INSULATION (RIGID POLYISOCYANURATE TYPE)

A. Preformed Rigid Polyisocyanurate Insulation: Cellular foam complying with ASTM C591, rigid molded, non-combustible. 2 lb./ft^3 nominal density. Maximum thermal conductivity (k) shall be 0.19 BTU-in/ft^2 hr. °F at 75°F mean temperature. Maximum Service Temperature; 300°F.

B. Vapor Retarder Jacket; Dow Saran Vapor Retarder Film and Tape, Polyguard zeroperm film and tape, or Knauf insulation expert FSK.

C. Covering Jacket; White Kraft outer surface bonded to aluminum foil and reinforced with fiberglass yarn.

2.05 FLEXIBLE TYPE INSULATION

A. Flexible Elastomeric Thermal Insulation: Closed-cell, foam material. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials. Maximum thermal conductivity (k) shall be 0.25 BTU-in/ft^2 hr. °F at 75°F mean temperature. Adhesive: As recommended by insulation material manufacturer.

B. Insulation shall have a flame-spread index of less than 25 and a smoke-developed index of less than 50 as tested by ASTM E 84 and CAN/ULC S-102, "Method of Test for Surface Burning Characteristics of Building Materials".

2.06 DUCT INSULATION

A. Duct insulation shall have a thermal resistance (R) value identification mark by the manufacturer applied no less than every 10 ft., as per Energy Code requirements.

B. Flexible Fiber Glass Blanket:

1. Product meeting ASTM C 553 Types I, II and III, and ASTM C 1290; Greenguard compliant.
2. 'K' Value of 0.27 at 75°F mean temperature. Maximum Service Temperature (Faced): 250°F.
3. Vapor Retarder Jacket: FSK conforming to ASTM C 1136 Type II.
4. Installation: Maximum allowable compression is 25%. Securement: Secured in place using outward cinching staples in combination with appropriate pressure-sensitive aluminum foil tape.
5. Density: 1.5 PCF. See Exhibit II for the thickness requirement at each density.

C. Rigid Fiber Glass Board:

1. Product meeting ASTM C 612 Type IA and IB.
2. 'K' Value of 0.23 at 75°F mean temperature. Maximum Service Temperature: 450º F.
3. Vapor Retarder Jacket: ASJ conforming to ASTM C 1136 Type I, or FSK or PSK conforming to ASTM C 1136 Type II.
4. Securement: Secured in place using adhesive and mechanical fasteners spaced a minimum of 12 in. on center with a minimum of 2 rows per side of duct. Insulation shall be secured with speed washers and all joints, breaks and punctures sealed with appropriate pressure-sensitive foil tape.
   a. Concealed Areas: Minimum 3 lb./ft.^{3}.
   b. Exposed Areas: 6 lb./ft.^{3} minimum density for duct less than 8 ft. - 0 in. above finished floor.

D. Polyisocyanurate Board: Closed cell polyisocyanurate core bonded to a triple laminated foil facing on both sides. Comply with ASTM C1289 Type I Class I. "K" value: 0.17 BTU in/(hr. sq.ft. degree F) at 75 deg. F.

2.07 EQUIPMENT INSULATION

A. Rigid Fiber Glass Board:

1. Product meeting ASTM C 612 Type IA and IB.
2. Concealed Areas:
    a. Density: Minimum 3 PCF.
    b. 'K' Value of 0.23 at 75°F mean temperature. Maximum Service Temperature: 450°F.
    c. Vapor Retarder Jacket: ASJ conforming to ASTM C 1136 Type I, or FSK conforming to ASTM C 1136 Type II.
3. Exposed Areas:
    a. Density: Minimum 6 PCF
    b. 'K' Value: ASTM C 177, 0.22 at 75°F mean temperature.

B. Foam Board. Polyisocyanurate core. Foil faced on one side and opposite side faced with white acrylic coated embossed aluminum, 4-mil. equal to "Dow Chemical Thermax Heavy Duty".

2.08 FIELD-APPLIED JACKETS

A. Piping:

1. PVC Pipe Jacket: High-impact, ultraviolet-resistant PVC; 20 mils thick; roll stock ready for shop or field cutting and forming. Adhesive: As recommended by insulation material manufacturer. PVC Jacket Color: White.
2. Aluminum Jacket: Factory cut and rolled to indicated sizes. Comply with ASTM B 209, 3003-alloy, and H-14 temper. Finish and Thickness: Corrugated finish, 0.010 inch thick. Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and kraft paper. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish, and thickness as jacket.
3. Stainless-Steel Jacket: ASTM A 666, Type 304 or 316; 0.10 inch thick; and factory cut and rolled to indicated sizes. Moisture Barrier: 3-mil-thick, heat-bonded polyethylene and kraft paper. Elbows: Gore type, for 45- and 90-degree elbows in same material, finish, and thickness as jacket. Jacket Bands: Stainless steel, Type 304, 3/4 inch wide.
4. Alumaguard Jacketing: Self adhesive, 60 mil thick, rubberized bitumen, foil faced membrane. Polyguard Products, Inc. Alumaguard 60, or equal.
5. Venture Guard Jacketing: 26.6 mil thick, Hypalon self adhesive membrane. Venture Tape Corp. Venture Guard, or equal.

B. Ductwork:

1. Aluminum Jacket: Deep corrugated sheets manufactured from aluminum alloy complying with ASTM B 209, and having an integrally bonded moisture barrier over entire surface in contact with insulation. Metal thickness and corrugation dimensions are scheduled at the end of this Section. Finish: Cross-crimp corrugated or stucco embossed finish. Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and kraft paper.

2. Stainless-Steel Jacket: Deep corrugated sheets of stainless steel complying with ASTM A 666, Type 304 or 316; 0.10 inch thick; and roll stock ready for shop or field cutting and forming to indicated sizes. Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and kraft paper. Jacket Bands: Stainless steel, Type 304, 3/4 inch wide.

3. Alumaguard Jacketing: Self adhesive, 60 mil thick, rubberized bitumen, foil faced membrane. Polyguard Products, Inc. Alumaguard 60, or equal.

4. Venture Guard Jacketing: 26.6 mil thick, Hypalon self adhesive membrane. Venture Tape Corp. Venture Guard, or equal. To be used on the bottom surface of rectangular ducts greater than 24 in. wide, due to lesser jacket weight that will avoid sagging issues over time.

2.09 COATINGS, MASTICS, ADHESIVES AND SEALANTS

A. Vapor Barrier Coatings: Used in conjunction with reinforcing mesh to coat insulation on below ambient services temperatures. Permeance shall be no greater than 0.08 perms at 45 mils dry as tested by ASTM F1249. Foster 30-65 Vapor Fas; Childers CP-24, or approved equal.

B. Lagging Adhesives: Used in conjunction with canvas or glass lagging cloth to protect equipment/piping indoors. Foster 30-36 Sealfas; Childers CP-50AMV1 Chil Seal, or approved equal.

C. Weather Barrier Mastic: Used outdoors to protect above ambient insulation from weather. Foster 46-50 Weatherite; Childers CP-10 Vi Cryl, or approved equal.

D. Fiberglass Adhesive: Used bond low density fibrous insulation to metal surfaces. Shall meet ASTM C916 Type II. Foster 85-60; Childers CP-127, or approved equal.

E. Elastomeric Insulation Adhesive: Used to bond elastomeric insulation. Foster 85-75; Childers CP-82, or approved equal.

F. Elastomeric Insulation Coating: Water based coating used to protect outside of elastomeric insulation. Foster 30-65, or approved equal.

G. Insulation Joint Sealant: Used as a vapor sealant on below ambient piping with polyisocyanurate and cellular glass insulation. Foster 95-50; Childers CP-76, or approved equal.

H. Metal Jacketing Sealant: Used as a sealant on metal jacketing seams to prevent water entry. Foster 95-44; Childers CP-76, or approved equal.

I. Reinforcing Mesh: Used in conjunction with coatings/mastics to reinforce. Foster Mast A Fab; Childers Chil Glass #10, or approved equal.

2.10 MATERIALS AND SCHEDULES

A. See Exhibits at the end of this section.

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. All materials shall be installed by skilled labor regularly engaged in this type of work. All materials shall be installed in strict accordance with manufacturer's recommendations, building codes, and industry standards.

B. Locate insulation and cover seams in the least visible location. All surface finishes shall be extended in such a manner as to protect all raw edges, ends and surfaces of insulation. No glass fibers shall be exposed to the air.

C. All pipe and duct insulation shall be continuous through hangers, walls, ceiling and floor openings, and through sleeves, unless not allowed by Fire Stop System.

D. Provide thermal insulation on clean, dry surfaces and after piping, ductwork and equipment (as applicable) have been tested. Do not cover pipe joints with insulation until required tests are completed.

E. All cold surfaces that may "sweat" must be insulated. Vapor barrier must be maintained; insulation shall be applied with a continuous, unbroken moisture and vapor seal. All hangers, supports, anchors, or other projections that are secured to cold surfaces shall be insulated and vapor sealed to prevent condensation. Cover valves, fittings and similar items in each piping system with insulation as applied to adjoining pipe run. Extra care must be taken on piping appurtenances to insure a tight fit to the piping system. For piping systems with fluid temperatures below ambient, all vapor retarder jacket (ASJ) seams must be coated with vapor barrier coating. All associated elbows, fittings, valves, etc. must be coated with vapor barrier coating and reinforcing mesh to prevent moisture ingress. Valve extension stems require Elastomeric insulation that is tight fitting to the adjoining fiberglass system insulation. Pumps, strainers, air separators, drain valves, etc. must be totally encapsulated with Elastomeric insulation.

F. Items such as boiler manholes, handholds, clean-outs, ASME stamp, and manufacturers' nameplates, may be left un-insulated unless omitting insulation would cause a condensation problem. When such is the case, appropriate tagging shall be provided to identify the presence of these items. Provide neatly beveled edges at interruptions of insulation.

G. Provide protective insulation as required to prevent personnel injury: Piping from zero to seven feet above all floors and access platforms including hot (above 140°F) piping and any other related hot surface.

H. All pipes shall be individually insulated.

I. If any insulation material has become wet because of transit or job site exposure to moisture or water, the contractor shall not install such material, and shall remove it from the job site.

3.02 PIPE INSULATION

A. Insulate piping systems including fittings, valves, flanges, unions, strainers, and other attachments installed in piping system, whether exposed or concealed

B. Insulation installed on piping operating below ambient temperatures must have a continuous vapor retarder. All joints, seams and fittings must be sealed.

C. Hanger Shields: Refer to Section 232010 "Piping Systems and Accessories".

D. Metal shields shall be installed between hangers or supports and the piping insulation. Rigid insulation inserts shall be installed as required between the pipe and the insulation shields. Inserts shall be of equal thickness to the adjacent insulation and shall be vapor sealed as required.

1. Pre-Insulated Type: Butt insulation to hanger shields and apply a wet coat of vapor barrier cement to the joints and seal with 3 in. wide vapor barrier tape.
2. Field Insulated Type: Provide high density insolating blocks per manufacturers recommended spacing between pipe and shield.
3. Tape shields to insulation.

E. Joints in section pipe covering made as follows:

1. All ends must be firmly butted and secured with appropriate butt-strip material. On high-temperature piping, double layering with staggered joints may be appropriate. When double layering, the inner layer should not be jacketed.
2. Standard: Longitudinal laps and butt joint sealing strips cemented with white vapor barrier coating, or factory supplied pressure sensitive adhesive lap seal.
3. Vapor Barrier: For cold services, Longitudinal laps and 4 in. vapor barrier strip at butt joints shall be sealed with white vapor barrier coating. Seal ends of pipe insulation at valves, flanges, and fittings with white vapor barrier coating. When using polyisocyanurate or cellular glass on below ambient piping/duct, seal all insulation joints with insulation joint sealant.

F. Fittings, Valves and Flanges:

1. Hot Services and Domestic Cold Water: Flexiblefitting insulation of the same material and thickness as the adjacent pipe insulation. Vapor seal domestic cold water with two (2) coats of white vapor barrier coating.
2. White PVC jacketing, with continuous solvent weld of all seams. Tape all fittings.

G. Flexible Pipe Insulation:

1. Split longitudinal joint and seal with adhesive.
2. Fittings made from miter-cut pieces properly sealed with adhesive, or ells may be continuous.

H. For piping exposed to the elements, jacketing shall be aluminum with a factory applied moisture barrier. Fitting covers shall be of similar materials. The insulation and jacketing shall be held firmly in place with a friction type Z lock or a minimum 2 in. overlap joint. All joints shall be sealed completely along the longitudinal seam and installed so as to shed water. All circumferential joints shall be sealed by use of preformed butt strips; minimum 2 in. wide or a minimum 2 in. overlap. Butt strips shall overlap the adjacent jacketing a minimum 1/2 in. and be completely weather sealed. Jacket at ells and tees shall be mitered, or pre-manufactured fitting jackets shall be provided, with additional aluminum holding bands, as required. All joints shall be sealed watertight using specified metal jacketing sealant as recommended by the manufacturer.

I. Apply PVC jacket where indicated, with 1 in. overlap at longitudinal seams and end joints. Seal with manufacturers recommended adhesive.

J. Apply aluminum jacketing to exposed insulated pipe, valves, fittings, and specialties, at an elevation of 8 feet or less above finished floor in mechanical/electrical rooms, penthouses, and services aisles/pipe chases. Fittings of aluminum-jacketed piping may be either aluminum or standard PVC fitting covers.

K. All exposed piping less than 8'-0" above finished floor in occupied spaces have a continuous aluminum jacketing.

3.03 DUCTWORK INSULATION

A. Provide external thermal insulation for duct. Not required where ducts have internal acoustical insulation. Make special provisions at dampers, damper motors, thermometers, instruments, and access doors. Apply as follows:

1. Rigid Board Type: Impale board over mechanical fasteners, welded pins or adhered clips, 12 in. to 18 in. centers; minimum of two (2) rows per side. Secure insulation with washer clips. Self-adhesive clips are not acceptable. Staple all joints. Seal breaks and joints in vapor barrier with 4 in. wide matching tape and 4 in. glass-fab applied with specified vapor barrier coating. Apply tape over corner beading where exposed.

2. Flexible Blanket Type: Install Duct Wrap to obtain specified R-value using a maximum compression of 25%. Installed R-value shall be per ECC of NYS. Firmly butt all joints. The longitudinal seam of the vapor retarder must be overlapped a minimum of 2 in. Where vapor retarder performance is required, all penetrations and damage to the facing shall be repaired using pressure-sensitive foil tape, and coated with vapor barrier coating prior to system startup. Pressure-sensitive foil tapes shall be a minimum 3 in. wide and shall be applied with moving pressure using a squeegee or other appropriate sealing tool. Closure shall have a 25/50 Flame Spread/Smoke Developed Rating per UL 723. Duct wrap shall be additionally secured to the bottom of rectangular ductwork over 18 in. wide using mechanical fasteners on 18 in. centers. Self-adhesive clips are not acceptable. Care should be exercised to avoid over-compression of the insulation during installation.

3. Exterior Ductwork: Self Adhering Cover: Membrane shall be a pre-manufactured self adhering product with an UV resistant, embossed facing. Water vapor transmission of the installed product shall be .020 perms or less. Product shall be suitable for continuous use in low temperatures of -10°F. Manufacturers shall be Flex-Clad 400, MFM Building Products Corp. or Alumaguard 60, Polyguard Products, Inc.

3.04 EQUIPMENT INSULATION

A. Apply insulation with joints firmly butted as close as possible to the equipment surface. Insulation shall be secured as required with adhesive, mechanical fasteners or banding material. Fasteners shall be located a maximum of 3 in. from each edge and spaced no greater than 12 in. on center.

B. Vapor retarders shall overlap a minimum of 2 in. at all seams and be sealed with appropriate pressure-sensitive tape and vapor barrier coating. All penetrations, facing damage, and mechanical fasteners shall be covered with a minimum 2 in. overlap of tape and vapor barrier coating.

C. Calcium Silicate Equipment Insulation: Secure blocks with galvanized steel bands, 12 in. O.C., then point with insulating cement. Field apply 8 oz. knit fiberglass cloth, cemented and applied over standard jacket. Properly cut at fittings to avoid wrinkles and coat with white mastic coating. Leave ready for painting.

D. Fiberglass Equipment Insulation: Secure fiberglass with pins, studs, or clips. Field apply 8 oz. knit fiberglass cloth, cemented and applied over standard jacket. Properly cut at fittings to avoid wrinkles and coat with white lagging adhesive/coating. Leave ready for painting.

E. Equipment insulation exposed to the elements shall be finished with minimum 0.030 in. thick outdoor weather able PVC, specified weather barrier mastic and glass cloth, or metal. All joints shall be positioned so as to shed water; with a minimum 3 in. overlap, and completely weather sealed.

F. For equipment insulation exposed in mechanical rooms or subject to mechanical abuse, finish with minimum 0.020 in. thick PVC Jacketing or metal. All other insulation shall be finished as appropriate for the location and service or as specified on the drawings.

EXHIBIT "I" - PIPE INSULATION MATERIALS

SERVICE	INSULATION MATERIAL	THICKNESS	REMARKS
Hot water and glycol/hot water (200°F and lower)	Glass fiber	1-1/2 in. and Larger: 2 in. 1-1/4 in. and Smaller: 1-1/2 in.	
Refrigeration Piping (Suction and liquid lines)	Flexible	1 in. and Larger: 1 in. 3/4 in. and Smaller: 1/2 in.	
Outdoor Refrigeration Piping (Suction and liquid lines)	Flexible	1 in. and Larger: 1 in. 3/4 in. and Smaller: 1/2 in.	Insulation shall be provided with a UV resistant coating.
Domestic cold water	Glass fiber	1-1/2 in. and Larger: 1 in. 1-1/4 in. and Smaller: 1/2 in.	
Outdoor Piping	Polyisocyanurate	Insulate pipe with double the thickness called for above	Cover with Alumaguard jacketing applied per manufacturer's recommendations
AHU-1 condensate drains and concealed AC unit condensate drains	Flexible	All Sizes: 1/2 in.	
Piping in exterior walls, spaces, overhangs, attics, exterior, or where subject to freezing.		Insulate pipe with double the thickness called for above	

EXHIBIT "II" - DUCT INSULATION MATERIALS

SERVICE	INSULATION MATERIAL	THICKNESS	REMARKS
HVAC Supply	Within mechanical rooms or exposed at 8 feet or less above finished floor: Rigid fiberglass	……..……..1-1/2 in.	Min. installed R value of 6
	Concealed: Flexible fiberglass	….……2 in. at 1.5 PCF	Min. installed R value of 6
Supply or Return ducts in cold attic spaces or other un-conditioned spaces	Flexible fiberglass	……..……..…5 in	Min. installed R value of 12
Exhaust ducts in cold attic spaces or other un-heated spaces	Flexible fiberglass	…….……. 3 in	Min. installed R value of 8
Supply ducts, exposed within the conditioned space served	…….	…NOT INSULATED…	Does not include the associated supply ductwork within the Mechanical Room or supply duct to the conditioned space.
Interior ductwork indicated to be lined	…….	…NOT INSULATED…	……
Return-air ducts within heated building envelope	…….	…NOT INSULATED…	……
Air conditioning supply (insulated	……	EXTERIOR INSULATION NOT REQUIRED	……

SERVICE	INSULATION MATERIAL	THICKNESS	REMARKS
double wall)			
Neutral ventilation air supply (between 65°F and 80°F)	……..	… NOT INSULATED …	……
Outside air ducts and plenums, connections and mixing boxes Combustion air ductwork	Rigid fiberglass	……..……. 2 in.	Min. installed R value of 8 Provide neat fit at intake plenum
Exhaust, relief or vent ducts and plenums	Exposed: Rigid fiberglass	……...……1-1/2 in.	Min. installed R value of 6
	Concealed: Flexible fiberglass	……...……2 in.	Insulate 15 ft. from exterior opening and plenums
Outdoor Ductwork	Polyisocyanurate board Rigid Fiberglass	……...……..2-1/2 in. ……...……..3 in.	Min. installed R value of 12 Cover with Alumaguard jacketing applied per manufacturer's recommendations.

EXHIBIT "III" - EQUIPMENT INSULATION MATERIALS

SERVICE	INSULATION MATERIAL	THICKNESS	REMARKS
Air removal assemblies and fabric filter assemblies	----------	SAME AS WATER PIPING	
Heating system expansion tanks and chemical feed tanks	----------	NOT INSULATED	----------

END OF SECTION

SECTION 23 09 23
BUILDING MANAGEMENT SYSTEM - DDC LOGIC/ELECTRIC ACTUATION

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Drawings. Provide a complete Building Management System (BMS), to perform the functions described in this Section. Provide wiring and conduit required to connect devices furnished as a part of, or accessory to, this automatic control system. Control wiring is defined as wiring up to and including 120 volts. Install wiring in accordance with requirements of "Electrical Wiring" in Section 230504, and the National Electrical Code. Provide all required devices for proper system operation, including special electrical switches, transformers, relays, pushbutton stations, etc.

1. All Actuation of valves and dampers shall be electric unless specifically called out elsewhere in the specifications or drawings.

B. The BMS System shall have the following capabilities as described in these specifications:

1. The network controllers and operator's workstations shall be connected directly to the Owner's Ethernet Network. The network controller shall also contain SNMP for integration to the Owner's Network Controllers System.
2. Offsite access for Owner's personnel shall be provided and shall have full workstation capability from remote location. Identical graphical displays shall be provided for offsite access to match the displays at the on-site Operator's Workstation. Connection to the site shall be via a high speed Ethernet connection.
3. The Network Controller must act directly as the WEB server. It must directly generate the HTML code to the requesting user (i.e. WEB browser), eliminating the need and reliance on any PC-based WEB server hardware or software.
4. The system shall be capable of sending both emails and text messages for alarms. A minimum of six (6) email addresses and cell phone numbers (for text messages) must be supported by the system. Coordinate with the Owner for email addresses, cell numbers and alarms.
5. All system variables in the temperature control system shall be Microsoft variables allowing them to be displayed and manipulated in other Microsoft products.
6. Network controllers shall all be flash upgradeable and not require changing chips for upgrades.

7. Short term logging of historical data shall be provided for every DDC input and output in the system. Each point shall be capable of being logged for a minimum of two (2) weeks.

C. The BMS shall consist of PC-based workstations and microcomputer controllers of modular design providing distributed processing capability, and allowing future expansion of both input/output points and processing/control functions. Further, the system shall be the backbone framework for the Security/Card Access/CCTV system through the front-end software.

D. The system shall consist of the following components:

1. Provide one (1) File Server, one (1) Operator Workstation Computer(s), and printer(s) as described in this specification. The Workstations shall be running the standard workstation software developed and tested by the manufacturer of the network controllers and the standalone controllers. No third party front-end workstation software will be acceptable.
2. Provide Ethernet-based network controllers as described in this specification. Controllers shall connect directly to the Operator Workstation over Ethernet, provide communication to the Standalone Digital Control Units and/or other Input/Output Modules and serve as a gateway to equipment furnished by others.
3. Provide the necessary quantity and types of standalone controllers to meet the requirements of the project for mechanical equipment control including air handlers, central plant control, and terminal unit control. Each standalone controller shall operate completely standalone, containing all of the I/O and programs to control its associated equipment.
4. A high speed Ethernet connection to the site shall be used for offsite access to the site. Coordinate with the Owner's IT professionals for high speed system access and shall comply with Owner's requirements to maintain the level of security required by the Owner. Coordinate with Owner and provide VPN (Virtual Private Network) as required, to comply with the Owner's IT professionals requirements.
5. BACnet Protocol Integration - BACnet:
    a. The neutral protocol used between systems will be BACnet over Ethernet and comply with ASHRAE BACnet standard 135-2003.
    b. A complete Protocol Implementation Conformance Statement shall be provided for all BACnet system devices.
    c. The ability to command share point object data, change of state data and schedules between the host and BACnet systems shall be provided.

1.02 QUALITY ASSURANCE

A. The complete automatic temperature control system shall be comprised of electric control devices with a microprocessor based Direct Digital Control System. All

work shall be installed only by skilled mechanics employed by the BMS Subcontractor.

B. The BMS Subcontractor shall have a minimum of five (5) years' experience in systems of similar size, type and complexity installed within a 100 mile radius.

C. The BMS Subcontractor shall have a local service department (within a 50 mile radius) and have available a minimum of three (3) factory trained technicians within a 24 hour period.

D. All components shall be fully tested and documented to operate as a complete system.

E. Supplier must guarantee that all replacement parts will be carried in stock for a period of ten (10) years minimum from the date that the system is commissioned.

F. Electrical standards: Provide electrical products that comply with the following agency approvals:

1. UL 916; Energy Management Systems for Temperature Control components and ancillary equipment.
2. UL 873; Temperature Indication and Regulating Equipment.
3. FCC, Part 15, Subpart J, Class A Computing Devices.

G. All products shall be labeled with the appropriate approval markings. System installation shall comply with NFPA, NEMA, Local and National codes.

1.03 ACCEPTABLE MAKES

A. The complete Building Management System is designed and based on that manufactured by Automated Logic. Acceptable Make: Andover, Honeywell (based on JACE), Automated Logic, Alertron.

1.04 SUBMITTALS

A. Submit for review, a brochure containing the following:

1. Detailed piping and wiring control diagrams and systems description for each system under control.
2. Detailed layout and nameplate list for component control panels and DDC panels.
3. Submit a valve and damper schedule showing size, pressure drop configuration, capacity, and locations. Provide apparatus bulletins and data sheets for all control system components.
4. A complete listing of input and output points, control loops and/or routines, including time of day functions, and facilities management system functions for each controlled system. This listing shall include point logical names, identifiers, and alarmable ranges.

5. Provide as part of a separate submittal a hard copy of all graphics showing system components, sensor locations, setpoints and fixed/variable data. Engineer shall review and approve graphic format prior to final acceptance of system.

1.05 SCOPE OF WORK

A. Except as otherwise noted, the control system shall consist of all Ethernet Network Controllers, Standalone Digital Control Units, workstations, software, sensors, transducers, relays, valves, dampers, damper operators and other accessory equipment, along with a complete system of electrical interlocking wiring as required to fill the intent of the specification and provide for a complete and operable system.

B. The BMS Subcontractor shall review and study all HVAC drawings and the entire specification to familiarize themselves with the equipment and system operation and to verify the quantities and types of dampers, operators, alarms, etc. to be provided.

C. All interlocking, wiring and installation of control devices associated with the equipment shall be provided under this Contract. The BMS Subcontractor shall demonstrate the operation of the system to the Owner and prove that it complies with the intent of the drawings and specifications.

D. Provide services and manpower necessary for commissioning of system. Commissioning reports showing the testing of each DDC point on the system shall be submitted to the Engineer for review and approval upon completion of the commissioning process. Refer to the Commissioning Specification Section 230800.

E. Provide owner with full open programing capability. All required software, licenses and passwords shall be provided.

1.06 WORK INCIDENTAL TO TEMPERATURE CONTROL

A. The BMS Subcontractor shall furnish the following materials, installation by the Contractor:

1. For piping work:
    a. Control valves in piping.
    b. Immersion sensing wells in piping systems.
    c. Valved pressure taps.
2. For sheet metal work:
    a. All automatic dampers, the BMS Subcontractor shall assemble multiple section dampers with required interconnecting linkages and extend required number of shafts through duct for external mounting of damper and motors.

b. The Contractor shall provide access doors or other means of access through ducts or ceilings and walls for service and adjustment of controllers, valves, and dampers.

B. Control manufacturer shall furnish written details, instructions and supervision for the above trades to ensure proper installation size, and location of any equipment furnished for installation by others.

1.07 CONTROL SYSTEM GUARANTEES

A. Guarantee the new control system to be free from defects in material and workmanship, for a period of one (1) year after final acceptance. Guarantee system to:

1. Maintain temperatures within 1°F above and below setting.
2. Humidity devices shall maintain relative humidity conditions within 3% of span 0-100% RH.

B. Provide one (1) year maintenance service of control components, to start concurrently with the guarantee specified above. Such service shall include software updates and 24 hour, 7 day emergency and seasonal inspection and adjustment of operating controls and replacement of parts or instruments found deficient and defective during this period.

C. Provide monitoring of the DDC system as soon as the system is operating and then for a minimum of one (1) year (24 hours/day, 7 days/week) after the acceptance date. A monthly report will be sent to the Owner with a description of general system status and any alarms or off-normal conditions.

D. Guarantee future availability of continuous, 24 hour, 7 day a week service for the systems through available maintenance contracts.

1.08 SYSTEM ADJUSTMENT AND CALIBRATION

A. When the Work has been completed, completely adjust and calibrate the control system. Review the operation of each system input and output, control loops and/or software routings, timing functions, operator entered constants and facilities management functions and observe that they perform their intended functions. Provide a complete values and points log, printed every hour, for one week to demonstrate control functions and programming. Provide one point log for summer operation and one winter. Points to be trended shall be selected by the Engineer. When above procedure has been completed and the control system is operating satisfactorily, submit a letter with one (1) copy of completed values and points log to the Owner's Representative advising them that the control system is 100% complete and operates in accordance with the Contract Documents.

B. After review and approval of points log by the Engineer, the BMS subcontractor shall schedule a technician on site for field review of system components, operation and graphics as part of final system appearance.

1.09 INSTRUCTIONS TO THE OWNER'S REPRESENTATIVE

A. Provide competent control technicians to instruct the Owner's operating personnel and turn over three (3) copies of maintenance manual. Provide a total of 64 hours of instruction at the site, 32 hours during start-up and 32 hours after six (6) months. Instruction sessions shall be scheduled at the Owner's convenience and shall be limited to four (4) hours per session. The instructions shall include, but not be limited to, the following:

1. System Overview.
2. System Software and Operation:
    a. System Access.
    b. Software Features Overview.
    c. Changing Setpoints and Other Attributes.
    d. Scheduling.
    e. Editing Programmed Variables.
    f. Displaying Color Graphics.
    g. Running Reports.
    h. Workstation Maintenance.
    i. Application Programming.
3. Operational sequences including start-up, shutdown, adjusting and balancing.
4. Equipment maintenance.

PART 2 - PRODUCTS

2.01 CONTROL DEVICES

A. Control Valves:

1. Sized by BMS Subcontractor and guaranteed to meet the heating and cooling requirements. Water valves shall be sized on the basis of 15% of the total system pressure drop, but not more than 10 ft. of head drop. Steam valves shall be sized for no more than a 5 psig pressure drop, or 30% (max.) of design steam pressure, whichever is smaller. Pressure drop for valves shall be submitted for review, including all CV values.
2. Valves shall be equal percentage type, equipped with characteristic type throttling plug, #316, stainless steel or Monel stem, removable composition discs, and rubber diaphragms. Provide with necessary features to operate in sequence with other valves or damper operators and adjustable throttling range as required by the sequence of operations.

3. Valves in 2 in. and smaller shall be screwed bodies; 2-1/2 in. and larger shall be flanged bodies; designed for 125 psi operating pressure. Arranged to fail-safe as called for; tight closing and quiet operating.

4. Electric Operators:

   a. Provide 24 VAC control operators which are 0-10 VDC input proportional with spring return as needed by control sequence and designed for water service valve bodies. Operator shall be synchronous motor driven with up to 150 in. lb. force and force sensor safety stop.

B. Temperature Sensors:

1. All temperature devices shall use precision thermistors accurate to ± 0.36°F over a range of -30 to 230°F.

2. Standard space sensors shall be provided in an off white, or white, enclosure for mounting on a standard electrical box.

3. Provide manual override of unoccupied mode. Where manual override of unoccupied mode of control is indicated on the drawings or sequence of operation, provide a push button for selecting after hours operation.

4. Provide manual adjustment slider with ± programmable scale. Programmable scale shall have the capability to be limited via the DDC System.

5. Provide a local LCD display for viewing the space temperature.

6. Duct temperature sensors shall incorporate a thermistor bead embedded at the tip of a stainless steel tube. Probe style duct sensors shall be used in air handling applications where the air stream temperature is consistent and is not stratified. Averaging sensors shall be employed in all mixing plenum and coil discharge applications and in any other application where the temperature might otherwise be stratified. The averaging sensor tube shall contain at least four thermistor sensors.

7. Immersion sensors shall be employed for measurement of temperature in all chilled water, hot water and glycol applications. Thermal wells shall be brass or stainless steel for non-corrosive fluids below 250°F and 300 series stainless steel for all other applications.

C. Humidity Sensors:

1. Humidity sensors shall be polymer resistance type.

2. Space humidity sensors shall have a sensing range of 05 to 95% with accuracy of +/ 3% RH.

3. Duct sensors and Outdoor air humidity sensors shall have a sensing range of 5 to 95% RH with accuracy of +/ 3% RH. Sensors shall be suitable for ambient temperature conditions of -40 to 212°F.

D. Electric Thermostats:

1. Provide a low voltage thermostat for control of single zone heating and air conditioning unit as specified in the sequence of operation. Electric thermostats shall include a display of the current space temperature as well as a mechanism for adjusting the setpoint locally. Aquastats on unit heaters shall stop the fan when the water temperature is below 100°F.

E. Temperature Sensor, Humidistat Sensor or Thermostat Guards:

1. Provide wire metal guards on thermostats and humidistats located in areas where instruments may be subject to damage, and where called for.

F. Electric Operators (Damper):

1. Provide 24 VAC control operators which are 0-10 VDC input proportional or two position with spring return as needed by control sequence and designed to operate control dampers. Operator shall by synchronous motor driven with up to 150 in. lb. force sensor safety stop and return as required.

G. Control (Motorized) Dampers:

1. Provide control dampers as shown on the drawings and diagrams, to meet the following minimum construction standards.
2. Leakage: Class 1, 4 CFM/sq. ft. at 1 in. W.C., tested per AMCA Standard 500-D-98 and AMCA Standard 511 and bearing AMCA's Certified Ratings for both air performance and air leakage.
3. Frame: 16 gauge galvanized steel structural hot channel with tabbed corners for reinforcement to meet 13 gauge criteria.
4. Blades: 14 gauge (equivalent thickness galvanized steel) roll forward air foil type for low pressure drop and low noise generation. Blades shall be parallel for two-position dampers and opposed, for modulating dampers.
5. Blade Seals: Ruskiprene, suitable for -72°F to +275°F mechanically locked into the blade edge.
6. Jamb Seals: Flexible metal, compression type.
7. Blade Axles: 1/2 in. plated steel hexagonal positively locked into the damper blade. Linkage conceded out of the air stream.
8. Bearings: Corrosion resistant, permanently lubricated stainless steel sleeve.
9. Dampers subject to corrosive fumes or humidity shall be constructed of stainless steel.
10. Dampers over 48 in. length and height shall be made in multiple sections.
11. Where damper sizes are not specifically indicated, they shall be sized by the Contractor. Maximum velocity shall be 1500 fpm and maximum pressure drop 0.1 in. w.g.

12. Where shown or required for proof of closure or open position, provide factory installed damper positioning switch package Ruskin Model SP-100.

13. Dampers shall be as manufactured by Ruskin CD60 Control Damper, or equivalent Tamco or Greenheck.

H. High Performance Control (Motorized) Dampers:

1. Provide high performance thermally isolated control dampers as shown on the drawings and diagrams, to meet the following minimum construction standards.

2. Leakage: Shall not exceed 4 CFM/sq. ft. at 4 in. W.C., tested per AMCA Standard 500-D-98 and AMCA Standard 511 and bearing AMCA's Certified Ratings for both air performance and air leakage. Holding torque shall not exceed 5 in. lbs./sq. ft. on opposed blade dampers, and 7 in. lbs./sq. ft. on parallel blades with a minimum torque of 40 in. lbs.

3. Frame: .125 in. extruded aluminum structural hot channel with tabbed corners for reinforcement.

4. Blade Seals: Ruskiprene II, suitable for -40°F and with locked into the blade edge extruded silicone, down to -70°F.

5. Jamb Seals: Flexible polycarbonate type.

6. Blade Axles: 1/2 in. plated steel hexagonal positively locked into the damper blade. Linkage conceded out of the air stream.

7. Bearings: Corrosion resistant, permanently lubricated molded synthetic.

8. Dampers over 48 in. length and height shall be made in multiple sections.

9. Where damper sizes are not specifically indicated, they shall be sized by the Contractor. Maximum velocity shall be 1500 fpm and maximum pressure drop 0.1 in. w.g.

10. Where shown or required for proof of closure or open position, provide factory installed damper positioning switch package Ruskin Model SP-100.

11. Dampers shall be as manufactured by Ruskin CDTI-50 or CDTI-50BF low temperature control damper, or equivalent Tamco or Greenheck.

I. Pressure Sensors:

1. Air pressure or differential air pressure measurements in the range of 0 to 10 in. water column shall be accurate to ± 1% of range using a solid-state sensing element. The range of the instrument selected shall be 2 times the operating pressure of the sensed variable. Acceptable manufacturer shall be Setra model C-264.

2. Liquid pressure or differential liquid pressure measurements shall be accurate to ± 0.25% of range using a solid-state sensing element. The range of the instrument selected shall be 2 times the operating pressure of the sensed variable. Unit shall be provided with isolation and bypass

manifold for start-up and maintenance operations. Acceptable manufacturer shall be Setra Model C-230.

3. Steam pressure measurements shall be accurate to ± 0.13% of range using a solid-state sensing element. The range of the instrument selected shall be 2 times the operating pressure of the sensed variable. Unit shall be provided with isolation and bypass manifold for start-up and maintenance operations. Acceptable manufacturer shall be Setra Model C-207.

4. Room pressure sensors shall be bi-directional, bleed airflow thermistor type. Sensor assembly shall contain three (3) individually wired, hermetically sealed bead-in-glass thermistors. The operating range shall be +3,000 FPM to -3,000 FPM, and device shall have an accuracy of ±2% of readings over the entire operating airflow range. Acceptable manufacturer shall be Ebtron Model GTC116-B.

J. Current Measurement Devices:

1. Measurement of three-phase power shall be accomplished with a kW/kWh transducer. The instrument shall utilize direct current transformer inputs to calculate the instantaneous value (kW) and a pulsed output proportional to the energy usage (kWh). Provide Veris Model 6000 Power Transducer or approved equal.

K. Carbon Dioxide Sensing Devices:

1. Space or outside air carbon dioxide (CO2) sensors shall be an infrared technology based detector, and shall contain an on board relay with field adjustable trip point and adjustable time delay. The sensor shall monitor CO2 over a range of 0 - 2000 PPM. Space CO2 sensors shall operate within the range of 32-122°F and 0-95% RH. Outside air CO2 sensors shall have an operation range of -40° to 122°F and 0-95% RH. The sensor shall have an accuracy of no more than 50 PPM in the expected range of measurement, and a drift of no more 20 ppm. The sensors shall be self-calibrating. Provide an LCD display for displaying PPM level and field adjustable settings. Greystone Product # CDD4 Series, Honeywell C7232, Siemens QPA20, GE Ventostat.

L. Carbon Monoxide Sensing Devices:

1. Wall mounted carbon monoxide (CO) sensor shall be microprocessor based (12 bit accuracy) and shall monitor CO over a range of 0-300 PPM (optional 200-500 PPM). The device shall have an accuracy of ±3% (electrochemical type) or ±5% (solid state type) and operate within the range of 32-122°F and 0-95% RH. The sensor shall have a calibration accuracy of 0.5%. Where required by the drawings or specifications, provide an LCD display for displaying PPM level and system configuration information and/or audible alarm with programmable trip point and disable jumper. Greystone Product # CMD or equivalent.

M. Combination CO_2, RH, Temperature Sensors:

1. Provide BACnet combination CO2/RH/Temperature measuring devices for mounting where indicated on the plans.
2. Each BACnet combination sensor shall consist of an integrated system of three or more environment sensing functions in a wall mounted package, with an integral microprocessor-based design capable of operating at least two (2) independent sensor nodes per measurement location.
3. BACnet combination sensors shall have an environmental operating range of no less than 32 – 122° F (0 – 50° C) and 0 – 95% RH, non-condensing.
4. CO_2 Sensor Design and Performance:
    a. CO_2 measurement shall be accomplished with Non-Dispersive Infrared (NDIR) technology using gold plated optics and diffusion sampling.
    b. CO_2 measurement uncertainty shall be no greater than ±75 ppm (or ±7% of Reading <500 ppm and ±7.5% for 800 – 1,200 ppm) at 77° F (25° C) for a CO_2 measurement range of at least 400 – 2,000 ppm.
    c. CO_2 measurement stability shall be <2% FS over the expected 15 year life of the typical sensor.
    d. Each CO_2 sensor node shall be factory calibrated, shall automatically self-calibrate during operation and shall not require routine recalibration throughout its normal service life.
5. Relative Humidity (RH) Sensor Design and Performance:
    a. Each RH sensor node shall measure ambient RH using planar laminated, electrolytic polymer capacitor technology.
    b. RH measurement range shall be 0 – 100% RH, non-condensing.
    c. RH measurement accuracy shall be ±2% from 20% – 80%RH at 77° F (25° C). Outside of this normal RH operating range, accuracy shall be ±3%.
    d. RH output resolution shall be at least 0.4% of Reading.
6. Temperature Sensor Design and Performance:
    a. Each temperature sensor node shall sense changes using integral bandgap voltage reference circuitry and perfectly proportional to absolute temperature (PTAT) ΔV technology.
    b. Temperature measurement accuracy shall be equal to or greater than ±1.08° F at 77° F (±0.6° C at 25° C).
    c. The operating temperature range shall be at least -58° F to 302° F (-50° C to 150° C).
    d. Output resolution shall be at least 0.36° F (0.2° C).
7. Power, Connectivity and Communications:

a. The BACnet combination sensor shall be capable of communicating with other devices using an RS-485 standard interface and BACnet-MS/TP protocol, implemented as a Master.

1) Communication speed shall be field-selectable between 9.6, 19.2, 38.4 and 76.8 kBaud.

b. BACnet devices shall implement the open protocol in compliance of the requirements of ASHRAE Standard 135-2008 and all BACnet products shall be BTL Listed.

c. The BACnet combination sensor shall be capable of field set-up and configuration using a simple dip-switch interface.

d. The BACnet combination sensor shall operate on 24 VAC (22.8 to 26.4 VAC), 50/60Hz.

1) The combination sensor design shall include protection from over voltage, over current transients and power surges.

2) The combination sensor shall use "watch-dog" circuitry to assure automatic processor reset after power disruption, transients and brown-outs.

e. The BACnet combination sensor design shall be capable of communicating to the network if one of the sensor functions becomes faulty, and will continue to operate the remaining CO_2 or RH/Temp sensor nodes.

8. The BACnet combination sensor enclosure shall be a low profile wall mount type, compatible in size for mounting with a standard single-gang electrical box or for surface mount applications.

a. The sensors shall be installed at locations that are protected from weather and/or water.

9. The manufacturer’s authorized representative shall review and approve wall-position placement for each measurement location indicated on the plans.

a. A written report shall be submitted to the consulting mechanical engineer if any measurement locations do not meet the manufacturer's recommendations or requirements.

10. Acceptable manufacturer shall be Ebtron Model IAQ-300-N.

N. Airflow Stations (DP Type):

1. Duct Mounted Air Flow Stations:

a. Rectangular: 16 gauge galvanized casing, 8 in. deep, with formed 1-1/2 in. integral 90° connecting flanges.

b. Oval: 18 gauge galvanized casing, 8 in. long between beads with 1 in. connecting sleeve on each end (10 in. overall length). Actual

O.D. dimensions are 1/4 in. less than specified duct I.D. dimensions.

c. Accuracy: Within 2% throughout the velocity range of 600 FPM and over, when installed in accordance with published recommendations.

d. Temperature: 350°F continuous operation, 400°F intermittent operation.

e. Humidity: 0-100% continuous operation.

f. Corrosion Resistance: Good salt air, excellent solvent and aromatic hydrocarbon resistance.

g. Element Material: 6063-T5 anodized aluminum.

h. Connection Fittings: 1/4 in. compression, suitable for use with thermoplastic or copper tube.

i. Design Equipment: Paragon Controls FE-1500.

j. Make: Paragon, Cambridge, Air Monitor.

2. Fan Inlet Air Flow Stations:

a. Material: 6063-T5 anodized aluminum, galvanized mounting brackets.

b. Accuracy: Within 2% throughout the velocity range of 600 FPM and over, when installed in accordance with published recommendations.

c. Temperature: 350°F continuous operation; 400°F intermittent operation.

d. Humidity: 0-100% continuous operation.

e. Connection Fittings: 1/4 in. compression, suitable for use with thermoplastic or copper tube.

f. Corrosion Resistance: Good salt air and mild acid resistance, excellent solvent and aromatic hydrocarbon resistance.

g. Design Equipment: Paragon Controls FE-1050.

h. Make: Paragon, Cambridge, Air Monitor.

3. Outside Air Flow Station:

a. Material: Element 6063-T5 anodized aluminum and casing 16 gauge G90 galvanized steel.

b. Accuracy: Within ± 0.5% of actual flow through the velocity range of 200 to 12,00 fpm when installed in accordance with published recommendation and within ±5% at a velocity of 100 fpm. Operating velocity range 100 to 2,800 fpm.

c. Temperature: 350°F continuous operation and 400° intermittent operation.

d. Humidity: 0 to 100%.

e. Design Equipment: Paragon Controls mode OAFE-1500.

f. Make: Paragon, Ruskin.

4. Air Volume/Velocity Transducers for Duct Outside Air and Fan Inlet Airflow Stations:

a. The transducer shall be a combination differential pressure transmitter, square rood extractor, scaling multiplier, and output filter with process indication, complete in a single package.

b. The measured air volume shall be locally indicated on a door mounted LED display meter scaled in CFM.

c. The transducer package shall be a factory calibrated for the flow-measuring element being served.

d. A transducer shall be provided for each individual airflow station.

e. Accuracy shall be plus or minus 0.25%.

f. An output signal of 0-10 VDC or 4-20 mA shall be generated for monitoring by the DDC system.

g. Design Equipment: Paragon Controls Microtrans.

h. Make: Paragon, Cambridge, Air Monitor.

O. Airflow Stations (Thermal Dispersion Type):

1. Provide thermal dispersion airflow/temperature measurement device (ATMD) at each location indicated in specifications and control sequences.

a. Fan inlet measurement devices shall not be used unless indicated on drawings or schedules.

b. Each ATMD shall consist of one to four sensor probes and a single, remote transmitter. Each sensor probe shall consist of one to eight independent sensor nodes in a gold anodized, aluminum 6063 alloy tube with 304 stainless steel mounting brackets.

c. Each sensor node shall consist of two hermetically sealed bead-in-glass thermistors. Chip thermistors of any type or packaging are not acceptable.

d. Sensor Density Requirements:

1) Sensor density (#/area) affects minimum installed distances required from disturbance types. Published sensor density data by the product manufacturer shall be submitted for approval. Sensor density shall be as follows:

Duct or Plenum Area (ft^2)	Total # Nodes / Location	Duct or Plenum Area (m^2)
<= 1	1 or 2	<= 0.093

>1 to <4	4	>0.093 to < 0.372
4 to < 8	6	0.372 to < 0.743
8 to < 12	8	0.743 to < 1.115
12 to <16	12	1.115 to < 1.486
>=16	16	>= 1.486

2) The number of individual sensor nodes for each rectangular location shall be maximized for performance within the placement conditions provided. In no instance shall field selected locations provide less distance between disturbances than required for maximum performance. When minimum distances allowed by the highest density of sensor distribution are exceeded, a lower density configuration that provides the same performance is acceptable.

3) Submittal documents shall include schedules indicating the number of sensors per location, the duct area and the equivalent density (#/area) for approval.

e. Each sensing node shall be individually wind tunnel calibrated at 16 points to NIST traceable airflow standards.

f. Each sensing node shall be individually calibrated in constant temperature oil baths at 3 points to NIST traceable temperature standards.

2. Measurement Performance:

a. Each sensing node shall have a temperature accuracy of ± 0.14°F (0.08°C) over the entire operating temperature range of -20°F to 160°F (-28.9°C to 71°C).

b. Each sensing node shall have an airflow accuracy of ± 2% of reading.

c. The ATMD shall be capable of measuring airflow rates over the full range of 0 to 5,000 FPM (25.4 m/s) between -20°F to 160°F (-28.9°C to 71°C).

d. A 3 year warranty shall be provided for the entire system.

3. Integral Transmitter and Communications:

a. The transmitter shall be powered by 24 VAC, be over-voltage and over-current protected, and have a watchdog circuit to provide continuous operation after power failures and/or brown-outs.

b. The transmitter shall determine the airflow rate and temperature of each sensing node prior to averaging.

c. The transmitter shall have two isolated and fused analog output signals and one RS-485 network connection.

d. Each analog output shall be field configurable as linear 0-5/1-5 VDC, 0-10/2-10 VDC or 4-20mA signals.

e. One analog output signal shall provide the average airflow rate.

f. One analog output signal shall be field configurable to output the average temperature, the velocity weighted temperature or a binary airflow alarm.

4. Listings and Certifications:

a. The ATMD shall be UL 973 listed.

b. The ATMD shall be BTL listed.

c. The ATMD shall carry CE Mark for European shipments indicating successful satisfaction of all requirements contained in the EMC Directives, or when otherwise required in the destination country.

5. Design Equipment: Ebtron Model GTC116, HTA-104.

6. Make: Ebtron, Kurz, Sierra.

P. Liquid Flow Measurement:

1. Hi Liquid flow measurement devices shall be accurate to ± 0.75% over a turn down ratio of 10:1. Insertion probe sensing element shall be made of 316l stainless steel. The sensing element shall have an elliptical shape that eliminates the separation point at a fixed or variable location ahead of the static pressure pick up point. Device shall only require one welded insert to mount to piping system. Acceptable manufacturer shall be Preso, model BAR.

Q. Safety/Status Devices:

1. Low Limit Detector: Electric type, with 20 ft. long serpentine element, with manual reset and auxiliary contacts to the DDC, set for 37°F for "freeze" protection and 55°F for fan discharge application. Provide a 20 ft. long element for every 25 sq. ft. of coil face area.

2. High Limit Detector: High limit thermostats shall be located as directed, and shall be manual reset type set at 120°F in the return and 180°F in the discharge. Thermostats shall be double pole so as to provide input capability for alarm at the temperature control system.

3. Pump status shall be provided through adjustable range current sensing element on pump motor.

4. Fan status shall be provided through adjustable range current sensing element on the fan motor.

R. Multi Gas Detection system

1. Wall mounted network controller capibale of detecting carbon monoxide, nitrogen dioxide, hydrogen sulfide, oxygen, methane, hydrogen and propane.
2. Devices shall have dry contact relays 5A @ 250VAC activated upon alarm levels.
3. Devices shall have three (3) alarm levels that are factory set and user adjustable.
4. Devices shall have visual alarm indicators and 85 dBA alarm.
5. Devices shall be 24 VAC / VDC power.
6. Devices shall communicate via RS485 Modbus and BACnet MS-TP master.
7. For spaces with multiple detection devices show a network master controller shall be provided for BMS system integration. This device shall take the signals from all the space multi gas detection units and relay and annunciate alarms.
    a. Unit shall be capable of supporting up to 96 transmitters.
    b. Unit shall have visual indicators for alarm levels.
    c. Unit shall be provided with a remote mounted two (2) light strobe alarm (yellow & Red)
    d. Unit shall have four (4) dry contact relays.
    e. Unit shall be 24 VAC / VDC power.
    f. Unit shall communicate via BACnet/IP.
    g. Unit shall be capable of logging alarms and levels within unit.
    h. Unit shall be mounted in an indistral enclosure.
8. Basis of design for Multi Gas Detectors: Honeywell E3Point.
9. Basis of design for Multi Gas Detector Network Controllers: Honeywell 301C-CDS-BIP.
10. Acceptable Makes: Honeywell, Armstrong Monitoring, Vulcain.

2.02 CONTROL CABINETS

A. BMS control panels shall be fully enclosed cabinet, baked enamel, steel, aluminum or composite material construction and shall meet the requirements of NEMA 1 enclosures. Panels shall have hinged door with a locking latch. Cover exposed electrical connections. Each component on front panel shall have an appropriate engraved label describing its function. Components inside the panel shall be appropriately labeled for ease of identification. Stick-on labels are not acceptable. Panels shall be either free-standing or wall-mounted. Provide support steel framing.

2.03 BUILDING MANAGEMENT SYSTEM

A. The BMS system shall consist of Network Controllers, standalone or application specific controllers, input/output unit modules, operator workstations, and file servers to support system configurations. The BMS system shall provide control, alarm detection, scheduling, reporting and information management for the entire facility.

B. The BMS shall be capable of being segmented, through software, into multiple local area networks per floor of building, distributed over a wide area network or sharing a single file server. This enables workstations to manage wide area network, and/or the entire system with all devices being updated and sharing the most current database. In the case of a single workstation system, the workstation shall contain the entire database - with no need for a separate file server.

C. For multi-workstation systems, a file server shall be utilized capable of residing directly on the Owner's Ethernet TCP/IP preferred network with no required gateways. This network may be dedicated for temperature control systems only so it does not interfere with other networks.

D. In addition to the above local area network and wide area network, the workstation software shall be capable of managing remote systems via remote high speed network as a standard component of the software.

E. The BMS system design shall include solutions for the integration of the following "open systems" protocols: BACnet, LonTalk and digital data communication to third party microprocessors such as chiller controllers, fire panels and variable frequency drives (VFD's).

1. The system shall also provide the ability to program custom ASCII communication drivers, which shall reside in the network control unit, for communication to third party systems and devices. These drivers shall provide real time monitoring and control of the third party systems.

2.04 NETWORK CONTROLLERS

A. Network Controllers shall be microprocessor based, multi-tasking, multi-user, and employ a real time operating system. Each Network Controller panel shall consist of modular hardware including power supply, CPU board, and input/output modules. A sufficient number of Network Controllers shall be supplied to fully meet the requirements of this specification and the point list on the drawings.

B. All Network Controllers on the Ethernet TCP/IP LAN/WAN shall be capable, out-of-the box, to be set up as a Web Server. The Network Controllers shall have the ability to store HTML code and "serve" pages to a web browser. This provides the ability for any computing device utilizing a TCP/IP Ethernet connection and capable of running a standard Internet browser (Microsoft Internet Explorer, Netscape Navigator, etc.) to access real-time data from the entire Temperature Control System via any Network Controllers.

1. Graphics and text-based web pages shall be constructed using standard HTML code. The interface shall allow the user to choose any of the standard text or graphics-based HTML editors for page creation. It shall also allow the operator to generate custom graphical pages and forms.
2. The WEB server interface shall be capable of password security, including validation of the requesting PC's IP address. The WEB server interface shall allow the sharing of data or information between any controller or process or network interface (BACnet, LonTalk and TCP/IP) that the Temperature Control System has knowledge of, regardless of where the point is connected on the Temperature Control System network or where it is acquired from.
3. The network controller shall act directly as the WEB server. It shall directly generate HTML code to the requesting user (i.e. WEB browser), eliminating the need for and reliance on any PC-based WEB server hardware or software. To simplify graphic image space allocation, HTML graphic images, if desired, shall be stored in any shared network device. The Web server shall have the ability to acquire any necessary graphics using standard pathing syntax within the HTML code mounted within the Temperature Control System WEB server. External WEB server hardware and software are not acceptable.

C. Hardware Specifications:
1. A minimum of 4MB of RAM shall be provided for Network Controllers with expansion up to 8MB.
2. Each Network Controller shall provide communication to both the Workstation(s) and the field buses. In addition, each Network Controller shall have at least three other communications ports that support a telephone modem, portable service tool, serial printer and connection to third party controllers such as a chiller control panel. On a LAN/WAN system, the Network Controller shall be provided with a 10Mbps plug-in Ethernet TCP/IP network interface card (NIC).
3. Input/Output (I/O): Each Network Controller shall support the addition of the following types of inputs and outputs:
    a. Digital Inputs for status/alarm contacts.
    b. Counter Inputs for summing pulses from meters.
    c. Thermistor inputs for measuring temperatures in space, ducts and thermowells.
    d. Analog inputs for pressure, humidity, flow and position measurements.
    e. Digital Outputs for on/off equipment control.
    f. Analog Outputs for valve and damper position control, and capacity control of primary equipment.

4. The system shall employ a modular I/O design to allow easy expansion. Input and output capacity is to be provided through plug-in modules of various types or DIN-mountable IOU modules. It shall be possible to combine I/O modules as desired to meet the I/O requirements for individual control applications.

5. Each Network Controller shall include a battery-backed, real time clock, accurate to 10 seconds per day. The Real Time Clock shall provide the following: time of day, day, month, year, and day of week. In normal operation, the system clock shall be based on the frequency of the AC power. The system shall automatically correct for daylight savings time and leap years.

6. The power supply for the Network Controllers shall be auto sensing, 120-220VAC, 60/50 Hz power, with a tolerance of ±20%. The controller shall contain over voltage surge protection, and require no additional AC power signal conditioning. Optionally, if indicated on the drawings, the power supply shall accept an input voltage of (-48 VDC).

7. Upon restoration of power after an outage, the Network Controller shall automatically and without human intervention: Update all monitored functions; resume operation based on current, synchronized time and status, and implement special start-up strategies as required.

8. Each Network Controller with the standard 120-220VAC power supply shall include a programmable DC power backup system rated for a minimum of 72 hours of battery backup to maintain all volatile memory or, a minimum of two (2) hours of full UPS including modem power. This power backup system shall be configurable such that at the end of a settable timeframe of running on full UPS, the unit shall shut off full UPS and switch to memory retention-only mode for the remainder of the battery power. The system shall allow the simple addition of more batteries to extend the above minimum battery backup times.

D. Software:

1. The Network Controller shall contain flash ROM as the resident operating system. Application software shall be RAM resident. Application software shall only be limited by the amount of RAM memory. There shall be no restrictions placed on the type of application programs in the system. Each Network Controller shall be capable of parallel processing, executing all control programs simultaneously. Any program may affect the operation of any other program. Each program shall have the full access of all I/O facilities of the processor. This execution of control function shall not be interrupted due to normal user communications including interrogation, program entry, printout of the program for storage.

2. The application software shall be user programmable. This includes all strategies, sequences of operation, control algorithms, parameters, and setpoints. The source program shall be English language-based and

programmable by the user. The language shall be structured to allow for the easy configuration of control programs, schedules, alarms, reports, telecommunications, local displays, mathematical calculations, passwords, and histories. The language shall be self-documenting. Users shall be able to place comments anywhere in the body of a program. Program listings shall be configurable by the user in logical groupings.

E. Control Software:

1. The Network Controller shall have the ability to perform the following pre-tested control algorithms:
   a. Proportional, Integral plus Derivative Control (PID).
   b. Two Position Control.
   c. Digital Filter.
   d. Ratio Calculator.
   e. Equipment Cycling Protection.
2. Mathematical Functions: Each controller shall be capable of performing basic mathematical functions (+, -, *, /), squares, square roots, exponential, logarithms, Boolean logic statements, or combinations of both. The controllers shall be capable of performing complex logical statements including operators such as >, <, =, and, or, exclusive or, etc. These shall be able to be used in the same equations with the mathematical operators and nested up to five parentheses deep.
3. Energy Management Applications: Network Controllers shall have the ability to perform any or all of the following energy management routines:
   a. Time of Day Scheduling
   b. Calendar Based Scheduling
   c. Holiday Scheduling
   d. Temporary Schedule Overrides
   e. Optimal Start
   f. Optimal Stop
   g. Night Setback Control
   h. Enthalpy Switchover (Economizer)
   i. Peak Demand Limiting
   j. Temperature Compensated Duty Cycling
   k. CFM Tracking
   l. Heating/Cooling Interlock
   m. Hot/Cold Deck Reset
   n. Free Cooling
   o. Hot Water Reset
   p. Chiller Sequencing

q. Static Pressure Reset/Optimizing

r. Demand Controlled Ventilation

s. Supply Air Temperature Reset

4. Each controller shall be capable of logging any system variable over user defined time intervals ranging from 1 second to 1440 minutes. Any system variables (inputs, outputs, math calculations, flags, etc.) can be logged in history. A maximum of 25,000 values can be stored in each log. Each log can record either the instantaneous, average, minimum or maximum value of the point. Logs can be automatic or manual. Logged data shall be downloadable to the Operator Workstation for long term archiving based upon user-defined time intervals, or manual command.

5. Alarm Management: For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms shall be tested each scan of the Network Controller and can result in the display of one or more alarm messages or reports.

   a. Up to eight (8) alarms can be configured for each point in the controller.

   b. Messages and reports can be sent to a local terminal, to the front-end workstation(s), or via modem to a remote-computing device.

   c. Alarms shall be generated based on their priority. A minimum of 255 priority levels shall be provided.

   d. If communication with the Operator Workstation is temporarily interrupted, the alarm shall be buffered in the Network Controller. When communications return, the alarm shall be transmitted to the Operator Workstation if the point is still in the alarm condition.

6. The Network Controller shall be able to generate user-definable reports to a locally connected printer or terminal. The reports shall contain any combination of text and system variables. Report templates shall be able to be created by users in a word processing environment. Reports can be displayed based on any logical condition or through a user command.

2.05 STANDALONE CONTROLLERS

A. Standalone Controllers shall provide control of HVAC and lighting. Each controller shall have its own control programs and shall continue to operate in the event of a failure or communication loss to its associated Network Controllers.

B. Standalone Controllers programs shall be stored in battery backed-up RAM and EPROM. Each controller shall have a minimum of 32K bytes of user RAM memory and 128K bytes of EPROM.

C. Standalone Controllers shall provide a communication port to the field bus. In addition, a port shall be provided for connection of a portable service tool to support local commissioning and parameter changes with or without the Network Controllers online. It shall be possible from a service port on any Standalone

Controller to view, enable/disable, and modify values of any point or program on any controller on the local field bus, any Network Controller or any Standalone Controller on a different field bus.

D. Support BACnet standard MS/TP bus protocol ASHRAE SS PC-15, Clause 9 on the control network.

E. Each Standalone Controller shall support the addition of the following types of inputs and outputs:

1. Digital Inputs for status/alarm contacts.
2. Counter Inputs for summing pulses from meters.
3. Thermistor Inputs for measuring temperatures in space, ducts and thermowells.
4. Analog inputs for pressure, humidity, flow and position measurements.
5. Digital Outputs for on/off equipment control.
6. Analog Outputs for valve and damper position control, and capacity control of primary equipment.

F. Input and output capacity shall be expandable through the use of plug-in modules. A minimum of two (2) modules shall be added to the base Standalone Controller before additional power is required.

G. Each Standalone Controller shall be able to exchange information on a peer to peer basis with other Standalone Controllers during each field bus scan. Each Standalone Controller shall be capable of storing and referencing global variables (on the LAN) with or without any workstations online. Each Standalone Controller shall be able to have its program viewed and/or enabled/disabled either locally through a portable service tool or through a workstation connected to a Network Controller.

H. Standalone Controllers shall have as a minimum, LED indication of CPU status, and field bus status.

I. Standalone Controllers shall have a real time clock in either hardware or software. The accuracy shall be within 10 seconds per day. The Real Time Clock shall provide the following information: time of day, day, month, year, and day of week. Each Standalone Controller shall receive a signal over the network from the Network Controllers, which synchronizes all Standalone Controllers real time clocks.

J. Upon restoration of power, the Standalone Controller shall automatically and without human intervention, update all monitored functions, resume operation based on current, synchronized time and status, and implement special start-up strategies as required.

K. Each Standalone Controller shall have at least three (3) years of battery back up to maintain all volatile memory.

L. For each system point, alarms can be created based on high/low limits or conditional expressions. All alarms shall be tested each scan of the Standalone Controllers and can result in the display of one or more alarm messages or reports.

1. Up to eight (8) alarms can be configured for each point in the controller enabling the escalation of the alarm priority (urgency) based upon which alarm(s) is/are triggered.
2. Alarm messages can be sent to a local terminal or modem connected to a Network Controller or to the Operator's Workstation(s).
3. Alarms shall be generated based on their priority. A minimum of 255 priority levels shall be provided.
4. If communication with the Network Controller is temporarily interrupted, the alarm shall be saved in the Standalone Controller. When communications return, the alarm shall be transmitted to the Network Controller if the point is still in the alarm condition.

M. Air Handler Controllers shall be capable of meeting the requirements of the sequence of operation intended for each system and allow for future expansion.

1. Air Handling Unit Controllers shall support all the necessary point inputs and outputs as required by the sequence and operate in a standalone fashion.
2. Air Handling Unit Controllers shall be fully user programmable to allow for modification of the application software.
3. An LCD display shall be optionally available for readout of point values and to allow operators to change setpoints and system parameters.
4. A manual override switch shall be provided for all digital and analog outputs on the Air Handling Unit Controller. The position of the switch shall be monitored in software and available for operator displays and alarm notification.

N. Air Terminal Unit Controllers:

1. Air Terminal Unit Controllers shall support, but not be limited to the control of the following configurations of Air Terminal Units to address current requirements as described in the Execution portion of this specification, and for future expansion:
    a. Single Duct Cooling Only
    b. Single Duct Cooling with Reheat (Electric or Hot Water)
    c. Fan Powered (Parallel or Series)
    d. Dual Duct (Constant or Variable Volume)
    e. Supply/Exhaust
2. Air Terminal Unit Controllers for single duct applications shall be provided with a built-in actuator for modulation of the air damper. The actuator shall have a minimum torque rating of 35 in.-lb., and contain an

override mechanism for manual positioning of the damper during startup and service.

3. Air Terminal Unit Controllers shall contain an integral velocity sensor accurate to ±5% of the full range of the box's CFM rating.

4. Each controller shall perform the sequence of operation described in Part 3 of this specification, and have the capability for time of day scheduling, occupancy mode control, after hours operation, lighting control, alarming, and trending.

5. Air Terminal Unit Controllers shall be able to communicate with any other Standalone Controllers on the same field bus with or without communication to the Network Controllers managing the field bus. Systems that fail to provide this (true peer-to-peer) capability will be limited to a maximum of 32 Air Terminal Unit Controllers per field bus.

O. Unitary Controllers:

1. Unitary Controllers shall support, but not be limited to, the control of the following systems as described in the Execution portion of this specification, and for future expansion:

   a. Unit Ventilators

   b. Heat Pumps (Air to Air, Water to Water)

   c. Packaged Rooftops

   d. Fan Coils (2 or 4 Pipe)

2. The I/O of each Unitary Controller shall contain the sufficient quantity and types as required to meet the sequence of operation found in the Execution portion of this specification. In addition, each controller shall have the capability for time of day scheduling, occupancy mode control, after hour operation, lighting control, alarming, and trending.

2.06 OPERATOR HARDWARE

A. The BMS workstation software shall be configurable as either a single workstation system (with a local database) or multi-workstation system where the database is located on a central file server. The client software on multi-workstation system shall access the file server database program via an Ethernet TCP/IP network running at either 100MBPS or 1024MBPS.

1. All Workstations shall be Intel Core Processor based personal computers operating under the Microsoft Windows Server 2012 R2. The application software shall be capable of communication to all Network Controllers and Standalone Controllers, feature high-resolution color graphics, alarming, reporting, and be user configurable for all data collection and data presentation functions.

2. For multi-workstation systems, a minimum of 256 workstations shall be allowed on the Ethernet network along with the central file server. In this client/server configuration, any changes or additions made from one

workstation shall automatically appear on all other workstations without the requirement for manual copying of files. Multi-workstation systems with no central database will not be acceptable. Multi-workstation systems with distributed/tiered file servers and a central (master) database will be acceptable.

B. File Server Requirements. The file server shall consist of the following:

1. Base Unit: 2.53GHZ/4-core/80W/8MB Xeon processor.
2. Memory: 8 GB, 1 x 8GB PC3-10600 registered dual rank x 4.
3. Hard Drives: (3) @ TB 3G SATA, 10K Hot Plug 3.5.
4. Optical Drive: Half-height SATA DVD- RW Optical Drive.
5. Network Controller: NCZ82T PC Express dual port multifunction gigabit server adapter.
6. 18.5 in. diagonal widescreen thin film transistor LCD active matrix, resolution 1366 x 768.
7. PCI Graphics Adapter w/8Mb RAM.
8. Provide server grade keyboard and mouse.
9. Software: Microsoft Windows 2012 R2.
10. HP ProLiant ML350 Series, or equal.

C. Workstation Requirements: The workstation shall consist of the following:

1. Base Unit: 3.33 GHz, 1.5 MB, L2 + 12 MD Shared L3 cache.
2. Memory: 12 GB DDR3-1066 MHz SDRAM.
3. Primary Hard Drive: 1.5 TB RAID 1 (2 x 1.5 TB SATA HDDS).
4. Secondary Hard Drive: 1.5 TB 7200 RPM SATA 2Gb/s.
5. CD Drive: Blu-Ray player and light scribe super multi DVD burner.
6. Graphics Card: 1 GB NVIDIA Geforce 460 2 DVI, mini-HDMI, VGA adapter.
7. 18.5 in. diagonal widescreen thin film transistor LCD active matrix, resolution 1366 x 768.
8. Keyboard and Mouse: USB keyboard and optical mouse.
9. Software: Microsoft Office Professional 2010.
10. HP Pavilion Elite HPE-800 Series, or equal.

D. Printer: Provide a workstation printer to display alarms and graphics. The printer is to be a HP Officejet Pro 8100, or equal.

2.07 WORKSTATION SOFTWARE

A. General Description:

1. The software architecture shall be object-oriented in design, a true 32-bit application suite utilizing Microsoft's OLE, COM, DCOM and ODBC

technologies. These technologies shall make it easy to fully utilize the power of the operating system to share, among applications (and therefore to the users of those applications), the data available from the Temperature Control System.

a. The workstation functions shall include monitoring and programming of all BMS controllers. Monitoring consists of alarming, reporting, graphic displays, long term data storage, automatic data collection, and operator-initiated control actions such as schedule and setpoint adjustments.

b. Programming of controllers shall be capable of being done either off-line or on-line from any operator workstation. All information shall be available in graphic or text displays. Graphic displays shall feature animation effects to enhance the presentation of the data, to alert operators of problems, and to facilitate location of information throughout the BMS system. All operator functions shall be selectable through a mouse.

2. The file server database engine shall be Microsoft SQL Server, or another ODBC-compliant, relational database program. This ODBC (Open Database Connectivity) compliant database engine shall allow for an Owner to utilize "their" choice of database and due to its "open" architecture, shall allow an Owner to write custom applications and/or reports that communicate directly with the database avoiding data transfer routines to update other applications. The system database shall contain all point configurations and programs in each of the controllers that have been assigned to the network. In addition, the database shall contain all workstation files including color graphic, alarm reports, text reports, historical data logs, schedules, and polling records.

3. The BMS workstation software shall allow the creation of a custom, browser-style interface linked to the user that has logged into the workstation software. This interface shall support the creation of "hot-spots" that the user may link to view/edit any object in the system or run any object editor or configuration tool contained in the software. Furthermore, this interface shall be able to be configured to become a user's "PC Desktop" - with all the links that a user needs to run other applications. This, along with the Microsoft Office Professional 2010 user security capabilities, shall enable a system administrator to setup workstation accounts that not only limit the capabilities of the user within the BMS software but may also limit what a user can do on the PC and/or LAN/WAN. This might be used to ensure, for example, that the user of an alarm monitoring workstation is unable to shutdown the active alarm viewer and/or unable to load software onto the PC.

4. The software shall be designed so that each user of the software can have a unique username and password. This username/password combination shall be linked to a set of capabilities within the software, set by and editable only by, a system administrator. The sets of capabilities shall

range from View only, Acknowledge alarms, Enable/disable and change values, Program, and Administer. The system shall allow the above capabilities to be applied independently to each and every class of object in the system. The system shall allow a minimum of 256 users to be configured per workstation. There shall be an inactivity timer adjustable in software that automatically logs off the current operator after the timer has expired.

5. The workstation software shall use a familiar Windows Explorer style interface for an operator or programmer to view and/or edit any object (controller, point, alarm, report, schedule, etc.) in the entire system. In addition, this interface shall present a "network map" of all controllers and their associated points, programs, graphics, alarms, and reports in an easy to understand structure. All object names shall be alphanumeric and use Windows long filename conventions. Object names shall not be required to be unique throughout the system allowing for point naming convention consistency. For example, each Air Temperature Unit Controller can have an input called Space Temperature and a setpoint called CFM Setpoint.

    a. The configuration interface shall also include support for template objects. These template objects shall be used as building blocks for the creation of the BMS database. The types of template objects supported shall include all data point types (input, output, string variables, setpoints, etc.), alarm algorithms, alarm notification objects, reports, graphics displays, schedules, and programs. Groups of template object types shall be able to be set up as template subsystems and systems. The template system shall prompt for data entry if necessary. The template system shall maintain a link to all "child" objects created by each template. If a user wishes to make a change to a template object, the software shall ask the user if he/she wants to update all of child objects with the change. This template system shall facilitate configuration and programming consistency and afford the user a fast and simple method to make global changes to the BMS.

6. Color Graphic Displays: The system shall allow for the creation of user defined, color graphic displays for the viewing of mechanical and electrical systems, or building schematics. These graphics shall contain point information from the database including any attributes associated with the point (engineering units, etc.). In addition, operators shall be able to command equipment or change setpoints from a graphic using the mouse. Requirements of the color graphic subsystem include:

    a. LCD active matrix, resolution 1366 x 768 displays. The user shall have the ability to import AutoCAD generated picture files as background displays.

    b. A built-in library of animated objects such as dampers, fans, pumps, buttons, knobs, gauges, and graphs which can be "dropped" on a graphic using a software configuration "wizard".

These objects shall enable operators to interact with the graphic displays in a manner that mimics their mechanical equivalents found on field installed control panels. Using the mouse, operators shall be able to adjust setpoints, start or stop equipment, modify PID loop parameters, or change schedules.

c. Status changes or alarm conditions shall be able to be highlighted by objects changing screen location, size, color, text, blinking or changing from one display to another.

d. Graphic panel objects shall be able to be configured with multiple "tabbed" pages allowing an operator to quickly view individual graphics of equipment, which make up a subsystem or system.

e. Ability to link graphic displays through user defined objects, alarm testing, or the result of a mathematical expression. Operators shall be able to change from one graphic to another by selecting an object with a mouse - no menus will be required.

7. The software shall allow for the automatic collection of data and reports from any controller through either a hardwire or modem communication link. The frequency of data collection shall be completely user-configurable.

8. The software shall be capable of accepting alarms directly from controllers, or generating alarms based on evaluation of data in controllers and comparing to limits or conditional equations configured through the software. Any alarm (regardless of its origination) shall be integrated into the overall alarm management system and shall appear in all standard alarm reports, be available for operator acknowledgment, and have the option for displaying graphics, or reports. Alarm management features shall include:

a. A minimum of 255 alarm notification levels, or classes of alarms. Each notification level shall establish a unique set of parameters for controlling alarm display, acknowledgment, keyboard annunciation, alarm printout and record keeping.

b. Automatic logging in the database of the alarm message, point name, point value, connected controller, timestamp, username and time of acknowledgement, username and time of alarm silence (soft acknowledgement).

c. Automatic printing of the alarm information or alarm report to an alarm printer or report printer.

d. Playing an audible beep or audio (wav) file on alarm initiation or return to normal.

e. Sending an email or text message to anyone listed in a workstation's email account address list on either the initial occurrence of an alarm and/or if the alarm is repeated because an operator has not acknowledged the alarm within a user-configurable timeframe. The ability to utilize email and texting of

alarms shall be a standard feature of the software integrated with the operating system's mail application interface (MAPI). No special software interfaces shall be required.

f. Individual alarms shall be able to be re-routed to a workstation or workstations at user-specified times and dates. For example, a critical high temperature alarm can be configured to be routed to a Facilities Dept. workstation during normal working hours (7am-6pm, Mon-Fri) and to a Central Alarming workstation at all other times.

g. An active alarm viewer shall be included which can be customized for each user or user type to hide or display any alarm attributes.

h. The font type and color, and background color for each alarm notification level as seen in the active alarm viewer shall be customizable to allow easy identification of certain alarm types or alarm states.

i. The active alarm viewer can be configured such that an operator shall type in text in an alarm entry and/or pick from a drop-down list of user actions for certain alarms. This ensures accountability (audit trail) for the response to critical alarms.

9. The software shall contain a built-in custom report generator, featuring word processing tools for the creation of custom reports. These custom reports shall be able to be set up to automatically run or be generated on demand. Each workstation shall be able to associate reports with any word processing or spreadsheet program loaded on the machine. When the report is displayed, it shall automatically spawn the associated report editor, which shall be the most recent version of Microsoft Office.

a. Reports can be of any length and contain any point attributes from any controller on the network.

b. The report generator shall have access to the user programming language in order to perform mathematical calculations inside the body of the report, control the display output of the report, or prompt the user for additional information needed by the report.

c. It shall be possible to run other executable programs whenever a report is initiated.

d. Report Generator activity can be tied to the alarm management system, so that any of the configured reports can be displayed in response to an alarm condition.

e. Standard reports shall include:

1) Points in each controller.

2) Points in alarm.

3) Disabled points.

4) Overridden points.

5) Operator activity report.

6) Alarm history log.

7) Program listing by controller with status.

8) Network status of each controller.

10. Spreadsheet-Style Reports: The software shall allow the simple configuration of row/column (spreadsheet-style) reports on any class of object in the system. These reports shall be user-configurable and shall be able to extract live (controller) data and/or data from the database. The user shall be able to set up each report to display in any text font, color and background color. In addition, the report shall be able to be configured to filter data, sort data, and highlight data that meets user-defined criteria.

11. HTML Reporting: The above spreadsheet-style reports shall be able to be run to an HTML template file. This feature shall create an HTML "results" file in the directory of the HTML template. This directory can be shared with other computer users, which shall allow those users with access to the directory to "point" their web browser at the file and view the report.

12. Scheduling: It shall be possible to configure and download from the workstation schedules for any of the controllers on the network.

    a. Time of day schedules shall be in a calendar style and shall be programmable for a minimum of one year in advance. Each standard day of the week and user-defined day types shall be able to be associated with a color so that when the schedule is viewed it is very easy, at-a-glance, to determine the schedule for a particular day even from the yearly view. To change the schedule for a particular day, a user shall simply click on the day and then click on the day type.

    b. Each schedule shall appear on the screen viewable as the entire year, monthly, week and day. A simple mouse click shall allow switching between views. It shall also be possible to scroll from one month to the next and view or alter any of the schedule times.

    c. Schedules shall be assigned to specific controllers and stored in their local RAM memory. Any changes made at the workstation shall be automatically updated to the corresponding schedule in the controller.

13. The programmer's environment shall include access to a superset of the same programming language supported in the controllers. In this environment, the programmer shall be able to configure application software off-line (if desired) for custom program development, write global control programs, system reports, wide area networking data collection routines, and custom alarm management software. On the same screen as the program editor, the programming environment shall include dockable debug and watch bars for program debugging and viewing

updated values and point attributes during programming. In addition, a wizard tool shall be available for loading programs from a library file in the program editor.

14. The workstation software shall have an application to save and restore field controller memory files. This application shall not be limited to saving and reloading an entire controller - it shall also be able to save/reload individual objects in the controller. This allows off-line debugging of control programs, for example, and then reloading of just the modified information.

15. The workstation software shall have the capability to easily configure groups of data points with trend logs and display the trend log data. A group of data points shall be created by drag-and-drop method of the points into a folder. The trend log data shall be displayed through a simply menu selection. This data shall be able to be saved to file and/or printed.

16. The workstation software shall automatically log and timestamp every operation that a user performs at a workstation, from logging on and off a workstation to changing a point value, modifying a program, enabling/disabling an object, viewing a graphic display, running a report, modifying a schedule, etc.

17. Fault Tolerant File Server Operation: The system shall provide the option to provide fault tolerant operation in the event of the loss of the CPU, disk drives, or other hardware required to maintain the operational integrity of the system. Operational integrity includes all user interfaces, monitoring of alarm points and access points, and executing access control functions. Fault tolerant technology is not provided unless specifically stated.

    a. The switchover mechanism provided shall be automatic. Should the failure be caused by hardware, then the system shall immediately switch to the Backup computer. Should the system failure be caused by software (instruction or data), the system shall not pass the faulted code to the Backup computer, otherwise the Backup shall fail in the same manner of the Primary computer.

    b. Switchover to the Backup computer shall be initiated and effective (complete) in a manner and time frame that precludes the loss of event data, and shall be transparent to the system users, except for an advisory alarm message indicating that the switchover has occurred.

    c. When the system fails-over from the Primary to the Backup computer, no alarm or other event shall be lost, and the Backup computer shall take control of all system functions.

    d. A single component failure in the system shall not cause the entire system to fail. All system users shall be informed of any detectable component failure via an alarm event. System users shall not be logged off as a result of a system failure or switchover.

e. The Primary computer shall provide continual indication that the Backup computer is unavailable until such time that the fault has been purged.

2.08 WEB BROWSER INTERFACE

A. Provide a web browser interface that will be accessible to any computer on the Owner's Intranet with Microsoft Internet Explorer 8.0 or higher. The system shall support a minimum of 5 simultaneous users to access the system. The Web Browser Interface shall include the following features.

1. Day-to-day operation of the system shall be accessible through a standard web browser interface, allowing technicians and operators to view any site in the system from anywhere on the network.
2. The browser-based interface must share the same graphical displays as the Operator Workstations, presenting dynamic data on site layouts, floor plans, and equipment graphics. The browser's graphics shall also support commands to change setpoints, enable/disable equipment and start/stop equipment.
3. Through the browser interface, operators must be able to navigate through the entire system, and change the value or status of any point in any controller. Changes are effective immediately to the controller, with a copy stored in the system database.
4. Through the browser interface, operators must be able to view pre-defined groups of points, with their values updated automatically.
5. Through the browser interface, operators must be able to change schedules - change start and stop times, and add new times to a schedule.
6. Through the browser interface, operators must be able to create and edit card access personnel records, and assign the card to any and all sites for access, in any combination.
7. Through the browser interface, operators must be able to view reports of access events and access privileges. Reports must be available based on start and end time, door, area, and person. Invalid attempts must be color-coded red in the report.
8. Through the browser interface, operators must be able to view live and recorded video from any digital video recorder on the network. The interface must offer an easy method of selecting the camera to view, and for recorded video, must offer selections for start and stop time when searching video clips.
9. All commands and user activity through the browser interface shall be recorded in the system's activity log, which can be later searched and retrieved by user, date, or both.
10. The same user accounts shall be used for the browser interface and for the operator workstations. Operators must not be forced to memorize multiple passwords.

11. The system shall be expandable to up to 25 concurrent browser-based users per server.

2.09 UTILITY METERING

A. General Requirements:

1. The following meters shall be included in this system:
   a. Electric Meter (Quantity one (1) per building).
   b. Gas Meter (Quantity one (1) per building).
   c. Water Meter (Quantity one (1) per building).
2. Provide all hardware, software, installation labor and information required to contractors involved in the project to effect the installation of an Automated Controller Polling system as specified herein. The system shall be capable of providing information to the facility operational staff and others empowered to have and use the information as directed by the administration. The system shall be complete in every respect as specified and shall provide all information required to affect the output of the reports defined in the relevant section of this specification. The supplier shall provide two certifications that the system is tracking with the utility meters. One certification shall be provided as the system is turned over to the owner. The second certification shall be provided after six to eight months of operation. The protocol for the certification process is included in this specification and shall be rigidly adhered to. The system information sensors cross contract section responsibilities, and as such require coordination. The system supplier shall be responsible to coordinate the contractor to see that the utility sensors required by their respective sections are provided and work properly. The system supplier is not responsible for the provision or installation of the primary sensing elements of this system. They are the responsibility of the section that provides the utility service to the facility and are specified under the appropriate sections. Further, it is not the responsibility of the system supplier to coordinate with the utility company to see that the sensors are supplied and are provided with the necessary information. That responsibility is also specified in the appropriate sections.

B. System Field Hardware and Installation:

1. Provide and install all hardware required to connect to utility primary meter auxiliary output sensors provided by others to collect information required to generate reports as defined in the report section of this document. The hardware shall collect and store data for retrieval by a central server through the facility intranet and over the Internet. A 10BaseT network tap with a Fixed IP address for the building controller shall be provided by others to provide system connectivity to the Intranet.
2. Contract with the utility companies to install auxiliary pulse contacts on all meters monitored.

3. The building controller shall be connected to an application controller that shall receive pulses proportional to utility use. Provide and install the application controller with necessary input characteristics to be compatible with the primary utility sensing equipment. Connect controller inputs to the meter auxiliary outputs at the point shown on the drawings where the utility meter sensor terminations are shown to be connected.

C. System Polling Server:

1. Provide at the system supplier facility a polling server service that will poll every meter for the consumption of utility commodity every sixty (60) minutes.
2. Data shall be stored in an approved supported SQL database such as Microsoft SQL Server. The server polling process shall be self-healing so as to automatically recover back data in conditions where Internet outages occur for an adjustable period of minimum six (6) hours to a maximum of seven days.
3. The data collection application controllers that interface directly with the meter pulsing head sensors shall be capable of storing data for a minimum period of the previous seven (7) days so as to provide the source for the data recovery outlined above.
4. The system shall incorporate a temperature-sensing device, and collect data from the same for outdoor air. This data shall be used to provide for the calculation of degree-day information for use in daily energy analysis formats.

D. User Report Interface:

1. The system shall provide the user with a menu driven interface, which shall contain a menu driven interface for the purpose of report configuration, storage and advanced analysis.

E. The application shall provide the following:

1. Provide a Site Manager interface to browse building sites and the meter sources, grouped by commodity. Information displayed shall provide for the ability to map meter sources back to their related software points at the data input interface for ready field identification and system cross reference.
2. Provide a Rate Manager interface, permitting the user to enter and store a unit cost for each commodity tracked in the system, giving the user the ability to analyze financial impact, as provided for in reports listed in the Energy Reports section of this specification.
3. Provide a Report Manager interface, which provides the user with the ability to select the desired Commodity to be examined and between Daily and Hourly Reports. The report manager interface shall be calendar driven to provide for easy selection of data set date ranges. The report manager interface shall permit the user to dynamically choose any number

of building sites to include in a report, as well as save reports that can be easily recalled for the purposes of analysis against events such as billing cycles.

4. Provide a function to allow the user to create and save groups of buildings to allow for ease of use when benchmarking buildings against each other.

5. Daily reports shall contain:

    a. Summary Report page plotting all buildings polled against each other for Consumption, Consumption per square foot, and Load Consumption Ratio.

    b. Summary Data page charting all buildings polled against each other for Consumption, Consumption per square foot, and Load Consumption Ratio.

    c. Building Area page ranking buildings from highest to lowest square footage.

    d. Energy Mark page ranking all buildings polled from highest to lowest energy savings potential based upon Energy per square foot, Load Ratio, and Energy used.

    e. Weather Data page providing daily weather history including outside air temperature, heating degree days, and cooling degree days.

    f. Page for each building polled containing:

        1) Total Consumption for period polled.

        2) Consumption per square foot of building area for period polled.

        3) Daily Consumption Total.

        4) Daily Consumption per square foot of building area.

        5) Daily Peak Demand and time.

        6) Daily Low Demand and time.

        7) Night Consumption as total.

        8) Night Consumption as a percentage of total consumption.

        9) Daily Night Consumption Total.

        10) Daily Night Consumption per square foot of building area.

        11) Day Consumption as total.

        12) Day Consumption as a percentage of total consumption.

        13) Daily Day Consumption Total.

        14) Daily Day Consumption per square foot of building area.

        15) Load Ratio comparing night and day consumption totals.

        16) Daily Load Ratio comparing daily night and day consumption.

6. Hourly reports shall contain:
    a. Page for each building polled containing:
        1) Total Consumption for period polled.
        2) Night Consumption as percentage of total consumption.
        3) Day Consumption as percentage of total consumption.
        4) Load ratio comparing night and day consumption totals.
        5) Consumption for each hour of period polled.

2.10 SURGE SUPPRESSION (SP) RECEPTACLE

A. Provide at each DDC panel and operator workstation locations, a surge suppression receptacle with metal oxide varister to dissipate the electrical energy of voltage spikes. 20 ampere, duplex, NEMA 5-20R configuration. Back and side wiring, high impact nylon body.

B. Acceptable Make: Hubbell 5352-S.

2.11 GRAPHICS

A. System Graphic:
    1. The equipment drawing will be three-dimensional. The values on the screen shall be reported in real time as well as dynamic to be updated as the value changes.
    2. All components of the drawing will show their actual field location and position. Sensors will be in the exact location in reference to piping and air stream. Icons or "library" images imported during the construction of the drawing will be accurate in depiction of the device and any interaction with other components of the drawing, i.e. don't draw piping into the motor of a pump icon.
    3. If there are size limitations or clutter from the number of components a link to a sub graphic having the same layout will be used to clarify.

B. Space Graphic:
    1. Floor plan drawings will be linked to the supplying air handling unit or in some cases to the exhaust fan. Electronic floor plans to be provided by Architect/Engineer.
    2. Floor plans showing areas served by more than one air handling unit will have the areas color-coded by air handling unit. If the air-handling unit serves different floors the color will be consistent for an air-handling unit for all floors.
    3. If an area has control other than DDC it will be noted with text and left white in the background.
    4. A temperature zone serving more than one space shall have a unique pattern, to distinguish that zone from other temperature zones. The

patterns should slight enough as to not obscure the space temperature, room number and borders detail but visible enough to be able to distinguish between different zones. A different "peppering" of symbols (of + ˆ * ≈) or patterns (hex, herringbone, verticals, etc.) will be used to define the zones.

5. Temperature zones dedicated to only one space will not have to be detailed.

6. Remote physical points such as differential monitors and the like shall be shown in their installed location.

C. The second level of graphics shall be all the DDC points to be installed under the contract overlaid on building floor plan and the Air Handling Unit and its associated systems. Electronic floor plans to be provided by Architect/Engineer.

D. Description of Operation:

1. The approved description of operation will appear on a text graphic in 12-point text written in paragraph form.

2. Additional notes may appear on the equipment graphic in an appropriate location.

E. Layout:

1. The subject device of equipment graphic will be centrally located on the drawing.

2. At the top center, the name of the equipment device will be displayed with its room number. Immediately below the PM# will be displayed. On a third line will be the capacity of the device in units common to that device i.e. air handling units in CFM, pumps in GPM.

3. The top right hand corner will contain links to associated graphics. The Description of Operation, submittal graphic, space graphic and graphic index page will be typical. Other links may be required. All graphic pages will have backward link to return to the main System Graphic.

4. The top left-hand corner will contain global data. Outside Air would be the most common other values may be required when related to the device operation. If the global data functions within the program of this unit, the point referenced in the program will be displayed.

5. The lower left-hand corner will display the operational modes of the device. Occupied, warm up, winterized and economizer would be common. Other modes will be displayed if the unit uses them.

6. In the upper right-hand area, just below the links, the setpoints of the device will be displayed. All setpoints in the various control loops of the device, DA temp, static pressure, MA will be placed in columns as the drawing permits.

7. The date of the last revision of the graphic will be displayed in the lower right corner.

F. Text:

1. Text will contrast with the background for easy reading.
2. The text will be free floating without borders or boxes unless specifically required.

G. The graphics shall include approved schematic of the equipment, sequence of operation and all wiring interface diagrams.

H. The graphic shall include all new systems, equipment and spaces.

PART 3 - EXECUTION

3.01 GENERAL SYSTEM REQUIREMENTS

A. The control of each system shall be guaranteed to perform as described in the Sequence of Operation on the drawings. Equipment, remote switches, in finished rooms shall be flush-mounted, if possible. Interlock supply and return fans, humidifiers with fans, condensers or cooling towers with air conditioning equipment and similar situations demanding coordinated operation.

3.02 SYSTEM COMPONENTS

A. Valves: Union or flanged connected. Locate close to apparatus controlled with pipe reducers and increasers located closest to valve. Locate, arrange, and pipe per installation diagram.

B. Mounting height for all room thermostats or sensors shall be 48 in. to the top of the cover.

C. Locate thermostats on walls symmetrical with adjacent items. Verify exact room location to avoid doors, fixed and portable equipment. Install to minimize damage. Do not install adjacent to lighting dimmers or other heat generating equipment.

D. Dampers and Damper Operators: Tag dampers for proper location. Install per manufacturer's printed instruction as to motor size and quantity, linkage arrangement, drive connection point. Adjust to close tightly. Allow for conduit sleeve or blank space for roof fan dampers. Where ducts are insulated, set damper operators at least 2 in. away from side of duct to allow for insulation.

3.03 SMOKE DAMPERS AND FIRE/FAN SHUT DOWN

A. Provide control for smoke dampers as required. Division 26 "Electric" to provide 120 volt power wiring and associated signal wiring to close all smoke partition smoke dampers associated with a particular air handling unit upon alarm at any duct smoke detector in that particular system.

B. Division 26 "Electric" to provide a signal to stop air handling unit fans and close air handling unit smoke dampers upon activation of the fire alarm system. Wiring to be directly to the motor starter.

C. The DDC Subcontractor shall provide control wiring for a digital input point for an end switch that shall prevent the operation of the air handling unit fans until its corresponding smoke dampers are proven fully open

D. Division 26 "Electric" shall also provide a signal to the DDC control system that the fire alarm system is activated.

3.04 LOW AND HIGH LIMIT SAFETY FUNCTIONS

A. Provide for all supply fan units. Wiring to be directly to the motor starter. High limit controller (firestat) shall be located in the unit discharge, set at 180□F and prevent the fan from operating until reset. High limit shall alarm DDC system. Low limit shall be strung on the discharge face of preheat coils set at 37□F. Low limit shall: prevent fan from operating, set heating coils to full heat, fully close the outside air damper, fully close the relief air dampers, open return air damper, and alarm DDC system until reset.

3.05 SYSTEM TESTING AND COMMISSIONING

A. At the time of installation, systems shall be tested for control device operation prior to the systems acceptance. A report of each systems performance shall be submitted to the Owner's Representative. The report shall include:

1. Field verification and demonstration checklist of analog input calibration, analog output operation, digital input function, and digital output operation.
2. Trend log of inputs and output, printed every two (2) hours, for one (1) week.
3. Refer to "Instructions and Adjustments".

3.06 SYSTEM DESCRIPTION - GENERAL

A. All systems shall maintain the scheduled or otherwise noted minimum outside air ventilation rate during building occupied hours.

B. Provide normally open hot water and normally closed cooling coil valves.

C. Provide normally open return air damper, normally closed relief air and normally closed outside air dampers and operators.

D. Mode of operation (occupied/unoccupied) including building warm-up and pull-down cycles, as well as all system functions shall be programmable and controlled by the BMS system.

E. Shutdown of air handling units and fans due to a fire alarm shall be by the Contractor. The fire alarm system will send a signal to the BMS system for

monitoring purposes only of each air handling unit and exhaust system. The BMS system will provide a staggered restart of the units once the alarm is cleared.

F. All setpoints shall be adjustable.

G. Two (2) outside air temperature sensors and two (2) outside air humidity sensors are to be provided as general inputs to the BMS system. The pair of readings shall be averaged for use by the system. If an individual reading is found to be out of range by comparison, then the other reading shall be used, and an alarm shall be generated.

H. Where the normal sequence position or status of a device is allowed to be manually over-ridden by the building Owner/operator, the device shall be returned to its normal "system off" position, if the system is shut down by the BMS system or building fire alarm system. This includes overriding manually set and locked setpoints. Upon system restart, the device shall return to its manually over-ridden status. Returning devices to their normal "systems off" position shall be done to reduce the potential of damage to the systems.

3.07 CONTROL SEQUENCE

A. Refer to plans for control diagrams, sequences and points lists.

END OF SECTION

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SECTION 23 20 10
PIPING SYSTEMS AND ACCESSORIES

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 078413 - Penetration Firestop Systems.

1.03 SUBMITTALS

A. Schedule of pipe materials, fittings and connections.

PART 2 - PRODUCTS

2.01 GENERAL

A. Pipe and fittings shall be new, marked with manufacturer's name and comply with applicable ASTM and ANSI Standards.

B. All adhesives, sealants, primers and paint used for piping in the interior of the building shall comply with the maximum Volatile Organic Compound (VOC) limits called for in the current version of U.S. Green Building Council LEED Credits EQ 4.1 and EQ 4.2.

2.02 STEEL PIPING AND FITTINGS

A. Pipe: ASTM A53, Schedule 40 weight; black or galvanized finish as called for; ends chamfered for welding connections.

B. Fittings: Same material and pressure class as adjoining pipe.

1. Welded Fittings: Factory forged, seamless construction, butt weld type, chamfered ends. Where branch connections are two or more sizes smaller than main size, use of "Weldolets", "Thredolets", or "Sockolets" are acceptable. Socket weld type, 2000 psi wp, where required.
2. Threaded Fittings: Cast or malleable iron, black or galvanized, as required; drainage type where called for.

C. Flanges, Unions and Couplings:

1. Threaded Connections:
   a. Flanges: Cast iron companion type; for sizes 2-1/2 in. and larger.
   b. Unions: Malleable iron, bronze to iron seat, 300 lb. wwp; for sizes 2 in. and smaller.
   c. Couplings: Malleable iron, 150 or 300 lb. wwp, based on system pressure. Steel thread protectors are not acceptable as couplings.

2. Welded Connections:

a. Flanges: Welding neck type.

b. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents and working temperatures and pressures. ASME B16.21, nonmetallic, flat, asbestos free, 1/8 in. maximum thickness unless thickness or specific material is indicated.

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

D. Gauge and Instrument Connections: Nipples and plugs for adapting gauges and instruments to piping system shall be IPS brass.

E. Base Elbows:

1. Cast iron or steel type, flange connections. Made from welding elbows, with welded pipe support and steel base. Reducing elbows where necessary.

ELBOW SIZE	SUPPORT SIZE	BASE PLATE
2 in. to 3 in.	1-1/4 in.	6 in. x 6 in. x 1/4 in.
4 in. to 6 in.	2-1/2 in.	8 in. x 8 in. x 1/4 in.
8 in. and larger	6 in.	14 in. x 14 in. x 5/16 in.

2. Anchor bolt holes in each corner of base for securely bolting to floor or concrete base; minimum 3/4 in. bolts.

2.03 COPPER TUBE AND FITTINGS - SOLDER JOINT

A. Pipe: ASTM B88; Type K, L or M, hard temper. Soft temper only where specified. Plans show copper tube sizes.

B. Tees, Elbows, Reducers: Wrought copper, ANSI B16.22 or cast bronze; ANSI B16.8 solder end connections.

C. Unions and Flanges: 2 in. and smaller use unions, solder type, cast bronze, ground joint, 150 lb. swp: 2-1/2 in. and over use flanges, cast bronze, companion type, ASME drilled, solder connection, 150 lb. swp.

D. Solder Materials: No-lead solder, using alloys made from tin, copper, silver and nickel.

E. Make: Harris "Stay-Safe 50" and "Bright", Engelhard "Silverbright 100", Willard Industries "Solder Safe (silver bearing), Canfield "Watersafe" or approved equal.

2.04 STAINLESS STEEL PIPE AND FITTINGS - PRESSURE-SEALED JOINTS

A. Pipe: Type 304/304L, Schedule 10S, stainless steel conforming to ASTM A312 with plain ends.

B. Couplings and fittings shall be formed of precision cold drawn stainless steel pipe with synthetic rubber O-ring seals.

C. O-ring seals shall be molded of synthetic rubber, Grade HNBR suitable for potable water up to 210°F or Grade EPDM suitable for water up to 250°F.

D. Fitting ends shall be pressed onto pipe using only a tool specifically designed for this purpose. Pipe ends must be fully inserted into the coupling and fitting housing up to the pipe stop. 500 psig maximum CWP rating.

E. Fittings: Elbows, tees, laterals, reducers, adapters as required. Same construction as couplings.

F. Design Basis: Victaulic Vic Press 316, Shurjoint, Viega Pro Press Stainless.

2.05 COPPER DRAINAGE TUBE AND FITTINGS - SOLDER JOINT

A. Pipe: ASTM B306, Type DWV, hard temper.

B. Fittings: Wrought copper, ANSI B16.29 or cast bronze, ANSI B16.23; solder end connections.

C. Solder Materials: No lead solder, using alloys made from tin, copper, silver and nickel.

D. Make: Harris "Stay-Safe 50" and "Bright", Engelhard "Silverbright 100", Canfield "Watersafe" or approved equal.

2.06 COPPER TUBE AND FITTINGS - BRAZED JOINT

A. Pipe: ASTM B88, Type K or L, hard temper.

B. Tees, Elbows and Reducers: Wrought copper, ANSI B16.22 or cast bronze, ANSI B16.18.

C. Unions and Flanges: Unions for 2 in. and smaller. Brazed type cast bronze ground joint, 150 lb. swp; flanged for 2-1/2 in. and larger, brazed type, cast bronze, companion type, gasketed and bolted, ASME drilled 150 lb. swp.

D. Brazing Materials: Class BcuP-2 for brazing copper to brass, bronze or copper. Harris, Inc. Stay-Silv 0, The Prince & IZane Companies Phoscopper O, Lenox WS 78161 or approved equal.

2.07 DIELECTRIC PIPE FITTINGS

A. Description: Assembly or fitting having insulating material isolating joined dissimilar metals to prevent galvanic action and stop corrosion.

B. Unions: Factory fabricated, for 250 psi minimum working pressure at 180°F, threaded or solder ends, insulating material suitable for system fluid, pressure and temperature.

C. Flanges: Factory-fabricated, companion-flange assembly, for 150 or 300 psig minimum pressure to suit system fluid pressures and temperatures with flange insulation kits and bolt sleeves.

D. Waterway Fittings: 300 psi maximum working pressure at 230°F, male threaded or grooved ends, electroplated ductile iron or steel body with LTHS high temperature polyolefin polymer liner.

E. Make: EPCO, Capitol Manufacturing, Watts, Victaulic, or approved equal.

F. The use of brass valves, brass nipples (3 in. and larger) and Shurjoint epoxy coated transition coupling may be used for dielectric isolation. Dielectric transition fittings for sizes 2 in. through 8 in., which shall provide effective insulation between the steel and copper systems to avoid galvanic local cell and stray current problems. The dielectric transition fitting shall be made of ductile iron per ASTM A536 Gr. 65-45-12, electric deposition coated, with a virgin PP (propylene) lining.

2.08 REFRIGERATION PIPING

A. Type L hard temper deoxidized, dehydrated, and sealed copper tubing, refrigerant grade.

B. Refrigerant grade wrought copper fittings. Long radius elbows.

C. Factory made suction traps.

D. Piping and system shall meet the requirements of Safety Code for Mechanical Refrigeration, ANSI/ASHRAE 15-1994 and ASME/ANSI B31.5.

E. Make: Mueller, Howell Metal, Cerro, Cambridge-Lee, Universal Tube.

2.09 HANGERS, INSERTS, AND SUPPORTS

A. Hangers, Inserts, Clamps: B-Line, Grinnell, Michigan Hanger, PHD Manufacturing, Anvil, Hilti.

B. Hangers:

1. Adjustable, wrought malleable iron or steel with electroplated zinc or cadmium finish. Copper plated or PVC coated where in contact with copper piping. Hot-dipped galvanized finish for exterior locations.

2. Adjustable ring type where piping is installed directly on hanger for piping 3 in. and smaller.
3. Adjustable steel clevis type for 4 in, and larger, and where insulation passes through hanger.
4. Hangers sized to permit passage of insulation through the hanger for refrigerant piping.
5. Nuts, washers and rods with electroplated zinc or cadmium finish. Hot-dipped galvanized finish for exterior locations.

C. Hanger Shields:

1. Pre-Insulated Type:
   a. Insulated pipes shall be protected at point of support by a 360° insert of high density, 100 psi waterproof calcium silicate, encased in a 180° sheet metal shield. Insulation insert to be same thickness as adjoining pipe insulation and extend 1 in. beyond sheet metal shield. Insulation shall be provided with a factory installed ASJ.
2. Field-Insulated Type:
   a. #18 USSG, galvanized steel shields, minimum 120° arc. Provide high density block, 18# density molded fiberglass inserts, between pipe and hanger shield to maintain proper spacing for insulation. Insulation inserts shall extend 1 in. beyond the sheet metal shields. Material shall comply with ASTM E84 25/50, have a thermal conductivity of K=.30 (stable) and have a service temperature of -120°F to +650°F. Install in accordance with manufacturer's printed instructions.
3. Shield Sizing:

PIPE SIZE	SHIELD LENGTH	MINIMUM GAUGE
1/2 in. to 3-1/2 in.	9 in.	20
4 in.	9 in.	20
5 in. and 6 in.	9 in.	20
8 in. to 12 in.	12 in.	18
14 in. to 24 in.	18 in.	16

4. Hanger shield gauges listed are for use with band type hangers only. For point loading (roller support), increase shield thickness by one gauge, and length by 50%.

D. Hanger Spacing Schedules: (Based upon most stringent requirement of MCNYS and ASME B31.9)

COPPER OR PLASTIC PIPE SIZE	COPPER PIPE HANGER SPACING	PLASTIC PIPE HANGER SPACING	HANGER ROD SIZE
3/4 to 1 in.	6 ft.	3 ft.	3/8 in.
1-1/4 in.	6 ft.	4 ft.	3/8 in.
1-1/2 to 2 in.	8 ft.	4 ft.	3/8 in.
2-1/2 to 4 in.	10 ft.	4 ft.	1/2 in.
5 in. and larger	10 ft.	4 ft.	3/4 in.

STEEL PIPE SIZE	STEEL PIPE HANGER SPACING	HANGER ROD SIZE
3/4 to 1 in.	8 ft.	3/8 in.
1-1/4 in.	10 ft.	3/8 in.
1-1/2 to 2-1/2 in.	12 ft.	3/8 in.
3 to 4 in.	12 ft.	1/2 in.
5 in. and larger	12 ft.	3/4 in.

E. Inserts: Carbon steel body and square insert nut, galvanized finish, maximum loading 1,300 lbs., for 3/8 in. to 3/4 in. rod sizes. Drill through decking for hanger rods and secure devices with integral support plate strap with sheet metal screws. Devices shall have a safety factor of four.

F. Beam Attachments:

1. C-Clamp, locknut, electroplated finish, UL listed, FM approved, for pipe sizes 2 in. and smaller.
2. Center load style with clamp attachments that engage both edges of beam, electroplated finish, UL listed, FM approved, for pipe sizes larger than 2 in., refer to "Supports" for additional requirements.
3. Welded beam attachments may be considered only upon the review and acceptance of the structural engineer of record with written confirmation of weld meet configuration, location and service/pipe size submitted to the Mechanical Engineer for review.

G. Supports:

1. Provide intermediate structural steel members where required for hanger attachment. Secure member to structure. Select size of members based on a minimum factor of safety of four.
2. For Weights Under 1000 lbs.: Insert, "U" shaped channel, beam clamps or other structurally reviewed support. The factor of safety shall be at least four. Follow manufacturer's recommendations.
3. For Weights Above 1000 lbs.: Drill through floor slabs and provide flush plate welded to top of rod or provide additional inserts and hangers to reduce load per hanger below 1000 lbs.
4. Make: Hilti, ITW Ramset, Phillips "Red Head", or approved equal.

H. Trapeze Hangers:

1. For use on 1-1/2 in. and smaller piping only.
2. Hangers shall be supported with rod sized with a safety factor of four.
3. May be manufactured type "U" shaped channel, or suitable angle iron or channel. Round off all sharp edges.
4. Securely fasten piping to trapeze with "U" bolt or straps, dissimilar metals shall not touch, use isolation gaskets.
5. Make: B-Line, Kindorf, Unistrut, or approved equal.

2.10 PIPING ACCESSORIES

A. Escutcheon Plates: Provide escutcheon plates on uninsulated piping in exposed and finished areas. Steel or cast brass polished chrome, split hinge type with setscrew, high plates where required for extended sleeves.

B. Pipe Guides: Cylindrical steel guide sleeve, proper length for travel, integral bottom base anchor, top half removable. Split steel spider to bolt to pipe, copper plated spider for copper pipe. Insulated style where pipe is required to be insulated. Make: Tri-State Industries, or equal.

C. Anchors:

1. Pipe support; same material as pipe; as manufactured by Pipe Shields Model C1000 or C2000, Keflex, Metraflex, Flexonics or Advanced Thermal Systems.
2. Pipe Anchors:
   a. Anchors shall be designed and located as to prevent stress to piping or building structural components from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stressing to connected equipment.

D. Pipe Roll Stand: Cast iron roll stand. Make: Advanced Thermal Systems, Carpenter and Patterson, ITT Grinnell, Pipe Shields.

2.11 SLEEVES

A. Standard Type:

1. Schedule 40 black steel pipe sleeves shall be used for sleeves in horizontal and vertical applications through structural surfaces. Sleeves shall extend a minimum of 1 in. beyond both sides of the structure surface being penetrated. The sleeve shall be sized to account for the total diameter of the service, inclusive of insulation and the appropriate annular space for firestopping installation or requirements of the sealing element manufacturer.

2. Full circle water stop collar for sleeves located in below grade walls, wet wells and waterproofed surfaces. The collar shall be fabricated from steel plate and welded to the sleeve around its entire circumference.

3. Schedule 40, PVC sleeves or sheet metal sleeves for nonstructural surfaces. Sheet metal sleeves shall be 18 gauge minimum and braced to prevent collapsing. Sleeves shall extend a minimum of 1/2 in. beyond both sides of the non-structural vertical surface being penetrated. The sleeve shall be sized to account for the total diameter of the service, inclusive of insulation and the appropriate annular space for firestopping.

B. Pre-Insulated Type:

1. Adjustable or fixed length metal cans, 24 gauge minimum sized for 1 in. spacing between insulation and can. Insulation shall consist of a 360° waterproofed calcium silicate insert sized to extend 1 in. beyond wall or floor penetration. Calcium silicate insert shall be the same thickness as adjoining pipe insulation. Spacing between shield and can packed at each end with double neoprene rope positively fastened.

2.12 SEALING ELEMENTS

A. Expanding neoprene link type, watertight seal consisting of interlocking links with zinc plated bolts.

1. Make: Thunderline "Link-Seal" Series 200, 300 or 400, Pyropac, Calipco.

B. Waterproof Type:

1. Exterior Walls, Below Grade, Above Floor: Synthetic rubber material with zinc plated bolts. Make: "Link-Seal" Series 200, 300 or 400, Pyropac, Calipco.

2.13 PIPING MATERIALS AND SCHEDULE

A. See Exhibit "A", "Schedule of Piping Materials" at end of this Section for (HVAC) piping.

PART 3 - EXECUTION

3.01 EQUIPMENT AND SYSTEMS

A. Provide equipment and systems in accordance with laws, codes, and provisions of each applicable section of these specifications. Accurately establish grade and elevation of piping before setting sleeves. Install piping without springing or forcing (except where specifically called for), making proper allowance for expansion and anchoring. Arrange piping at equipment with necessary offsets, union, flanges, and valves, to allow for easy part removal and maintenance. Offset piping and change elevation as required to coordinate with other work. Avoid contact with other mechanical or electrical systems. Provide adequate means of draining and venting units, risers, circuits and systems. Install drains consisting of a tee fitting with a 3/4 in. ball valve with hose end cap and chain, at low points in hydronic piping system mains, and elsewhere as required for system drainage.

B. Conceal piping unless otherwise called for. Copper tubing shall be cut with a wheeled tubing cutter or other approved copper tubing cutter tool. The tubing must be cut square to permit proper joining with the fittings. Ream pipes after cutting and clean before installing. Cap or plug equipment and pipe openings during construction. Install piping parallel with lines of building, properly spaced to provide clearance for insulation. Make changes in direction and branch connections with fittings unless submitted and accepted per Part 2. Do not install valves, union and flanges in inaccessible locations. Provide trap seal of adequate depth on drain pans.

C. Provide reducers at all control valves, where control valve is smaller than pipeline size. Reducers for steam control valves shall be eccentric type. Provide unions at each side of every control valve and reducers directly adjacent to the unions.

D. Provide reducers at all balance valves, where balance valve is smaller than pipeline size.

3.02 PIPING OVER ELECTRICAL EQUIPMENT

A. Contractor shall route piping to avoid installation directly over electric equipment, including, but not limited to panels, transformers, disconnects, starters, motor control center, adjustable speed drives and fused switches.

B. Piping shall not be installed in the dedicated electric and working space as defined by NEC 110. Dedicated electrical space is generally equal to the depth and width of electrical equipment, and extends 6 ft. above the electrical equipment, or to a structural ceiling. Dedicated working space is a minimum of 30 in. wide or the width of equipment (whichever is larger) a minimum of 6 ft.-6 in. tall, with a depth of 3 ft. to 9 ft. depending on the voltage.

3.03 WATER AND GLYCOL SYSTEMS

A. Top connection for upfeed, bottom or side connection for downfeed. Grade off level; up in direction of flow and down toward drain.

3.04 REFRIGERATION PIPING

A. Fittings brazed with silver brazing alloy. Guarantee refrigerant charge for one year from date of final acceptance. Provide for flexibility at compressor connections. Piping and system shall meet the requirements of Mechanical Refrigeration Safety Code, ANSI B9.1. Clean piping, then pump-down and evacuate system to 0.1 in. VAC break vacuum with dry nitrogen and re-evacuate to 0.1 in. VAC and hold for four (4) hours; then charge system. Charge with refrigerant as recommended by manufacturer.

3.05 HANGERS, INSERTS AND SUPPORTS

A. Piping shall not be supported by wires, band iron, chains, or from other piping. Support each pipe with individual hangers from concrete inserts, welded supports, or beam clamps of proper configuration and point loading design requirements for each location including the designated safety factor. Trapeze hangers are acceptable for racking of multiple pipes of 1-1/2 in. or less in size. Follow manufacturer's safe loading recommendations. Suspend with rods of sufficient length for swing and of size as called for, using four nuts per rod. Provide additional rustproofed structural steel members, where required for proper support. Provide oversized hangers where insulation/supports must pass between pipe and hanger. Only concentric type hangers are permissible on piping larger than 2-1/2 in., "C" types are permitted for piping 2-1/2 in. and smaller. Provide riser clamps for each riser at each floor.

B. Provide a pipe hanger within 12 in. of pipe unions and piping connections to equipment, in order to facilitate disconnections of piping without pipe sagging.

3.06 HANGERS ATTACHED TO JOISTS

A. Individual hangers may be suspended directly from the bottom chord panel point provided that the sum of the concentrated loads within the chord panel does not exceed 100 pounds and the attachments are concentric to the chord. (Eccentrically loaded joists using beam clamps or other attachment methods are not acceptable.)

B. For nominal concentrated loads between panel chords, which have been accounted for in the specified uniform design load for the joists, this Contractor is to provide struts to transfer the load to a panel point on the opposite chord as reviewed and acceptable by the Structural Engineer of Record.

3.07 PIPE CONNECTIONS

A. Solder Connections: Nonacid flux and clean off excess flux and solder.

B. Brazed Connections: Make joints with silver brazing alloy in accordance with manufacturer's instructions. Remove working parts of valves before applying heat. "Walseal" fittings may be used; if sufficient alloy is showing, face braze such joints.

C. Threaded Connections: Clean out tapering threads, made up with pipe dope; screwed until tight connection. Pipe dope must be specific for each application.

D. Flanged Joints: Select appropriate gasket material, size, type and thickness for service applications. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

E. Dielectric Pipe Fittings: Provide dielectric protection devices at ALL equipment connections where dissimilar metals meet. In addition, provide dielectric unions in all piping systems. Dielectric protection systems are not required for air or gas systems.

3.08 WELDING

A. Welding shall be performed in compliance with the welding procedure specifications prepared by the National Certified Pipe Welding Bureau. Welded pipe fabricated by certified welder. Contractor shall submit proof of current certification of each welder if requested by Owner. Use full-length pipe where possible; minimum distance between welds, 18 in. on straight runs. Welds must be at least full thickness of pipe inside smooth and remove cutting beads, slag and excess material at joints; chamfer ends. Minimum gap 1/8 in., maximum 1/4 in., for butt welds. One internal pass and one external pass minimum required on slip-on flanges. Do not apply heat to rectify distorted pipe due to concentrated welding; replace distorted pipe. When welding galvanized pipe, apply cold galvanizing on joint after welding.

3.09 HANGER SHIELDS

A. Provide at hangers for refrigerant piping. Pre-insulated type or field-insulated type at Contractor's option.

3.10 SLEEVES

A. Provide for pipes passing through floors, walls or ceilings. Not required for floors which are core-drilled, except where floor is waterproofed.

B. Pre-Insulated Type: Required for refrigerant piping.

C. Standard Type: Provide for piping, except as called for.

D. Extend 1/8 in. above finished areas. In above grade mechanical and other areas with floor drains; use steel pipe sleeves 2 in. above floor. Use pipe sleeves in bearing walls, structural slabs, beams and other structural surfaces, and where called for. Sleeves shall be as small as practical, consistent with insulation, so as to preserve fire rating. Fill abandoned sleeves with concrete. Provide rubber

grommet seals for pipes passing through ducts or air chambers or built-up housings.

3.11 ANCHORS

A. Provide piping system anchors where shown on the plans, and as recommended by the expansion joint/loop manufacturer. Where an anchor is shown at a change in piping direction, it shall fully control movement in both directions. In lieu of a single anchor fabricated for two directional control, two (2) individual anchors may be provided. Provide detailed fabrication drawings for all field-fabricated anchors.

B. Design anchors and equipment and piping supports including comprehensive structural engineering analysis by a qualified professional engineer, licensed to practice in the State of New York using the performance and design criteria specific to this project.

3.12 ALIGNMENT GUIDES

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

B. Install two (2) or more guide(s) on each side of flexible expansion loop. Install guides nearest to expansion joint not more than four (4) pipe diameters from expansion joint.

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

3.13 SLEEVE PACKING

A. Seal void space at sleeves as follows:

1. Interior Locations: Firmly pack with fiberglass and caulk.
2. Exterior Walls and Below Grade Cored Holes: Use sealing element.
3. Fire Rated, Partitions and Floor Slabs: Use fire rated sealing elements, materials and methods. Provide per manufacturer's instructions to maintain firestop.
4. Waterproofed Walls and Floors: Use waterproof sealing element, device, or compound.

3.14 ESCUTCHEON PLATES

A. Provide polished chrome escutcheon plates for uninsulated exposed piping passing through floors, walls or ceilings in finished areas.

3.15 CLEANING HOT WATER AND GLYCOL SYSTEMS

A. Provide the services of an experienced Water Treatment Subcontractor.

B. After each closed system has been tested and thoroughly flushed, the entire piping system shall be cleaned by, or as per, the Water Treatment Subcontractor.

C. Operate pumps and arrange control system so that all control valves are open. Fill, vent and circulate system with this solution, while rising to design temperature.

D. Remove, clean and/or replace air vents, strainers, and check valves, which do not function properly. After cleaning strainers, circulate for additional time, then clean strainers again; repeat until strainers are found clean. Drain and refill system.

E. Pumps shall not be operated continuously until system is flushed, strainers cleaned and water treatment is complete.

F. Water Treatment:

1. After system cleaning, furnish report of water test to determine quality.
2. Provide complete glycol treatment facilities to Owner, including glycol analysis, feed equipment, metering equipment, pumps, and chemical, obtained from Calgon, Vulcan, Bird Archer, Heating Economy Service, Inc., Mogul, Garratt-Callahan Company, Metropolitan, or Allen-Murray.
3. Recommendations for glycol treatment reviewed by Owner's Representative before systems are placed into service.
4. Add glycol treatment as necessary to prevent deterioration of piping system, glycol deterioration and equipment due to oxygen, acid, scaling, etc.
5. Water treatments shall be deemed complete when circulation has been established throughout, and glycol runs clear and clean from deposits and discoloration. Submit typewritten letter to inform Engineer upon completion of the Work.
6. Once water has been run clean, water to be drained and 40% propylene glycol solution to be added to the system.

3.16 TESTS

A. Test piping and accessories before insulation, or concealment. Repeat as many times as necessary to prove tight system. Notify Owner's Representative at least seven days in advance of each test. Isolate valves and equipment not capable of withstanding test pressures. Make leaks tight; no caulking permitted. Remove and replace defective fittings, pipe or connections. Furnish necessary pumps, gauges, equipment, piping, valving, power and labor for testing. Certify that tests have been successfully completed.

B. Schedule of Test Requirements:

1. Hot,Glycol, Water: Hydrostatic, 100 psig at high point of system; two (2) hours duration.

2. Refrigeration:
    a. After installation, charge system with dry nitrogen to end equipment manufacturer's recommended pressure.
    b. System shall hold this charge with no pressure drop for 24 hours.
3. Gas Piping: Test with air to a maximum test pressure of 50 psi for 2 in. and smaller piping, 30 psi for 2-1/2 in. and larger piping for two (2) hour duration and as required by local utility purveyor. Provide a pressure relief valve in the system set for 10 psi more than the test pressure.
4. Compressed Air Piping (Other than Temperature Controls): Test with air to a maximum test pressure of 1.5x working pressure or 100 psi, whichever is fewer, two (2) hour duration. Provide a pressure relief valve in the system being tested set for 10% more than the test pressure.
5. Test: No change in pressure under stable temperature conditions.
6. Equipment: Test at working pressures.

3.17 PROTECTION AGAINST PHYSICAL DAMAGE

A. In concealed locations where piping, other than cast-iron or steel, is installed through holes or notches in studs, joists, rafters or similar members less than 1-1/2 in. from the nearest edge of the member, the pipe shall be protected by shield plates. Protective steel shield plates having a minimum thickness of 0.0575 in. (No. 16 gage) shall cover the area of the pipe where the member is notched or bored, and shall extend note less than 2 in. above sole plates and below top plates.

3.18 PIPE LINE SIZING

A. Pipe sizes called for are to be maintained. Pipe sizing changes made only as reviewed by Engineer. Where discrepancy in size occurs, the larger size shall be provided.

EXHIBIT "A" - PIPING MATERIALS (HVAC)

(Note at end of Exhibit "A")

SERVICE	PIPE MATERIALS	FITTINGS	CONNECTIONS
Hot water heating	Schedule 40, black steel	Malleable iron and butt weld	Screwed 2 in. and smaller; Welded 2-1/2 in. and larger; (SEE NOTE 1)
Hot water heating (optional)	Type L copper	Wrought copper or cast bronze, solder end	No-lead solder for 2 in. and smaller; 95/5 for 2-1/2 in. and larger
Refrigerant	Type L refrigerant grade hard temper, deoxidized copper	Wrought copper, solder end	Sil-Flo "5" silver brazing
Vent, overflow, drain	Schedule 40, galvanized steel or Type M copper	Cast iron drainage type or wrought copper	Threaded or solder
Glycol	Schedule 40, black steel	2000# forged steel or cast iron for screwed; butt weld fittings for welded or flanged	2-1/2 in. and larger butt welded or flanged; 2 in. and smaller screwed or socket welded (SEE NOTE 1)
Glycol (optional)	Type L copper	Wrought copper	No-lead solder
Domestic water	Type L copper	Solder end	No-lead solder
Natural gas and gas vent	Schedule 40, black steel	Butt weld, 2-1/2 in. and larger; Screwed 2 in. and smaller; 150#	Welded or screwed; provide adequate drip, scale pockets
Snow melting and radiant floor	SEE "RADIANT FLOOR AND SNOW MELTING SYSTEM SECTION 238316.11		
Water treatment (max. 100 psi up)	Schedule 80, PVC	Socket type PVC	Solvent welding

NOTES FOR EXHIBIT "A":

NOTE 1: Screwed piping permitted in Crawl Spaces, Mechanical Rooms and Boiler Rooms.

END OF SECTION

SECTION 23 21 10
WATER SYSTEMS SPECIALTIES

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.02 SUBMITTALS

A. Submit product data on water system specialties.

1.03 GENERAL REQUIREMENTS

A. Equipment and accessories shall be rated for a minimum of 125 psi wwp, and 250°F temperatures. Manufacturer's written installation procedures shall become a part of these specifications.

PART 2 - PRODUCTS

2.01 AIR SEPARATOR

A. The air separator shall have an internal stainless steel air collector tube with 5/32 in. diameter perforations and 63% open area designed to direct accumulated air to the compression tank or air vent via an NPT vent connection at top of unit.

B. The air separator shall have a removable galvanized steel system strainer with 3/16 in. diameter perforations and a free area of not less than five times the cross-sectional area of the connecting pipe. The strainer shall be located at the bottom of the vessel to reduce floor space required for strainer removal.

C. A blowdown connection shall be provided to facilitate routine cleaning of the strainer and the separator.

D. Vessel shell diameter to be three times the nominal inlet/outlet pipe diameter, with a minimum vessel volume for sufficient velocity reduction. The air separator must be designed, constructed and stamped for 125 psig at 350°F in accordance with Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code, and registered with the National Board of Boiler and Pressure Vessel Inspectors. The air separator(s) shall be painted with one (1) shop coat of air dry enamel.

E. A manufacturer's Data Report for Pressure Vessels, Form U-1 as required by the provisions of the ASME Boiler and Pressure Vessel Code, shall be furnished for each air separator upon request.

F. The air separator shall be sized for a maximum pressure drop of 2 ft. wg. at full system flow rate, but the inlet air outlets sizes shall not be smaller than the line size as shown on drawings.

G. Designer Equipment: Bell & Gossett.

H. Manufacturer: Armstrong, Bell & Gossett, Taco, Thrush, John Woods Co.

2.02 PRESSURIZED EXPANSION TANKS AND ACCESSORIES

A. Steel tanks, 125 psi wwp, ASME construction, with reinforced opening of size and location as required. Red oxide coating outside and final exterior coat of paint; factory applied. Heavy duty butyl rubber removable bladder. Full acceptance vessel. Maximum operating temperature of 240°F. Provide ring stand.

B. Design Equipment: Taco.

C. Manufacturers: Armstrong, Bell & Gossett, Taco, Thrush.

2.03 HYDRONIC BUFFER TANKS AND ACCESSORIES

A. Steel tanks, 125 psi wwp, ASME construction, with four (4) 4" flanged openings. Red oxide coating outside and final exterior coat of paint; factory applied. Automatic air vent on top. 2" HCFC Free foam insulation with painted metal jacket. Maximum operating temperature of 240°F. Provide ring stand and lifting lugs.

B. Accessories:

1. Temperature gauge
2. Pressure gauge
3. Manway
4. 1" bottom drain
5. (2) Two 3/4" tapings with plugs at 18" and 40" from bottom of tank

C. Design Equipment: Lochivar.

D. Manufacturers: Lochivar, Cemline, Taco, Wessels.

2.04 RELIEF VALVES

A. To relieve full heating capacity.

B. Provide an ASME labeled safety relief valve as called for on the plans/details.

C. Manufacturer: ITT, Bell & Gossett, Watts, Kunkle, Spence, Keckley.

2.05 FLOW BALANCERS

A. Balancing and flow meter stations suitable for use on heating and cooling systems. Constructed for 125 psi and 250°F.

B. Provide one 0-35 FT HD range meter complete with hoses, shut-off valves, and vent valves, and deliver to Owner and obtain receipt. 6 in. and Smaller: Calibrated balance valve with provisions for connecting a portable differential pressure meter. Flow balancer is to be suitable as a service valve. Meter connections to have built-in check valves. An integral pointer shall register degree of valve openings. Valve shall have internal seals.

1. Balance valve sizes shall be based upon gpm range rather than pipe size.

Balance Valve Size	**GPM Range**
1/2 in.	Up to 2.5
3/4 in.	2.5 - 4.5
1 in.	4.5 - 10
1-1/4 in.	10 - 15
1-1/2 in.	15 - 30
2 in.	30 - 60
2-1/2 in.	60 - 100
3 in.	100 - 180
4 in.	180 - 300
5 in.	300 - 450
6 in.	450 - 600

2. Design Equipment: Bell & Gossett "Circuit Setter".

3. Manufacturers: Bell & Gossett, Armstrong, Taco, Tour & Anderson, Oventrop Hydrocontrol, Watts.

2.06 STRAINERS

A. Cast semi-steel body or cast iron construction for steel piping and bronze body construction for copper piping; equipped with removable, monel or stainless steel water screen; maximum pressure drop 2 psi with free area at least four times area of pipe. Provided with blow-off outlet.

B. Sizes 5 in. and Smaller, Y-Pattern Strainer: 125 psig working pressure; flanged ends for NPS 2-1/2 in. and larger, threaded connections for NPS 2 in. and smaller, bolted cover, perforated stainless steel basket and bottom drain connection.

C. Sizes 6 in. and Larger, Basket Strainer: 125 psig working pressure; flanged end connections, bolted cover, perforated stainless steel basket and bottom drain connection.

D. Design Equipment: Mueller.

E. Manufacturers: Elliott, Keckley, Mueller, Webster, Watts, Spirax-Sarco.

2.07 TRIPLE DUTY VALVE

A. Provide as shown on plans, a straight, angle or straight-angle pattern valve designed to perform the functions of a center guided nonslam check valve, shutoff valve and calibrated balancing valve.

B. 2 in. and Smaller: The valve shall be of brass construction with connections per ANSI B1.20.1-83 suitable for 200 psi working pressure for operation temperatures up to 250°F. The valve shall be fitted with a chrome plated brass ball, glass and carbon filled PTFE seating rings, EPDM seals and brass stem. Check valve to have chatter preventing stainless steel sprint and EPDM seals.

C. 2 in. and Larger: The valve shall be of heavy-duty cast iron (NPT and flanged models only) construction with connections per ANSI B1.20.1-83 suitable for 175 psi working pressure for operating temperatures up to 250°F. The valve shall be fitted with a bronze seat, replaceable bronze disc with EPDM seat insert or stainless steel stem, and chatter preventing stainless steel spring. The valve design shall permit repacking under full system pressure.

D. Cv rating shall be provided at every 10% increment opening for the straight and angle valve. Manufacturer shall supply the Cv rating for read-out of flow determination and system pressure drop.

E. The valve shall be equipped with brass readout valves (with integral check valve) to facilitate taking differential pressure readings across the orifice for accurate system balance. The valve shall be produced at an ISO 9001 approved facility.

F. Triple duty valve sizes shall be based upon gpm range rather than pipe size. The valve shall be capable of system flow at the lowest open flow pressure drop. Submit performance chart for system balancing for each valve indicating design flow and minimum and maximum turn-down pressure drops.

G. Design Equipment: Bell & Gossett 3DV (2 in. and smaller) or 3DS (2 in. and larger).

H. Manufacturers: Armstrong Flo-Trex, Bell & Gossett, Taco plus Two, Grundfos, Thrush.

2.08 AIR VENTS

A. Manual air vents shall be a 3/4 in. ball valve with bronze body, nickel plated bronze ball, hose end, cap and chain, Watts B6000CC, PurgenVent M7910MAV, Nibco 1905.

B. Automatic air vents shall be float type, 35 psig rated, Armstrong No. 502CV OR float type, 150 psig rated, Armstrong No. 75, Spirothern, Taco tty-vent. Spirotop. Provide unit with an appropriate rating, as necessary for location.

C. High Capacity Automatic Air Vent:

1. Cast iron body. 150 psig rated. Stainless steel float.

2.09 GLYCOL MAKE-UP SYSTEM

A. Provide the following apparatus including all external piping and wiring:

1. One (1) fifty gallon polyethylene solution tank, with cover, mounted in a welded steel frame. Frame shall be furnished with an epoxy coating to resist chemical attack.
2. One (1) close coupled pump, rotary gear type, bronze construction with stainless steel shaft, internal pressure relief valve. Motor shall be 1/2 HP, 115 VAC, 60 Hz at 1,725 RPM. Pump shall be capable of delivering 1.7 GPM at 70 psi. Pump to be mounted under the tank and pre-piped at the factory.
3. One (1) low level cut-off and alarm shall be mounted on the tank.

B. One (1) pressure switch to activate glycol pump on descending pressure. Pressure switch shall be 5-65 psi range with an adjustable differential of 10-30 psi.

C. Manufacturers: Wessels Series GMP, Armstrong GLA, Neptune Glycol Feeder, or equal.

2.10 GLYCOL SOLUTION

A. The closed loop system shall contain a preblended solution of industrially inhibited propylene glycol and deionized water. The solution percent concentration shall be 40% by volume resulting in freeze (slush) protection to -3°F or lower, and burst protection to -35°F or lower.

B. The water used for the dilution of the glycol must meet the following water quality criteria: <25 ppm Sulfate; <25 ppm Chloride; <1 ppm Calcium; <1 ppm magnesium; <25 ppm Silica. Electrical conductivity umho/cm @ 25 C. 1.0 max. Total water hardness must be less than 60 ppm and meet the Type II Reagent Water Specification as per ASTM D-1193.

C. The selected coolant must meet or exceed the ASTM D-1384 corrosion test for coolants in glassware @ 190°F for 336 hours. The supplier prior to delivery must provide a Certificate of Assurance.

D. The solution shall contain a fluorescent dye to facilitate easy leak detection.

E. Approved Coolant Manufacturers are:

1. Interstate Chemical Company INTERCOOL NFP - Propylene Glycol.
2. Dow Chemical Company Dowfrost HD - Propylene Glycol.
3. Interstate Chemical Company INTERCOOL NFP 50 AA and NFP-40 AA (For boilers and other equipment with aluminum alloy heat exchangers).

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. Obtain detailed instructions from each manufacturer for proper method of installation.

3.02 SYSTEM FILLING

A. After cleaning, fill each system from low point.

B. With pumps off, vent mains, risers, run-outs, and units, working consecutively from low to high point of building. Obtain approximately 5 psi at highest point. Obtain proper air cushion in compression/expansion tanks.

3.03 AIR VENTING

A. Provide where specifically called for in piping details and at all points in piping systems where air may collect due to changes in piping elevation.

1. Manual air vent assembly consisting of 1-1/4 in. x 4 in. air collection chamber with 3/4 in. hose end ball valve with cap and chain.
2. Automatic air vent with a ball valve for the purpose of isolation and service or replacement.
3. Unless otherwise indicated, automatic air vents shall only be installed in Mechanical Rooms. Pipe high capacity air vent discharge down to floor.

B. Equipment Vents:

1. When equipment is above mains: Connect run-outs or risers to upper quadrant or top of mains. Install vent assembly concealed within enclosure, consisting of 1 in. diameter by 4 in. to 6 in. long air collection chamber with 1/4 in. soft copper tube to manual valve. Mount securely near bottom of enclosure, but not fastened to enclosure. For individual units, radiators, fan convectors and units with return grilled: Provide screwdriver operated manual valve, operated from discharge grille or access door. Drill enclosure and position valve for operating without removing enclosure.
2. When equipment is below mains: Connect piping run-outs or risers to bottom or lower quadrant of mains. Vent assembly not required in unit.

Provide means of purging and draining each unit if required. Use tees instead of ells at low point of run-outs.

3.04 AIR SEPARATOR

A. Provide supports and provide blow-down with hose end drain valve. Hang unit from structure at an elevation low enough to allow for upward pitch of piping to compression tank.

3.05 RELIEF VALVES

A. Hot Water System: Pipe discharge to glycol feeder and place hanger at elbow. Install piping so as not to introduce stress of PRV body.

3.06 STRAINERS

A. Install strainers on supply side of each control valve, pressure reducing valve, solenoid valve, in-line pump and elsewhere as indicated. Install NPS 3/4 in. nipple and ball valve in blowdown connection of strainers NPS 2 in. and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2 in.

3.07 FLOW BALANCERS

A. Where flow balancers are smaller than pipe line size, provide reducers directly adjacent to flow balancers.

B. Provide on zone or riser returns, on each hydronic unit and where called for. Meter connection points shall not point downward.

C. On terminal heating and cooling unit details where a shut-off valve is shown in conjunction with the flow balancer (3 in. and smaller), if the Armstrong "CBV" or Tour & Anderson "ST" is used, the shut-off valve may be deleted.

3.08 TRIPLE DUTY VALVES

A. Provide an increaser on discharge side of triple duty valve to match full flow pipe size, if triple duty valve is smaller than line size.

3.09 GLYCOL MAKE-UP SYSTEM

A. Set unit on a 6 in. concrete pad.

B. Pipe all relief valves to solution tank.

C. Install pressure switch in system main piping. Wire switch such that it activates pump when system pressure drops.

3.10 GLYCOL SOLUTION

A. The Coolant Manufacturer shall analyze the fluid two (2) times during the warranty period to ensure the glycol water solution continues to provide corrosion protection within industry standards and at no cost to the Owner.

B. No chemical additions shall be made to the glycol water solution until the Coolant Manufacturer has completed an analysis. Should such a chemical addition be required, it will be done in accordance with the recommendations on the analyticals as supplied by the manufacturer.

C. The Contractor shall meter the initial water fill for the purpose of hydrostatic pressure testing and/or system flushing. After completion of this requirement, the water shall be metered out. This will provide the contractor with a precise measure of coolant required to fill the system as well as the amount of water trapped in the system. This process will allow for any adjustments required prior to delivery of the premixed glycol solution and ensure that the solution strength is in compliance with the specification.

D. Should the concentration still require adjustment after the system has been filled and as a result of trapped water, then drain the required amount of fluid from the system and replace it with the same manufacturer's coolant in its concentrated form. Repeat this process until compliance with this specification is achieved.

END OF SECTION

SECTION 23 21 23
PUMPS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required, for the complete installation designed in Contract Documents.

1.02 SUBMITTALS

A. Shop drawings and performance curves, on pumps and pump accessories clearly indicate which equipment is being submitted.

B. Provide catalog information on motors as specified in Section 230513.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Pumps shall be non-overloading over their entire performance range with motors capable of running continuously without undue noise, heating, or sparking. Impellers shall be statically and dynamically balanced. Provide mechanical seals for closed systems, constructed of carbon rings with ceramic mating seat up to 220°F. Provide packing type seals for open systems only. Provide materials suitable for water pressures, temperature and conditions for each application. Provide tapped discharges and suction connections for gauges, vent and drain. Provide factory trimmed impeller if required, to meet initial delivery requirements.

B. Provide the services of a factory service engineer or machinist to check each pump alignment before pump is started, using laser equipment.

2.02 SELECTION CRITERIA

A. Pumps shall be non-overloading over their entire performance ranges, with trimmed impeller as required to meet initial delivery requirements. Pump selection shall not take into account, or infringe on the service factor of the motor.

B. Select pumps at appoint within the maximum efficiency for a given impeller casing combustion. Deviations within 3 percent of maximum efficiency are permissible, provided that the lesser efficiency is not less than the scheduled efficiency.

C. Pumps may not be selected such that the impeller diameter is larger than 90 percent of the published maximum diameter for the casing.

2.03 CIRCULATOR PUMPS

A. The pump shall be a maintenance-free, in-line, single stage, wet rotor type with the motor mounted directly to the pump volute. The pump body shall be constructed of cast iron and rated at 125 psi working pressure. The impeller shall be secured directly to the motor shaft by means of a split cone. The motor shaft shall be constructed of aluminum oxide ceramic and shall be supported by two radial bearings mounted in a bearing plate and rotor can. The pump shall not have a coupling or mechanical seal.

B. Design Equipment: Taco.

C. Make: Taco, Armstrong, Bell & Gossett, Grundfos, Wilo.

2.04 IN-LINE CENTRIFUGAL PUMPS

A. Designed for continuous operation between 40° and 225°F. In-line, close-coupled, single stage, bronze fitted construction. All pump internals shall be capable of being serviced without disturbing piping connections. Replaceable shaft sleeves at the seal or packing. Enclosed type impeller, keyed to the shaft and secured by a locking cap screw. Factory guaranteed operating performance. Pumps used in a variable speed pumping system shall contain couplings suitable for very low and intermittent torque loads.

B. Provide spare seal kit per pump model and turn over to owner.

C. Design Equipment: Taco 1600 Series.

D. Make: Armstrong, Bell & Gossett, Taco, Grundfos CBS, Paco VL, Wilo.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings and accessories.

B. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

C. In-line pumps shall be installed using continuous-thread, hanger rods and elastomeric hangers of size required to support weight of in-line pumps.

3.02 ALIGNMENT

A. Engage a factory-authorized service representative to perform alignment services for all pumps that use a coupler attached to the device train, whether base mounted or inline mounted. Alignment shall be accomplished with a laser shaft alignment system.

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.

E. Provide an alignment report indicating alignment setup data, tolerances and final results.

3.03 STARTUP SERVICE

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

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.
3. Clean strainers on suction piping.
4. Perform the following startup checks for each pump before starting:
    a. Verify bearing lubrication.
    b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
    c. Verify that pump is rotating in the correct direction.
5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
6. Start motor.
7. Open discharge valve slowly.

3.04 DEMONSTRATION

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

END OF SECTION

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SECTION 23 31 00
SHEET METAL AND DUCTWORK ACCESSORIES CONSTRUCTION

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services required for the complete installation designed in Contract Documents.

1.02 QUALITY ASSURANCE

A. Ductwork shall be fabricated and installed in compliance with latest edition of the following standards.

1. SMACNA Duct Construction Standards - Metal and Flexible Ductwork.
2. SMACNA Duct Liner Application Standard.
3. SMACNA HVAC Air Duct Leakage Test Manual.
4. 2015 International Energy Conservation Code.
5. NFPA Standard 96.
6. Plans and Specifications which exceed the requirements in any of the referenced standards.
7. 2015 International Mechanical Code.

B. All sheet metal shall be fabricated and installed by an experienced Contractor specializing in this type of work.

C. All ductwork and fittings shall have a computer generated label affixed to the exterior surface of each section, detailing all applicable information including the duct dimensions, gauge, reinforcement type/class and connection type by systems manufacturer. Galvanizing thickness shall be clearly stenciled on each duct section.

D. All ductwork on the project shall meet the SMACNA Duct Cleanliness For New Construction Guidelines, "Advanced Level" of duct cleanliness for production, delivery, storage and installation of ductwork.

1.03 SUBMITTALS

A. Ductwork Shop Drawings.

B. Duct Access Doors.

C. Flexible Duct.

D. Submit a complete shop standard manual including miscellaneous materials, and construction details for all shop fabricated materials including, but not limited to,

volume dampers, turning vanes, duct sealant, equipment flexible connections, access doors, flexible duct, acoustical duct lining, etc.

1.04 GENERAL

A. All adhesives, sealants, primers and paint used for ductwork in the interior of the building shall comply with the maximum Volatile Organic Compound (VOC) limits called for in the current version of U.S. Green Building Council LEED Credits EQ 4.1 and EQ 4.2.

1.05 DUCTWORK CLASSIFICATION

A. Duct systems are to be classified and constructed per the SMACNA Velocity-Pressure classification system as follows:

1. All ductwork shall be constructed for a minimum pressure class of 2 in. w.g. (unless stated otherwise) for the following systems, as applicable:
   a. Supply duct downstream of terminal units.
   b. Garage low pressure supply ductwork.
   c. Return ductwork.
   d. Low pressure exhaust ductwork.
2. Supply duct upstream of terminal units shall be constructed for a minimum pressure class of 3 in. w.g. unless otherwise stated or required as per below.
3. Lab fume exhaust shall be constructed for minimum pressure class of 3"in w.g.
4. Pressure classes above 3 in. w.g. shall be provided as follows, based upon the external static pressure as scheduled for each specific fan.

Scheduled External Static Pressure	**Pressure Class**
Over 3 in. up to 4 in. w.g.	4 in. w.g.
Over 4 in. up to 6 in. w.g.	6 in. w.g.
Over 6 in. up to 10 in. w.g.	10 in. w.g.

1.06 DUCTWORK SHOP DRAWINGS

A. Prepare minimum 1/4 in. scale drawings:

1. Detailed ductwork shop drawings shall include size, layouts and pressure classifications. Any ductwork installed without benefit of review by the Engineer of Record may be subject to replacement at the expense of the Contractor.
2. Constructed from actual field inspections and measurements so as to assure a complete job.
3. Incorporate dimensions of actual equipment proposed for use on the project.

4. Showing adequate sections, elevations, and plan views and indicating the bottom of ductwork elevations from the finished floor.

5. Indicating all volume dampers, fire dampers, smoke dampers, damper access doors and other accessories required for a completed project.

B. Call to the attention of the Engineers immediately, any major deviations from the Contract Drawings, which must be made. All deviations shall be documented in writing.

C. Indicate roof, wall and floor opening dimensions and locations shown on shop drawings.

D. Submit prints to each Contractor of the other trades for review for interference's and coordination with their work.

PART 2 - PRODUCTS

2.01 DUCTWORK MATERIALS

A. Unless otherwise called for, provide materials in accordance with Exhibit I at the end of this section.

2.02 SQUARE AND RECTANGULAR DUCTWORK

A. Galvanized Sheetmetal: Comply with ASTM A653 and A924, with G90/Z275 coating. Stainless-steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in Exhibit "I"; cold rolled, annealed, sheet. Aluminum sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view. Gauges per SMACNA HVAC Duct Construction Standards, Metal and Flexible.

B. Transverse and longitudinal duct seams reinforcement shall conform to appropriate tables and figures per SMACNA Velocity-Pressure Classification for duct construction.

1. Transverse joints shall be sealed with duct joint sealant. "Ductmate" or "Nexus" 4-bolt connection systems may be used in lieu of standard construction.

2. Field assembled longitudinal seams shall be sealed with duct sealant. Factory or shop fabricated rolled or machine pressed longitudinal seams does not require sealant.

C. Corner closures shall be required as described and illustrated by SMACNA Duct Construction Standards.

D. Throat radius on all elbows shall not be less than the dimension of the duct plane of radius. Where this cannot be maintained, use shorter radius with internal guide vanes, or square elbow with turning vanes.

E. Bracing and hanging of ductwork shall be per SMACNA Standards for size and system class of ductwork being used.

F. Any transformations shall not reduce the ductwork cross-sectional area. Maximum angle in straight duct, 20° for diverging flow and 30° for contraction flow. Transformation from square to round or flat to oval seams welded or brazed.

2.03 ROUND DUCTWORK

A. Standard Round Ductwork:

1. Galvanized Sheet metal: Comply with ASTM A653 and A924, with G90/Z275 coating. Stainless-steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in Exhibit "I"; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D or No. 3 as indicated in Exhibit "I". Aluminum sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view. Gauges per SMACNA Duct Construction Standards. Spiral lock-seam or longitudinal fusion-welded.
2. All spiral ducts shall have locked seams so made as to eliminate leakage under pressure for which this system has been designed. Longitudinal seams duct shall have fusion-welded butt seams.
3. No stovepipe will be allowed.
4. Round Ductwork Fittings:
    a. All fittings fabricated per SMACNA Standards for round and flat-oval ductwork, material to match straight pieces of ductwork.
    b. Fittings shall have continuous, welded seams.
    c. 90° tees shall be conical type. 90° tees and 45° laterals up to and including 12 in. diameter tap size shall have a radiused entrance into the tap, produced by machine or press forming. The entrance shall be free of any restrictions.
    d. Round taps off the bottom of rectangular ducts down to diffusers shall be made with a 45° square to round shoe-tap.
5. Elbows:
    a. Diameters 3 in. through 8 in.: Two-section stamped and continuously welded elbows, material to match straight pieces of ductwork.
    b. Over 8 in.: Gored construction with standing seam construction and internally sealed or continuously welded. Less than 35° - two gores, 36° to 71° - three gores, over 71° - five gores.
    c. Fabricated to a centerline radius of 1.5 times the cross-section diameter.

d. Adjustable elbows maybe used for round up to 12 in. diameter in Velocity-Pressure Classes 2 in. w.g. and below. Seal adjustable joints airtight after installation.

6. Joints:

a. For duct construction pressure 3 in. w.g. or greater:

1) Round Joints:

a) Unexposed Duct 3 in. - 30 in. Diameter: Connect round duct with a one piece interior slip coupling, at least two gauges heavier than duct wall, beaded at center and fastener to duct with screws. Seal joint with an approved sealant applied continuously around both end of coupler prior to assembling and after fastening.

b) All Exposed Duct and Unexposed Duct 30 in. - 72 in. Diameter: Install using a three piece, gasket flanged-joint consisting of two internal flanges, with integral mastic sealant, and one external closure band, which compress the gasket between the internal flanges.

(1) Acceptable Manufacturer: Ductmate Industries "Spiralmate" system E-2 Flange by Sheet Metal Connectors Inc., QF Duct Clamp by Nord Fad.

c) Above 72 in. Diameter: Install using companion angle flanged joints as defined in Figure 3-1 of the 2005 SMACNA Manual, "HVAC Duct Construction Standards, Metal and Flexible" Third Edition. Refer to manual for proper sizing and construction details.

b. Pipe-to-pipe joints in diameters up to 60 in. shall be by the use of sleeve couplings, reinforced by rolled beads.

c. Pipe-to-fitting joints in diameters up to 60 in. shall be by slip-fit of projecting collar of the fitting into the pipe.

d. Insertion length of sleeve coupling and fitting collar shall be 2 in. up to 36 in. diameter and 4 in. above 36 in. diameter.

e. Pipe-to-pipe and pipe-to-fitting connections in ductwork above 60 in. in diameter shall be made by angle ring flanges. The flange on the pipe shall be a 2 in. x 2 in. x 3/16 in. angle attached to the pipe with a continuous weld. The fittings shall have a loose ring "Van Stone" flange. A 5/8 in. flange shall be provided to act as a gasketing surface for sealing with the angle ring being a rolled, welded ring 2 in. x 2 in. x 3/16 in. Bolt hole spacing for angle rings shall be 6 in. centers.

f. If longitudinal seam duct greater than 60 in. in diameter is supplied in lengths greater than 4 ft., one angle ring must be welded to the duct on 4 ft. centers for support.

2.04 DUCTWORK SEALING

A. SMACNA Duct Sealing Classification shall be used for duct systems using the following criteria:

1. Ductwork and all plenums with pressure class ratings shall be constructed to Seal Class A, as required to meet the requirements of SMACNA Duct Construction Standards and with standard industry practice, including transverse joints, longitudinal seams, fitting connections, and all penetrations of the duct wall.
2. Openings for rotating shafts shall be sealed with bushings or other devices that seal off air leakage. Pressure sensitive tape shall not be used.
3. All connections shall be sealed, including but not limited to spin-ins, taps, other branch connections, access doors, access panels and duct connections to equipment.
4. Sealing that would void product listings is not required.
5. Spiral lock seams need not be sealed.

B. Duct sealant for indoor applications shall be non-fibrated, water based, Hardcast Iron-Grip IG-601, Ductmate PRO Seal, Foster 32-17 or Childers CP146.

C. Duct sealant for outdoor applications shall be fibrated, water based, Hardcast Versa-Grip VG-102, Ductmate Fiberseal, Foster 32-17 or Childers CP148.

D. Sealants and tapes shall be listed and labeled in accordance with UL 181A or UL181B and marked according to type.

2.05 TURNING VANES

A. Provide in mitered elbows as shown on contract drawings. Vanes 36 in. or longer shall be double wall air foil type. All turning vanes shall be installed as per the latest SMACNA Standards. Turning vane size and spacing shall be as per SMACNA. Turning vane spacing greater than SMACNA Standards is not acceptable.

B. Turning vanes shall be Harper, Duro Dyne or Ductmate double wall turning vanes fabricated from the same material as the duct.

C. Turning vane front and back panels shall be securely locked together with adequate crimping to prevent twisting of vane. Vane shall be capable of withstanding 250 pounds of tensile load when secured according to the manufacturer's instructions.

D. Rails for mounting turning vanes shall have self locking, friction fit tabs designed to facilitate proper alignment of vanes. Tab spacing shall be as specified in

Figure 4-3 of the 2005 SMACNA Manual, "HVAC Duct Construction Standards, Metal and Flexible". Rail systems with non-compliant tab spacing shall not be accepted.

E. Acoustical Turning Vane: Shall be used in applications that require quiet operating systems. Mounting rails shall have friction insert tabs that align the vanes automatically.

F. Acceptable Manufacturer: Ductmate Industries PRO-Rail Turning Vane Duro Dyne Vane Rail, Sheet metal connectors EZ rail.

2.06 DAMPERS IN DUCTWORK

A. Blade Type Volume Dampers: Constructed per SMACNA, one gauge heavier than duct material, securely fastened to 3/8 in. sq., cold rolled steel operator rod. Provide elevated dial regulator for 2 in. insulated ductwork.

B. Multiple Blade Type Volume Dampers: Provide multiple blade volume dampers in ductwork above 12 in. in height.

1. Heavy duty, manual balancing dampers suitable for application in HVAC systems with velocities to 1,500 ft. per minute, open position and max. pressure of 3 in. w.g. close position. Ruskin MD, Greenheck MBD-15, nailor 1820.
2. Fabrication:
    a. Frame: 5 in. x minimum 16 gauge roll formed, galvanized steel hat-shaped channel, reinforced at corners. Structurally equivalent to 13 gauge U-channel.
3. Blades:
    a. Style: Single skin with 3 longitudinal grooves.
    b. Action: Opposed.
    c. Orientation: Horizontal.
    d. Material: Minimum 16 gauge equivalent thickness, galvanized steel.
    e. Width: Nominal 6 in.
4. Bearings: Molded synthetic sleeve, turning in extruded hole in frame.
5. Linkage: Concealed in frame.
6. Axles: Minimum 1/2 in. diameter, plated steel, hex-shaped, mechanically attached to blade.
7. Control Shaft: 3/8 in. square plated steel.
8. Finish: Mill galvanized.
    a. Actuator: Hand quadrant for 3/8 in. square extended shaft.
    b. Hand Quadrant Standoff Bracket: 2 in. standoff for insulated ductwork.

c. Oillite bearings.

d. Factory Sleeve: Minimum 20 gauge thickness, minimum 12 in. length.

C. Fire Dampers: See "Fire Dampers" Section.

D. Automatic Air Dampers: Furnished as part of "Building Management System" Section 230923.

E. Blast Gates: Aluminum housing, locking thumbscrew, galvanized slide blade.

2.07 FLEXIBLE AIR DUCTS AND CONNECTORS

A. Flexible air ducts and connectors shall be constructed in compliance with NFPA Bulletin 90A, 90B and UL Standard 181 and shall be listed and labeled as Class I Air Duct.

B. Flexible air ducts and connectors shall be tri-laminate:

1. Consisting of corrosion resistant galvanized steel helix encapsulated by a double lamination of polyethylene or spun bond nylon.

2. Factory applied (R 6.0) fiberglass exterior insulation, sheathed in a seamless, tri-directionally reinforced, metalized polyester, exterior vapor barrier.

3. R-value shall be classified by Underwriters Laboratories, and certified by the Air Diffusion Council, in accordance with ADC Flexible Duct Performance and Installation Standard (1991), using ASTM C-518, at installed wall thickness, on flat insulation only. Comply with ASHRAE/IESNA 90.1.

4. Recommended operating pressure for flexible ductwork shall be three times maximum system press but not less than 6 in. w.g. positive pressure for 4 in. - 20 in. dia., 5 in. wg. negative pressure through 16 in. dia., 1 in. negative pressure for 18 in. and 20 in. dia. Maximum velocity of 5500 fpm.

5. Operating temperature range - 20°F to 250°F, intermittent @1/2 in. pos. w.g. max., -20°F to 140°F, continuous at maximum pressure.

6. Flame Spread: 25 max. smoke developed rating: 50 max.

7. Porous inner core flexible duct shall not be used.

C. Static pressure and thermal performance shall be tested and certified in accordance with Air Diffusion Council (ADC) Test Code FD-72-R1 under conditions of 140°F for 164 hours and 180°F for 4 hours.

D. Acoustical performance shall be certified in accordance with ASTM E 477 and/or Air Diffusion Council Test Code FD-72-R1.

1. Minimum Acoustic Performance:

a. The insertion loss (dB) of a 6 foot length of duct when tested in accordance with ASTM E477 at a velocity of 1000 feet per minute shall be at least:

	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
8 inch dia.	26	27	27	31	32	27
12 inch dia	22	26	24	31	31	20

E. Friction loss and leakage for flexible duct only shall be certified in accordance with Air Diffusion Council Test Code FD-72-R1. Leakage for connections shall be accordance with UL 181 requirements.

F. Basis-of-Design: Flexmaster 6B (R-6.0) .

G. Acceptable Manufacturers:

1. Dundas-Jafine Type SPC R6.0/ Type SPC R8.0. Hart & Cooley Type F216 (R-6.0)/ Type F218 (R-8.0)
2. Flexible Technologies, Inc. Thermaflex Type M-KE (R-6.0)/ Type M-KE (R-8.0)
3. Atco Rubber Products, Inc. Type 036 (R-6.0)/Type 031 (R-8.0).

2.08 FLEXIBLE CONNECTIONS TO FANS AND EQUIPMENT

A. Basis of Deign: Ventfabrics, Inc.

B. Acceptable Manufacturers: Ductmate Industries, Inc., Duro Dyne Inc., Elgen Manufacturing, Ward Industries, Inc.; a division of Hart & Cooley, Inc.

C. Materials: Flame-retardant or noncombustible fabrics, water and mildew resistant UL Standard 214.

D. Coatings and Adhesives: Comply with UL 181, Class 1.

E. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 in. wide attached to two (2) strips of 2-3/4-in. wide, 0.028-in. thick, galvanized sheet steel or 0.032 in. thick aluminum sheets. Provide metal compatible with connected ducts.

F. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.

1. Minimum Weight: 26 oz./sq. yd.
2. Tensile Strength: 480 lbf/in. in the warp and 360 lbf/in. in the filling.
3. Service Temperature: Minus 40 to plus 200°F.

G. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.

1. Minimum Weight: 24 oz./sq. yd.
2. Tensile Strength: 530 lbf/in. in the warp and 440 lbf/in. in the filling.
3. Service Temperature: Minus 50 to plus 250°F.

H. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.

1. Minimum Weight: 14 oz./sq. yd.
2. Tensile Strength: 450 lbf/in. in the warp and 340 lbf/in. in the filling.
3. Service Temperature: Minus 67 to plus 500°F.

I. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-in. movement at start and stop.

2.09 ACCESS DOORS

A. General:

1. Provide access doors of adequate size to allow easy access to the equipment that will require maintenance. Provide insulated or acoustically lined doors to prevent condensation where applicable.
2. Manufacturer to provide an installed neoprene gasket around perimeter of access door for airtight seal.
3. Systems 3 in. w.g. or less shall utilize a hinged, cam, or hinged and cam square framed access door.
4. Systems 4 in. w.g. and above shall utilize a sandwich type access door. Construct doors in accordance with Figure 7-3 of the 2005 SMACNA Manual, "HVAC Duct Construction Standards, Metal & Flexible" Third Edition.

5. Approved Manufacturer: Ductmate Industries "Sandwich" style door Ruskin ADR, Ward DSA..
6. All access doors shall be continuous piano hinged type, unless noted otherwise.
7. Non-hinged only allowed where clearance to ceiling does not allow a full 90° swing.
8. Double panel insulated type when used in insulated duct.
9. Single panel uninsulated type allowed in un-insulated duct.
10. Pressure rated according to system in which being installed. Door-to-frame and frame-to-duct gasketing.
11. Provide specified Seal Class A or B ductwork sealing around frame, and hand adjust the latch tension for proper seal, on all access doors other than sandwich panel (Ductmate) style.
12. MINIMUM access door size for ducts 12 in. or less in depth is 12 in. x 8 in.
13. MINIMUM access door size for ducts 12 in. to 18 in. in depth is 18 in. x 14 in.
14. MINIMUM access door size for ducts more than 18 in. in depth is 24 in. x 18 in.
15. In ducts which require multiple section fire dampers due to duct size, provide one access door for each fire damper section.
16. Access doors for fire and smoke dampers shall be permanently labeled with 1/2 in. high lettering reading "SMOKE DAMPER" or "FIRE DAMPER".

B. Door Types:

1. Low Pressure Systems (2 in. w.g. pressure class): National Controlled Air ADH-1, Ruskin ADH22, Vent Products 9701, Air Balance FSA-100, Safe Air SAH, Nailor.

2. Medium and High Pressure Systems (3 in. w.g. pressure class and higher):
    a. Rectangular Duct: Ductmate Industries "Ultimate" Style Door. Sheet metal connector hinged access door, Ruskin ADH.
    b. Round Duct: Ductmate Industries Round Sandwich type, Ruskin ADR, Ward DSA. 8 in. x 4 in. for ducts 14 in. and less in diameter. Round Sandwich type 16 in. x 12 in. for ducts more than 14 in. in diameter.
    c. Furnish and install factory supplied protector molding on cut medal edge for all access doors.

2.10 CABLE SUSPENSION SYSTEM

A. Ductwork not required to be exterior insulated in exposed installations may be installed using a cable suspension system.

B. Ductwork shall be installed using load rated, stainless steel cable suspension systems. Cables shall be pre-cut lengths, type 316 stainless steel with fused ends, and pre-made end attachments.

C. Cable grips shall be of 316 stainless steel and have an internal tamperproof cable release mechanism.

D. Stress distribution saddles shall be prescribed in addition for the support of rectangular duct on corners as necessary.

E. Hangers shall have a manufacturer's published safe working load and have a 5 to 1 safety factor.

F. Hang and support ductwork as defined in the latest edition of SMACNA Manual, "HVAC Duct Construction Standards, Metal & Flexible".

G. Adjustable steel cable hanging system consisting of spring loaded, serrated clamping mechanism shall be tested and certified in compliance with all applicable SMACNA standards for upper and lower attachment methods.

1. All approved systems must be installed using matching components including steel cable, clamping mechanism and hardware approved by the manufacturer for its corresponding load rating. No Substitution of manufacturer's components is permitted.
2. Approved systems must be installed per the manufacturer's specific instructions and must not exceed the stated working load rating at any point throughout the system.

H. Supports, bar/angle reinforcements, and other products that are not part of the duct that are manufactured of uncoated mild steel shall either be painted with two (2) coats of primer or shall be manufactured of a galvanized equivalent material.

I. Approved Manufacturer: Ductmate Industries "Clutcher" Cable Hanging System or Gripple Inc.

2.11 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Heavy cast zinc alloy instrument test port 3/4 height for ductwork with insulation and 2" height for ductwork with insulation.

C. Install duct test holes where required for duct traverse testing and balancing purposes.

PART 3 - EXECUTION

3.01 REQUIREMENTS

A. Equipment and systems shall be installed in accordance with local and state codes and regulations having jurisdiction. Bracing and hanging of ductwork shall be per SMACNA - HVAC Duct Construction Standard.

B. Install all ductwork concealed and tight to the structure above unless noted otherwise on shop drawings. Fabricate only after the approval of shop drawings, and in locations to avoid interferences. Ductwork installed without approved shop drawings, which requires removal/modification and/or reinstallation due to conflicts or improper installation shall be repaired at no cost to the Owner.

C. Sizes given on contract drawings are inside dimensions.

D. Keep openings continuously closed and sealed with protective plastic wrapping during construction to prevent entrance of dirt and debris.

E. Extend access openings, damper rods and levers, to outside of external insulation make systems airtight.

F. No piping, conduit or other obstruction to airflow is permitted in ductwork.

G. Provide necessary openings, hanger inserts, framing, chases, and recesses, not provided by other trades.

H. Exposed exhaust or return registers and grilles shall be flush with face of duct; exposed supply registers and grilles shall be mounted outside airstream with 45° shoe-tap extension collars.

I. Provide 14 gauge sleeves for ducts passing through Mechanical Room floors. Set sleeves 4 in. above finished floor in Mechanical Rooms, seal watertight to floor.

J. Where a return or exhaust duct is shown to be left open ended, provide hardware mesh screen at opening.

K. Do not utilize flexible ductwork or connection in any way to connect variable or constant volume boxes to ductwork.

L. For duct penetrations of non-rated walls, provide sheet metal angle framing or sheet metal closure panels around the entire perimeter of each duct wall penetration on both sides of the wall, where the gap exceeds 1/4 inch. Where the gap is less than 1/4 inch, the gap may be caulked on both sides of the wall. Non-rated wall penetrations SHALL NOT be fire caulked under any circumstances.

M. For duct penetrations of rated walls, see Specification Section 230500 - Basic Mechanical and Electrical Requirements.

N. Ductwork that is called for to be welded shall be fully welded, continuous around the entire perimeter at all joints/seams, and shall be fully airtight and watertight.

3.02 FLEXIBLE CONNECTIONS

A. Provide flexible connections for the intake and discharge connections of duct connected to fans and air handling equipment.

B. Round connections are to be made with adhesive and metal drawbands with ends tightly bolted.

C. Rectangular connections shall be made with material securely held in grooved seam between flanges. Attach with adhesive and mechanical fasteners on 6 in. centers.

D. Connections shall be made with a minimum of 2 in. space between duct and equipment collars, installed in line, and with 1 in. excess material folded so as not to interfere with airflow through connection.

E. Mechanically fastened and sealed, with specified duct sealant, at duct and equipment connections.

3.03 FLEXIBLE AIR DUCTS AND CONNECTORS

A. "Air duct" applies to conduit or passageway for conveying air to or from heating, cooling, air conditioning or ventilating equipment but not including the plenum as defined in NFPA 90A. "Air connector" applies to conduit for transferring air between an air duct or plenum and an air terminal device or an air inlet or an air outlet as defined by the NFPA 90A.

B. For round to oval connections, provide round-oval flexible adapter.

C. Flexible air ducts and connectors shall be provided in fully extended condition, free from kinks.

D. Flexible air ducts and connectors shall not be used in systems with entering air temperatures in excess of 250°F.

E. Flexible air ducts and connectors shall use only the minimum length required to make the connection and shall be installed in the horizontal or vertical position. Flexible elbows are not acceptable. Do not exceed a maximum length of 36 in., fully extended.

F. Flexible air ducts and connectors shall use minimum 1/2 in. wide positive locking, steel worm drive clamp, or nylon plenum rated straps for joints and connections. One clamp or strap for the inside core liner and one clamp or strap for the outer jacketing. When non-metallic (nylon) straps are used, they should be listed and labeled to standard UL 181B. Fastener package should be marked UL 181 B-C.

G. Collars to which flexible duct is attached shall be beaded and a minimum of 2 in. in length. Wrap twice with UL 181 tape and secure with clamp or strap. Sleeves used for joining two sections of flexible duct shall be beaded and a minimum of 4 in. in length. The draw band shall be positioned behind the bead on the metal collar.

H. Outer vapor barrier and insulation shall be slid over inner core and collar, wrapped twice with UL 181 tape and secured with a clamp or strap.

I. Connections shall be per SMACNA "HVAC Duct Construction Standards - Metal and Flexible", Air Diffusion Council "Flexible Duct Performance and Installation Standards" and NAIMA Installation Standards.

J. Flexible duct shall be supported at manufacturer's recommended intervals, but no greater distance than 2'-6" on center and prior to all 90 degree bends. Maximum permissible sag shall be 1/2 in. per foot of support spacing. Provide a minimum of one hanger on each run of flexible duct.

K. A connection to rigid duct or equipment shall be considered a support joint. Long horizontal duct runs with sharp bends shall have additional supports before and after the bend approximately one duct diameter from the centerline of the bend.

L. Hanger or saddle material in contact with the flexible duct shall be of sufficient width to prevent any restriction of the internal diameter of the duct when the weight of the supported section rests on the hanger or saddle material. In no case shall the material contacting the flexible duct be less than 1-1/2 in. wide. Factory installed suspension systems integral to the flexible duct are an acceptable alternative hanging method when the manufacturer's recommended procedures are followed.

M. The hanger shall be strapped around the flexible duct and secured to the structure above. Hangers shall not be attached to other mechanical or electrical objects. Hangers may be attached to an approved trapeze. Ceiling grid shall not be used to fabricate a trapeze. Support hangers shall be installed horizontal. Screws shall not be used to penetrate the flexible duct to attach to the hanger.

N. Provide flexible duct connections and splices in accordance with manufacturer's recommended installation instructions.

O. Seal flexible duct connections with sealing materials listed and labeled in accordance with UL 181B. Mechanically secure connections with approved clamping materials.

3.04 TURNING VANES

A. Install only in square elbows of equal dimensions.

B. Install as per latest SMACNA Standards.

C. Secure vane runners to duct with spot welding, riveting or sheet metal screws.

D. When installing in ductwork with internal insulation.

1. Install runners in ductwork inside insulation and bolt through insulation and duct sides, welding bolts to insure rigid installation. Provide build-outs for duct Velocity-Pressure classes above 2 in. w.g.

3.05 DUCT CLEANLINESS AND CLEANING AFTER INSTALLATION

A. Duct Cleanliness:

1. All ductwork on the project shall meet the SMACNA Duct Cleanliness For New Construction Guidelines, "Advanced Level" of duct cleanliness for production, delivery, storage and installation of ductwork.

2. Prior to shipment to the jobsite, all duct ends and openings must be covered with a heavy duty, dual-ply, clear polyethylene protective film. Open ends are to be kept covered during transport, storage, and installation. As ductwork is installed at the job site, open ends are to be covered to maintain cleanliness.

3. The film must be securely affixed to protect against dirt and debris, and must be translucent to facilitate inspection of interior surfaces without removing the film. The film is have a elongation rating of 600% and a break strength of 13.1 lbs./in. The film shall contain no VOC's, and shall leave no residue on duct after removal.

4. Manufacturer: Ductmate Industries ProGuard (heavy duty grade clear), surface shield duct cover shield, production products, Inc. Profab duct wrap film.

B. Cleaning After Installation:

1. Interior surfaces shall be free of dust and debris prior to initial startup. Protect equipment which may be harmed by excessive dirt with filters, or bypass during cleaning. Provide adequate access into ductwork for cleaning purposes. Any cleaning of duct systems shall comply with recommendations of NAIMA and NADCA.
2. Clean external surfaces of foreign substances that might cause corrosion, deterioration of the metal, or where ductwork is to be painted.
3. Clean debris from system before fans are turned on.
4. Keep openings continuously closed during the construction period.
5. Pay damages resulting from dirt blown on painted or other finished surfaces.
6. Repair or replace damaged fan wheels, dampers, or other system parts damaged as a result of debris.
7. Clean system as many times as required until the entire system is dirt free.

3.06 INSTALLATION OF ROUND DUCTWORK

A. Use factory-fabricated couplings for joints.

B. After the joint is slipped together, sheet metal screws are placed 1/2 in. from the joint bead for mechanical strength.

C. Sealer is applied to the outside of the joint and covering the screw heads.

D. Flanged joints shall be made with neoprene rubber gaskets.

3.07 TEST OF DUCTWORK

A. Conduct duct leakage tests per SMACNA "HVAC Air Duct Leakage Test Manual" and per the requirements of the 2015 International Energy Conservation Code, for all ductwork systems designed to operate at static pressures of 3.0 in. w.g. or greater. Representative sections totaling no less than 25% of the total duct area, per system, for the designated pressure class shall be tested as well as all associated ductwork located out-of-doors. All areas shall be as selected by the Engineer. Positive pressure leakage testing is acceptable for negative pressure ductwork. The rate of air leakage (CL) must be less than or equal to 6 for rectangular duct and 3 for round duct, as determined by equation 4 - 8 in 2015 IECC, which reads: $CL=F/P^{0.65}$ where F = measured leakage rate in CFM per 100 sq. ft. of duct surface, and P = static pressure of the test. When leakage above stated limits occurs, ascertain location of leaks and repair as required. Repeat tests as required to obtain allowable leakage rates. Prepare a report similar to that suggested by SMACNA and submit for review. Duct testing shall be conducted in the presence of the Owner's Representative.

B. Provide test reports indicating pressure tests performed. Include date, section tested, test pressure and leakage rate.

C. Ductwork not required to be tested for leakage, shall be checked and guaranteed to meet the standards of the specified SMACNA Duct Seal Class A. Air balancing and testing shall be used to determine satisfactory operation of duct systems. Balancing reports indicating excessive leakage amounts shall be required to rebuild, repair or seal ductwork having excessive leakage.

3.08 DAMPERS AND AIR CONTROL DEVICES

A. Provide volume dampers at all air outlets, diffusers, grilles and as noted on plans. Provide volume dampers at all low pressure supply, return and exhaust, branch ducts and as noted on the plans.

B. Provide dampers necessary to permit proper balancing of air quantities. Comply with code requirements for smoke and fire control. Prevent introduction of uncontrolled outside air into building through roof and wall openings.

C. When dampers are installed in acoustically lined ductwork, install with insulated "build-outs" per SMACNA.

D. Install fire dampers in accordance with "Fire Dampers" Section and applicable codes.

E. Install all dampers furnished as part of "Building Management System" Section.

3.09 ACCESS DOORS

A. Provide for access to upstream side of duct mounted reheat coils, dampers, damper motors, fire dampers, smoke dampers, smoke detectors, control devices, fan bearings, and equipment requiring periodic inspection or service. Provide labels for fire and smoke dampers as called for in Part 2 - Products.

B. For ducts that are too small to install an access door of the minimum specified size, provide a 12 in. long section of removable ductwork for maintenance and inspection access. Removable ductwork shall be fastened between device requiring access and next duct section with duct flanges or duct clamp with PVC foam seal. For ducts that are required to be insulated, provisions shall be made to allow insulation to be easily removed and re-installed.

3.10 DUCT SUPPORTS

A. Provide per SMACNA, same material as duct. Hanger bands to extend down sides and turn under bottom 2 in. Minimum two metal screws per hanger. Angle iron on larger duct spaced per building structural system but not greater that 8 ft. Provide extra support angles as required.

3.11 AIR AND WATERTIGHT DUCTWORK

A. Where water and snow may accumulate on ductwork or where odors or corrosive gasses may collect, ductwork and plenums shall be made watertight by soldering, brazing or welding of joints. Grade ducts down toward waste points and/or toward louvers. Provide valve and drain piping from low point to waste point.

1. Intake and exhaust plenums.
2. Chemical fume hood exhaust.
3. Engine exhaust systems.
4. Chemistry Room exhaust system.

B. Test for Watertightness: Before concealment, apply water by hose to check for leaks, witnessed by Owner's Representative.

3.12 SMOKE DETECTION

A. Smoke detectors shall be furnished by Division 26 "Electrical". Install detectors located in ductwork. Clearly indicate locations of smoke detectors on the sheet metal shop drawings.

B. Increase duct size at smoke detectors, where required for proper installation, per smoke detector manufacturer's recommendations. Coordinate minimum duct size required with Division 26 "Electrical".

3.13 DUCT SEALING

A. Preparation:

1. Clean surfaces of dirt, oil, grease and loose of foreign matter that could impair adhesion, using soap and water or solvent.
2. Allow surfaces to dry completely before proceeding.

B. Installation of Sealant System:

1. Apply sealant system to duct joints, fasteners, and seams in accordance with manufacturer's instructions.
2. Apply sealant by brush, putty knife or caulk gun, to full coverage. Remove excess adhesive immediately.
3. Completely seal duct joint, fasteners and seams without voids, to a minimum 20 mil thick wet film.
4. Apply and store at ambient temperature of 40°F to 100°F; and protect from freezing until dry.

C. Field Quality Control:

1. Allow duct sealant system to cure a minimum of 72 hours before operating the system.

EXHIBIT I - DUCTWORK MATERIALS

SERVICE	MATERIAL	SPECIAL REQUIREMENTS
Supply, return, vent, relief, outside and exhaust	Lock forming quality, galvanized steel ASTM A653 and A924, galvaneal/paint grip if not insulated and exposed	Joints and features as called for
Exterior ductwork	Galvaneal/paint grip (ready for paint) if not insulated, otherwise same as above	Horizontal top surfaces crossbrocken for positive water drainage, Duct joints, seal Class A, and outdoor duct sealant per spec
Fume hood and corrosive exhaust	Type 316 stainless steel	Braze or weld airtight/watertight
Accessories, dampers and air turns	Same material and gauge as parent duct	----------
Field constructed apparatus casings	Galvanized steel ASTM 525	Sealed airtight

END OF SECTION 23 31 00

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SECTION 23 33 13
FIRE DAMPERS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services required for the complete installation as shown on the Contract Documents.

1.02 SUBMITTALS

A. Submit product data, types, schedule of sizes, locations, and installation arrangements of all dampers.

B. Submit manufacturer's UL listed installation details for each mounting arrangement.

1.03 QUALIFICATIONS

A. Provide work in accordance with the latest requirements of the Mechanical Code of New York State UL 555, UL 555S and UL555C. Fire dampers shall be Underwriter's Laboratories classified and labeled.

PART 2 - PRODUCTS

2.01 FIRE DAMPERS

A. Curtain type damper of galvanized steel (304 stainless steel for ductwork containing shower room exhaust, wet location exhaust, and corrosive fume exhaust) construction with fusible link, 20 gauge frame and 24 gauge blades. UL listed and labeled.

1. 100% free area with welded head.
2. Square, rectangular, round or oval duct connection as required by duct connections.
3. 1-1/2 hour rated dampers for walls or floors rated less than three hours. Three-hour rated dampers for three and four hour walls or floors.
4. With factory fabricated sleeve with fixed and slip flanges.
5. Fusible link temperature rating of 165°F. .

B. Design Equipment: Ruskin Model IBD2 Style B.

C. Make: Ruskin, Air Balance, National Controlled Air, Prefco, Venco, Greenheck, Nailor.

PART 3 - EXECUTION

3.01 LOCATIONS

A. Provide fire dampers in all one, two and three hour rated wall and floor penetrations.

3.02 INSTALLATION

A. Provide sleeve, angles, and access doors for installation in accordance with the latest requirements of SMACNA, NFPA, UL and damper manufacturer.

B. Provide sheet metal access doors with labels, as called for in Specification Section 233100 in ductwork for dampers and accessories.

C. Provide ceiling or wall access doors for dampers and accessories.

D. Install dampers square and free from racking.

E. Do not compress or stretch the damper frame into the duct or opening.

F. Provide bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Attach multiple damper section assemblies together in accordance with manufacturer's instructions. Install support mullions as reinforcement between assemblies as required.

3.03 CERTIFICATION

A. Contractor shall certify that dampers are accessible for servicing, are installed properly, and are operational. Submit three (3) copies of signed certification to the Owner's Representative for review.

3.04 IDENTIFICATION

A. Provide damper tags and charts.
   1. Fasten tag to ductwork adjacent to the dampers.
   2. Number each damper and make chart listing.
      a. Number.
      b. Location.
      c. Air system in which they are installed.

B. Submit three (3) copies of chart to the Owner's Representative for review.

END OF SECTION

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SECTION 23 34 00
FANS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Drawings.

1.02 SUBMITTALS

A. Submit product data for all fans, motors, drives, and accessories. Include all fan curves fan operating point, and sound data.

1.03 QUALITY ASSURANCE

A. Capacity, size and arrangement, static pressure, brake horsepower, component parts and accessories shall be provided as called for or scheduled. Guaranteed full capacity delivery through duct systems finally installed and under conditions listed. The manufacturer shall guarantee sound-power level ratings not exceeding those of the design equipment. All equipment shall be statically and dynamically balanced to acceptable tolerances with weights permanently fastened. Fan wheels shall be rebalanced in the field, if necessary.

B. Pressure Classification:

Maximum Total Sp	Class
Up to 3-3/4 in. WG-STD	I
Up to 6-3/4 in. WG-STD	II
Up to 12-3/4 in. WG-STD	III

C. Conventional Motors:

1. Motor sizes shall be as scheduled. Refer to Specification Section 230513 for motor types, efficiency requirements, and acceptable motor manufacturers. All belt-driven fan motors shall be mounted on either an adjustable slide base or a pivoting base.

D. EC Motors:

1. Motors shall be Electronically Commutated Type (EC), variable speed, DC, brushless motors specifically designed for use with single phase, 277 volt (or 120 volt), 60 hertz electrical input.
2. Motor shall be complete with and operated by a single-phase integrated controller/inverter that operates the wound stator and senses rotor position to electronically commutate the stator.
3. Motors shall be designed for synchronous rotation. Motor rotor shall be permanent magnet type with near zero rotor losses. Motor shall have built-in-soft start and soft speed change ramps.

4. Motor shall be able to be mounted with shaft in horizontal or vertical orientation. Motor shall be permanently lubricated with ball bearings. Motors shall be direct coupled to the blower.
5. Motor shall maintain a minimum of 85% efficiency over its entire operating range and have a turndown to 20% of full speed, (80% turndown).
6. Provide manual remote fan speed output control for field adjustment of the fan airflow setpoint.
7. Inductors shall be provided to minimize harmonic distortion and line noise.
8. Provide isolation between fan motor assembly and unit casing to eliminate any vibration from the fan to the terminal unit casing.
9. Provide a motor that is designed to overcome reverse rotation and not affect life expectancy.
10. The fan manufacturer shall provide a factory installed PWM controller for either manual or DDC controlled fan CFM adjustment. The manual PWM controller shall be field adjustable with a standard screwdriver. The remote PWM controller shall be capable of receiving a 0-10 VDC signal from the DDC controller (provided by the controls contractor) to control the fan CFM. When the manual PWM controller is used, the factory shall present the fan CFMs as shown on the schedule.
11. Acceptable Manufacturers: Emerson Ultratech, U.S. Motors-Nidec, GE-ECM, A.O. Smith or equivalent.

E. Drive Systems:

1. Provide fans with belt or direct drive systems as scheduled. V-belt drives as recommended by drive manufacturer, unless otherwise specified or scheduled.
    a. Size drive for 200% of motor rating when motor is 10 HP and larger. Size for 150% of motor rating when motor is less than 10 HP.
    b. Motors 5 HP and larger shall be provided with a minimum of two (2) belts. All belt sets shall be matched.
    c. Cast iron or cast steel pulleys.
    d. Provide belt and shaft guards for each driven device. Provide openings in both the motor and fan sections of the guard so that the motor and fan speeds can be checked without removing the belt guard.
    e. Belts shall be oil and heat resistant, non-static type.
    f. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts.

g. All belt drive fan motor selections must include an allowance for medium drive losses as established by AMCA Publication 203.

F. Motor Pulleys:

1. 5 HP and Smaller: Adjustable type to produce 15% speed change above and below scheduled fan speed. 7-1/2 HP and Larger: Fixed type.
2. 5 HP and Smaller: "A" section, 2.6 in. minimum pitch diameter.
3. 7-1/2 HP to 20 HP: "B" section, 4.6 in. minimum pitch diameter.
4. 25 HP and Larger: "C" section 7.0 in. minimum pitch diameter.
5. Drive ratio not over 4:1.

G. Bearings:

1. Bearings shall be designed and individually tested specifically for use in air handling applications. Construction shall be heavy-duty regreasable ball type in a pillow block cast iron housing selected for a minimum L50 life in excess of 200,000 hours as maximum cataloged operating speed.
2. Provide extended lube lines mounted to a bracket located on the fan housing with grease relief fittings on each line. Lube lines shall be exposed copper or Teflon tubing covered with braided stainless steel.

H. Wheels and Propellers:

1. All wheels and propellers shall be balanced in accordance with AMCA Standard 204-96, balance quality and vibration levels for fans. Wheel shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency.
2. Blades on all sizes shall be continuously welded to the backplate and deep spun inlet shroud.
3. All hubs shall be keyed and securely attached to the fan shaft.

I. Blower Shafts:

1. All blower shafts shall be AISI-C-1045 hot rolled and accurately turned, ground and polished. Shafting shall be sized for a critical speed of at least 125% of maximum cataloged operating speed.

J. Coating:

1. All steel fan components shall contain an electrostatically applied, baked polyester powder coating. Paint must exceed 1,000-hour salt spray under ASTM B117 test method.

K. Vibration isolation for units shall be furnished by the fan manufacturer unless otherwise noted. Provide rubber in shear type vibration isolators.

L. Certifications:

1. Fan shall be listed by Underwriters Laboratories (UL 705). Fan shall bear the AMCA certified ratings seal for sound and air performance.
2. All units shall bear an engraved aluminum nameplate and shall be shipped in ISTA certified transit-tested packaging.

PART 2 - PRODUCTS

2.01 CENTRIFUGAL BLOWER/CENTRIFUGAL VENT SETS

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

1. Acme, Cook, Greenheck, New York Blower, Twin City, PennBarry.

B. Centrifugal Blower:

1. Construction:
   a. Fan shall be bolted and welded construction utilizing corrosion resistant fasteners. The scroll wrapper and scroll side panels shall be minimum 12-gauge steel. The entire fan housing shall have continuously welded seams for leak proof operation and shall have a minimum 1-1/4 in. outlet discharge flange.
   b. A performance cut-off shall be furnished to prevent the recirculation of air in the fan housing.
   c. Bearing support shall be minimum 1/4 in. welded steel.
   d. Lifting eyes shall be provided for ease of installation.
   e. High temperature exterior paint.
   f. Fan shall be configured for horizontal discharge.
2. Accessories:
   a. Shaft Cooler.
   b. Heavy duty discharge shutter with counter balance.
   c. Access Door - Bolt.
   d. Drain with cap.
   e. Outlet Screens.
   f. OSHA Belt Guard.
   g. Weather Cover.
   h. Shaft Seal.
   i. Hinged Access Door.
   j. Disconnect Switch - Factory wired and mounted.

3. Flat Blade Wheel:
    a. Wheel shall be steel. Non-overloading, centrifugal backward inclined, flat blade type.
    b. Basis-of-Design: Product indicated in schedule.

2.02 ROOF FANS

A. Manufacturers: Subject to compliance with requirements of this section, provide products by one of the following:
    1. Acme, Cook, Greenheck, Twin City, PennBarry.

B. Spun Aluminum Downblast Centrifugal Exhaust Ventilator:
    1. Construction:
        a. The fan shall be bolted and welded construction utilizing corrosion resistant fasteners. The spun aluminum structural components shall be constructed of minimum 16-gauge marine alloy aluminum, bolted to a rigid aluminum support structure.
        b. The aluminum base shall have continuously welded curb cap corners for maximum leak protection, and shall be tall enough to cover the wood nailer on roof curb.
        c. The discharge baffle shall have a rolled bead for added strength.
        d. An integral conduit chase shall be provided through the curb cap and into the motor compartment to facilitate wiring connections.
        e. Bearings and drives shall be mounted on a minimum 14-gauge steel power assembly, isolated from the unit structure with rubber vibration isolators. These components shall be enclosed in a weather-tight compartment, separated from the exhaust airstream.
        f. Hinged at curb so that entire fan can be tilted upward for maintenance, access to dampers, and access to damper motor.
        g. 1/2 in. x 1/2 in. aluminum wire mesh bird screen.
    2. Wheel:
        a. Wheel shall be centrifugal backward inclined, constructed of 100% aluminum, including a precision machined cast aluminum hub.
    3. Accessories:
        a. Backdraft Damper - Motorized.
        b. Roof Curb - In accordance with Section 230530.
        c. Disconnect Switch - Factory wired and mounted.
        d. Fan Speed Controller (For Direct Drive Models Only) - Factory wired and mounted.
    4. Basis-of-Design: Cook ACE.

2.03 CEILING MOUNTED EXHAUST FANS

A. Manufacturers: Subject to compliance with requirements of this section, provide products by one of the following:
   1. Panasonic, Broan.

B. Motor/Blower:
   1. Totally enclosed DC brushless motor technology rated for continuous run.
   2. Power Rating shall be 120 volts and 60 Hz.
   3. Fan shall be UL listed for tub/shower enclosure when used with a GFCI branch circuit wiring and use in insulated ceiling (TYPE I.C.).
   4. Motor equipped with thermal cut-off fuse control.
   5. Removable with permanently lubricated plug–in motor.

C. Housing:
   1. Rust proof paint, galvanized steel body.
   2. Detachable 6" diameter duct adapter.
   3. Built-in backdraft damper.
   4. Expandable extension bracket up to 24".
   5. Double hanger bar system allowing for ideal positioning.
   6. With UL listed factory radiation damper where called for in the plans.

D. Grille:
   1. Attractive design using PP material.
   2. Attaches directly to housing with torsion springs.

E. Warranty:
   1. The factory warranty shall be a minimum of 6 years limited warranty on the motor and 3-year limited warranty on parts. Ventilating fan shall be ceiling mount type, ENERGY STAR rated with variable speed of 0-80 CFM and no more than 0.3 sone as certified by the Home Ventilating Institute (HVI) at 0.1 static pressure in inches water gauge. Power consumption shall be no greater than 12.1 watts and ENERGY STAR rated. The motor shall be enclosed with brushless DC motor engineered to run continuously. Power rating shall be 120v/60Hz. Duct diameter shall be no less than 6”. Fan shall be UL and cUL listed for tub/shower enclosure when used with GFCI branch circuit wiring. Fan shall be UL listed for use in insulated ceiling (TYPE I.C.). Fan shall be California Title 24 compliant.

F. Performance:
   1. Ventilating fan shall be ceiling mount type, ENERGY STAR rated with variable speed of 0-80 CFM or 0-100 CFM, and no more than 0.3 sone as

certified by the Home Ventilating Institute (HVI) at 0.1 static pressure in inches water gauge. Power consumption shall be no greater than 12.1 watts and ENERGY STAR rated. The motor shall be enclosed with brushless DC motor engineered to run continuously. Power rating shall be 120v/60Hz. Duct diameter shall be no less than 6". Fan shall be UL and cUL listed for tub/shower enclosure when used with GFCI branch circuit wiring. Fan shall be UL listed for use in insulated ceiling (TYPE I.C.). Fan shall be California Title 24 compliant.

2. For bathrooms:
   a. The bathroom fans shall run continuously.
   b. Provide fans with integral 20-minute delay-off timer to re-index the fan back to low speed.
   c. Provide a 2-pole wall switch, coordinate with division 26000. The wall switch shall turn ON the LED light AND index the fan to high speed. When the switch is OFF, the light shall turn OFF the fan shall index to low speed after 20 minutes.
   d. UL listed for wet location when protected by a GFCI circuit. Fan/light unit to be installed over tub/shower and centered as much as is allowable by the building structure.
3. For all other spaces:
   a. The fans shall run continuously.
   b. Fan airflow shall be set as scheduled on the contract documents.
   c. No LED light kit.

G. DC Motor Technology:
1. Allows the fan to run continuously at a pre-set lower level as scheduled. The fan then elevates to a maximum level of operation when the switch is turned on.
2. When fan faces static pressure, its speed is automatically increased to ensure that the desired CFM is not compromised, which allows the fan to perform as rated.

H. Basis of Design: As Per Schedule.

2.04 INLINE BLOWERS/INLINE FANS

A. Manufacturers: Subject to compliance with requirements of this section, provide products by one of the following:
1. Acme, Cook, Greenheck, Hartzell, New York Blower, Twin City, PennBarry.

B. Square Centrifugal Blowers:
1. Construction:

a. The fan shall be bolted construction utilizing corrosion resistant fasteners. Housing shall be minimum 18-gauge galvanized steel with integral inlet and outlet flanges.

b. Pivoting motor plate shall utilize threaded L-studs for positive belt tensioning.

c. Bolted access doors shall be provided on three (3) sides, sealed with close cell neoprene gasketing.

d. Housing shall be pre-drilled to accommodate universal mounting feet for vertical or horizontal installation.

2. Wheel:

a. Wheel shall be aluminum, non-overloading, centrifugal backward inclined, flat blade type. Hub shall be cast and precision machined, also constructed of 100% aluminum.

3. Accessories:

a. OSHA Belt Guard.

b. Motor Cover.

c. Disconnect Switch - Factory wired and mounted.

d. Motorized Damper

e. Speed Controller (For Direct Drive Models Only) - Factory wired and mounted.

4. Basis-of-Design: Cook SQN.

2.05 CEILING MOUNTED DE STRATIFICATION FAN

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

1. Zoo Fans, Leading Edge, Macro-Air, Big Ass Fans.

B. Construction:

1. Enclosed air foil blades. Blades constructed of composite.

2. Totally enclosed motor. All motors shall be direct-drive permanent split capacitor type, with permanently sealed ball bearings. All motors to have built in, self-resetting (internal) thermal overload protector.

3. Remote variable speed control switch.

4. Fans shall be UL listed Standard 507 with matching UL listed solid state controls.

5. All fans to have factory installed secondary support cable assembly connected to the motor shaft, with galvanized cable 1/8 in. 7 x 7 with rated breaking strength of 920 lbs., and must comply with CSA Standard C22.2.

6. Swivel mounting base if used in a sloped ceiling application.

C. Accessories:

1. Totally enclosed impact resistant fan guard.

D. Basis-of-Design: Product indicated in schedule.

2.06 CONTROL (MOTORIZED) DAMPERS

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

1. Ruskin, Tamco, Greenheck.

B. Provide control dampers as shown on the drawings and diagrams, to meet the following minimum construction standards:

1. Leakage: Class 1, 4 CFM/sq. ft. at 1 in. w.c., tested per AMCA Standard 500-D-98, and AMCA Standard 500-D-98, and AMCA Standard 511 and bearing AMCA's Certified Ratings for both air performance and air leakage.
2. Frame: 16-gauge galvanized steel structural hat channel with tabbed corners for reinforcement to meet 13-gauge criteria.
3. Blades: 14 gauge (equivalent thickness galvanized steel) roll forward air foil type for low pressure drop and low noise generation. Blades shall be parallel for two-position dampers and opposed, for modulating dampers.
4. Blade Seals: Ruskiprene, suitable for -72°F to 275°F mechanically locked into the blade edge.
5. Jamb Seals: Flexible metal compression type.
6. Blade Axles: 1/2 in. plated steel hexagonal positively locked into the damper blade. Linkage concealed out of the airstream.
7. Bearings: Corrosion resistant, permanently lubricated stainless steel sleeve.
8. Dampers subject to corrosive fumes or humidity shall be constructed of stainless steel.
9. Dampers over 48 in. in length and height shall be made in multiple sections.
10. Where damper sizes are not specifically indicated, they shall be sized by the Building Management System Contractor. Maximum velocity shall be 1500 FPM and maximum pressure drop 0.1 in. w.g.
11. Where shown or required for proof of closure or open position, provide factory installed damper positioning switch package Ruskin Model SP-100.
12. Dampers shall be as manufactured by Ruskin CD 60 control damper, or equivalent Tamco, Greenheck or Nailor.
13. Basis of Design: Ruskin CD60.

PART 3 - EXECUTION

3.01 INSTALLATION OF EQUIPMENT

A. Provide equipment in accordance with manufacturer's instructions. All fans shall meet the intent of the system performance requirements. Provide rubber in-shear vibration isolation for all fans unless otherwise called for. Provide necessary support steel for equipment. Provide guards for all exposed belts, shafts, and fan wheels. Change pulley sizes or adjust sheaves as required to make systems deliver specified quantities of air as listed on the Contract Drawings.

END OF SECTION

SECTION 23 35 16.11
OVERHEAD VEHICLE EXHAUST SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Drawings.

1.02 SUBMITTALS

A. Submittals shall include shop drawings and product data for all specified equipment, materials and accessories.

PART 2 - PRODUCTS

2.01 GENERAL

A. The vehicle exhaust system equipment and accessories shall be a standard product of a single manufacturer.

B. Warranty: Two (2) year parts and labor.

2.02 CENTRIFUGAL FAN

A. Refer to section 233400 - Fans for additional fan information.

B. The fan shall be specifically designed for the conveyance of diesel smoke and gases in accordance with Federal, State, and local code requirements as it applies to conveying explosive and carcinogenic particulate and gases produced by internal combustion engines. The fan housing and all components exposed to the combustible properties of the atmosphere within the ductwork created by the vehicle exhaust are explosive proof. The housing as well as the fan impeller shall have a construction of non-sparking, non-ferrous metal (cast aluminum).

C. Fan shall be horizontal discharge with motorized discharge damper. Fan shall be equipped with bottom drain.

D. Provide Teflon shaft seals to keep aluminum housing and fan drive shaft from making abrasive contact.

E. The fan motor shall be provided with a totally enclosed fan cooled motor. The motor shall be located outside of the air stream.

2.03 DUCT SYSTEM

A. All ductwork shall be 22 gauge galvanized spiral, with all hardware including screws shall be steel.

B. 14 in. diameter hose shall be provided for connection to the vehicle. The hose shall contain high visibility yellow strips, and be 2100°F rated continuous and be rated for 2370°F intermittent. Hose to have external metal helix with heat resistance outer fabric, middle insulation layer and inner layer of stainless steel mesh.

C. 8 in. diameter hose shall be provided for connection to the vehicle. The hose shall contain high visibility yellow strips, and be 1200°F rated continuous and be rated for 1380°F intermittent. Hose to have external metal helix with heat resistance outer fabric, middle insulation layer and inner layer of stainless steel mesh.

D. The exhaust system shall be designed to transport exhaust emissions in the main duct a minimum of 4,000 feet per minute ad provide a capture velocity no less than 5,800 feet per minute. The velocities shall be calculated at an average temperature of 250°F and static resistance of water gauge.

E. The duct system shall be substantially air-tight to comply with CLASS 2 Product-conveying duct codes established by BOCA - Building Officials Code Administrators, UMC - Uniform Mechanical Codes, ACGIH - American Conference of Governmental Industrial Hygienists, SMACNA - Sheet Metal Air Conditioning Contractors National Association.

2.04 MISCELLANEOUS VEHICLE EXHAUST SYSTEM MODIFICATIONS

A. Flexible hose assembly shall not be allowed to touch or rub the body of the vehicle at any time. No attachments to the body of the vehicle is permitted.

B. The boom to be a minimum of 20 ft. long one piece extruded aluminum with channel to accept ball bearing rollers of the traveling trolley on bottom side. Rubber impact end stops are to be mounted on each end of the boom. The traveling trolley shall be galvanized steel assembly with four upper ball bearing wheels to fit inside boom profile and two lower ball bearing wheels to fit on outside if track profile to prevent rocking or shifting of the trolley as it moves along the full length of the boom.

C. Provide blast gate at inlet of all hoses. Blast gate shall be full size of hose.

D. Provide all required equipment shown on drawings.

E. Provide stainless steel tapered inlet nozzle, lifting sleeve add-on for nozzle, and 10ft lifting pole.

2.05 DESIGN EQUIPMENT

A. Monoxivent Vehicle Exhaust Ventilation Apparatus.

2.06 MANUFACTURERS

A. Monoxivent, Car-Mon Products, Inc., Harvey Industries, Inc., and PlymoVent.

PART 3 - EXECUTION

3.01 GENERAL

A. Install equipment in accordance with manufacturer's instructions. Provide necessary support steel for exposed work ductwork. Provide guards for all exposed belts, shafts and fan wheels. Change pulley sizes or adjust sheaves as required to make systems deliver specified quantities of air as listed on the Contract Drawings. Provide necessary power and control wiring from control unit to exhaust fan.

END OF SECTION

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SECTION 23 36 00
VARIABLE VOLUME TERMINAL UNITS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation as shown on the Contract Drawings.

1.02 SUBMITTALS

A. Submit product data for terminal units including room number, maximum and minimum CFM, accessories, pressure drops, discharge and sound power data by octave band. Clearly indicate box sizes being proposed. Submit separately the controller and control interface devices being utilized.

PART 2 - PRODUCTS

2.01 TERMINAL UNITS

A. General Unit Construction:

1. Unit shall be pressure independent and unit casing shall be constructed of 22 gauge welded galvanized steel. Each unit shall be internally lined with 1/2 in. minimum 1-1/2 lb./ft.^{3} fiberglass insulation which meets NFPA 90A and UL 181. Factory label each unit with size, location, minimum and maximum CFM, and calibration chart. Air terminal units shall be capable of operating at 10 in. w.g., pressure maximum without damage. Maximum casing leakage at 3 in. W.G. shall be 2%.
2. Units to be certified under ARI Standard 880-94 Certification Program and carry ARI seal.
3. Units shall be provided of heating coil, with factory access door option.

B. Control and Volume Regulating Devices:

1. Internal unit damper shall be constructed of galvanized steel with blade-end seals for tight shut-off with a maximum damper leakage of 2% against a maximum of 3 in. w.g. Damper shall be mounted on a galvanized steel shaft extending through the unit on torque free bearings. Terminal shall have normally open dampers. Minimum and maximum air quantities shall be factory set, but may be field adjustable. Neither the radiated or discharge sound power levels shall exceed the ratings of design equipment as scheduled on the Contract Drawings.

C. Hydronic Reheat Coil:

1. Coil shall be factory installed on the terminal unit and shall be constructed of 1/2 in. copper tube with aluminum plate fins. Tested at the factory to 250 PSI hydrostatic pressure. Control valves shall be provided by the

temperature control subcontractor as described in Section 230923. Output capacity and rows as scheduled on the Contract Drawings.

D. Terminal Volume Controller (Microprocessor Based):

1. Provide unit with airflow velocity and total pressure sensor suitable for up to 3000 fpm inlet velocity. Sensor shall be averaging type with multiple sampling points on cross grids. Pressure independent microprocessor based electronic controller shall modulate airflow to maintain space temperature.
2. Provide a 24 volt electric damper actuator. The actuator shall be reversible with a switch and have a visual position indicator. The housing shall be NEMA type 2 with a flammability rating conforming to UL94. The actuator shall be maintenance free and have a minimum life span of 60,000 cycles. Actuator shall be Bellimo NMB24-3US. Johnson M 9109 - AGA2, Honeywell MNG110A1003.
3. Provide factory mounted transformers for controller and actuator suitable for 120 volt, 1 phase-input power.
4. Wall mounted thermistor type electric space sensor provided by Control subcontractor. Controller shall interface with Building Management System to provide analog outputs for space temperature and airflow and accept analog inputs position the actuator for warm-up or pull-down and change space temperature set-point for night set-back, set-up or occupancy sensor status. Controller shall sequence reheat coil to maintain space.
5. The VAV box manufacturer shall provide the box and the airflow sensor . The temperature control subcontractor shall field install the microprocessor based controller and damper motor.

E. Design Equipment: As Scheduled.

F. Acceptable Makes: Anemostat, Carrier, Carnes, Envirotech, Krueger, Titus, Tuttle and Bailey, Trane, Nailor.

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

A. Suspended terminal units from the building structural system independent of the ceiling system. If this cannot be accomplished, provide additional intermediate angle iron from which the units shall be suspended. Level each unit. Access to the terminal unit controls shall be accomplished by remove of ceiling panels or through an access door. Coordinate locations of access doors.

END OF SECTION

SECTION 23 37 13

REGISTERS AND DIFFUSERS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services required for the complete installation designed in Contract Documents.

1.02 SUBMITTALS

A. Registers/Grilles/Diffusers: Submit product data including room schedule listing size, CFM, throw, direction of throw, accessories, finish, material type, color chart, pressure drop and noise criteria.

1.03 GENERAL REQUIREMENTS

A. Each manufacturer shall check noise level ratings for registers and diffusers to insure that the sizes selected will not produce noise to exceed N.C. - 24, measured at occupant level; notify Owner's Representative of problems prior to submittal.

B. Pressure drop, airflow and noise criteria selection is based on design equipment. Manufacturers not submitting design makes must provide written certification in front of submittal that equipment submitted has been checked against and performs equal to the design make.

C. Borders and frames shall be coordinated with materials and ceiling systems to integrate with architectural ceiling details and finishes scheduled.

D. Locations of ceiling mounted air terminal devices shall be coordinated with locations shown on architectural reflected ceiling plans.

E. 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. 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.

1.04 REQUIREMENTS FOR REGISTERS

A. General:

1. A register is defined as a grille plus a volume damper.
2. Registers shall be installed "sight-proof" where possible, i.e.: High wall register with horizontal blades inclined up, or along a wall with blades facing the wall.
3. Borders and frames shall be of the same material as register face unless specified otherwise.

B. Mounting Frames:

1. Provide with screw holes in register face punched and countersunk at factory, and mounting frame drilled and tapped to suit. Sponge rubber gasket between frame and wall or ceiling for all surface mounted frames.
2. Frame shall be overlap type and shall be suitable for type of ceiling where register is to be installed.

C. Finishes:

1. Baked enamel (of colors as selected from the manufacturer's standard color chart) etched and lacquer, natural anodized, as scheduled.

D. Design Equipment: Titus unless otherwise noted.

E. Manufacturers: Anemostat, Carnes, Krueger, Titus, Price, Tuttle and Bailey, Nailor.

1.05 REQUIREMENTS FOR DIFFUSERS

A. General:

1. Provide four way blow unless otherwise noted.
2. Where manufacturer's size recommendations require duct sizes or connections differing from design, Contractor shall provide at no change in contract price.
3. Suitable for recessed mounting unless otherwise indicated.
4. Provide square to round neck transitions as required.
5. Provide sponge rubber gasket for all surface mounted frames.

B. Finishes:

1. Baked enamel (of colors as selected from the manufacturer's standard color chart) etched and lacquer, natural anodized, as scheduled.

C. Frame style shall be suitable for ceiling type in which diffuser is to be installed.

D. Design Equipment: Titus unless otherwise noted.

E. Manufacturers: Anemostat, Carnes, Krueger, Titus, Price, Tuttle and Bailey, Nailor.

PART 2 - PRODUCTS

2.01 SUPPLY TYPES

A. Type 1 - (Smooth Face Type):

1. Steel construction with 22 gauge back pan and 22 gauge face panel with rolled edges that finishes flush with ceiling system.
2. Round neck - minimum 1-1/4 in. collar for duct connection.

3. Frame suitable for ceiling type.
4. With optional directional air flow pattern controllers that are concealed behind the face or in the neck.
5. Face panel shall be removed and securely held in place to the back pan without noise or vibration.
6. Horizontal airflow pattern.
7. Panel Size: 24 in. x 24 in.
8. Model: Titus OMNI.

B. Type 2 - (Spiral Duct Drum type):
1. Aluminum 20 gauge construction with adjustable horizontal and vertical vanes and rotating barrel for up to 60 deg. of directional control.
2. Diffuser shall be designed to fit tightly to spiral ductwork.
3. Opposed blade damper with front face operator.
4. Model: Titus S-DL-SV.

C. Type 3 - (Drum type):
1. Aluminum 20 gauge construction with adjustable horizontal and vertical vanes and rotating barrel for up to 60 deg. of directional control.
2. Diffuser shall be designed to fit tightly to rectangular ductwork.
3. Opposed blade damper with front face operator.
4. Model: Titus DL-SV.

2.02 RETURN/EXHAUST TYPES

A. Type A - (Exhaust and Return Grilles):
1. Steel construction with 22 gauge frame and blades, with horizontal bars on a 3/4 in. spacing set at 35° fixed deflection.
2. 1-1/4 in. wide flange.
3. The blades shall be parallel to long dimension.
4. Model: Titus 350-RL.

B. Type B - (Aluminum Exhaust and Return Grille):
1. Aluminum construction with horizontal blades on a 3/4 in. spacing and set at 35° fixed deflection.
2. 1-1/4 in. wide border with minimum thickness of .040 - .050 in. interlocked at all four corners and mechanically fastened.
3. The blades shall be parallel to long dimension.
4. Model: Titus 350-FL.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install equipment in strict accordance with manufacturer's instructions. Rough in or install per reflected ceiling plan or in location instructed by Owner's Representative.

B. When the final connection to an exhaust or return grille is made, a 12 in. minimum height plenum box must be supplied to all grilles. Plenum dimensions shall match grille size. Paint inside of plenum box flat black.

C. Seal all supply and return registers, grilles and diffusers during construction operations to limit dust entering HVAC systems and ductwork. Seals may be removed just prior to testing and balancing, but not without the approval of the Owner's Representative.

END OF SECTION

SECTION 23 37 23.16
PENTHOUSES

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services required for the complete installation designed in Contract Documents.

1.02 SUBMITTALS TO THE ARCHITECT/ENGINEER

A. Penthouses including materials, finishes and accessories.

B. Provide original color charts for selection of finish.

PART 2 - PRODUCTS

2.01 PENTHOUSES

A. Housings shall be minimum 18 gauge aluminum bolted to a minimum 8 gauge aluminum support structure.

B. The aluminum base shall be of bolted and welded construction.

C. Provide a curb as per Specification Section 230530.

D. Provide aluminum bird screen.

E. Design Equipment: Cook, TR.

F. Makes: PennBarry, Carnes, Greenheck, Arrow, Cook.

PART 3 - EXECUTION

3.01 GENERAL

A. Install penthouses as per manufacturer's recommendations.

END OF SECTION

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SECTION 23 51 02
PREFABRICATED FLUE GAS VENTING SYSTEM

PART 1 - GENERAL

1.01 WORK INCLUDED

A. All work in this section shall comply with the General Mechanical Specifications.

B. This section includes specifications for furnishing and installing Non-Positive and Positive Pressure Vent systems for Condensing and Non-Condensing applications.

1.02 QUALITY ASSURANCE

A. Where applicable, products furnished under this section shall conform to the requirements of NFPA 54 and NFPA 211, and shall comply with UL 1738, Standard for Venting Systems for Category I, II, III, and IV Gas-Burning Appliances, and all other applicable standards.

B. All flue gas carrying components of the vent system shall be obtained from a single manufacturer.

C. The flue gas venting system materials must be furnished by the manufacturer of the boiler or water heater if the efficiency is greater than 85%, as per the requirements of NFPA 85 and 211.

D. The flue gas venting system shall have a warranty of ten (10) years (minimum).

1.03 SUBMITTALS

A. Submit a fully dimensioned, scaled shop drawing, showing plan and elevational views of the entire flue gas venting system. The detailed drawing shall indicate all section sizes and the specific fittings to be installed. The drawing shall include all supports (vertical and horizontal) applicable to the project. The drawing shall be prepared and approved by the system manufacturer.

B. Submit product data showing complete material and construction details for flue gas venting system and accessories.

C. Submit Drawings showing floor and roof openings, which shall indicate exact sizes and locations.

D. Provide documentation of a product warranty of ten (10) years or more.

PART 2 - PRODUCTS

2.01 TYPE B GAS VENT

A. General:

1. Suitable to serve hot water boilers and hot water heaters utilizing natural gas.

2. Factory built all metal flue gas vent system with modular components. Suitable for outdoor installation and up to 450°F flue temperature.

3. Designed to handle negative or neutral internal pressures.

4. Double wall with minimum 1/2 in. air space between the walls.

5. Adjustable lengths with closely fitting sliding internal section with graphited mineral fiber packing gland and a sliding outer section to absorb thermal expansion.

6. B vent shall be used for all parts of the system. Single wall vent connectors are not acceptable.

B. Outer Jacket:

1. Galvanized steel.

C. Inner Gas Pipe:

1. Aluminized steel.

D. Accessories:

1. Rain cap.

2. Wall support assembly, wall guide assembly and plate support assembly.

3. Fittings to suit job conditions.

4. Drained tee cap, tee connection, inside V bands, ventilated roof thimble, external channel bands, and other necessary hardware as required for complete installation.

E. Design Equipment: Metal-Fab, Inc.

F. Manufacturers: Metalbestos, Metal-Fab, Hart and Cooley, Van-Packer, Schebler.

2.02 SPECIAL GAS VENT

A. Vent shall have a 1 in. space, and have an inner liner constructed of AL29-4C superferritic stainless steel with a minimum thickness that shall meet or exceed

the requirements of UL 1738. All products shall be factory-built special gas type, engineered and designed for use on Category I, II, III, and IV appliances.

B. Maximum positive pressure rating of 6 in. wc.

C. Maximum continuous flue gas temperature shall not exceed 550°F (288°C).

D. Vent shall be constructed with an inner conduit constructed of AL29-4C superferritic stainless steel with a minimum thickness that shall meet or exceed the requirements of UL 1738. The closure system shall be a Ring-and-Tab mechanical closure system that is integral to the system.

E. The outer wall casing shall be constructed of 430 stainless steel that shall not require additional surface preparation, such as painting, in order to withstand the outdoors or high humidity environments.

F. Inner conduit and outer wall casing shall be constructed in a fashion which prevents cross-alloy contamination and allows free movement between the two, allowing for varying rates of expansion and contraction to occur.

G. System is to be sized in accordance with the appliance manufacturer's specifications, NFPA 54-National Fuel Gas Code (ANSI Z223.1), ASHRAE recommendations, and other applicable codes.

H. Contractor shall supply double wall AL29-4C product for all exhaust gas carrying runs. Combustion air intake shall be single wall galvanized ductor PVC with insulation as specified in Specification Section 230710.

I. Joints to be sealed with factory supplied sealant. Joints shall be designed to minimize collection of condensate in both horizontal and vertical runs. Joints shall not use screws or other lesser alloy fasteners that penetrate the inner conduit.

J. General Electric RTV106 High Temperature Silicone Sealant shall be used to seal all joints on systems where the maximum flue gas temperature will not exceed 550°F. Sealant shall be per manufactures installation instructions be maintain product listings.

K. RTV Sealant may be used to seal all joints on systems where the maximum flue gas temperature will not exceed 300°F. Sealant shall be per manufactures installation instructions be maintain product listings.

L. Design Equipment: Heat Fab.

M. Acceptable Manufacturers: Heat-Fab, Hart and Cooley, Ampco, Schebler.

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION

A. Provide flue gas venting systems of sizes as shown on Drawings. Sizes are clear inside dimensions. Maintain minimum clearances between vent system and existing construction.

B. Install in strict accordance with NFPA 54, NFPA 211 and manufacturers recommendations.

C. Provide adjustable lengths between two fixed points to permit thermal expansion.

D. Seal joints with sealant suitable for temperature in excess of specified intermittent flue temperature ratings.

E. Support as recommended by the manufacturer. Provide all necessary braces, guides, guy wires, tensioners and supports. Fasteners shall penetrate wall and terminate on inside of wall with steel bearing plates.

F. Provide threaded hose end ball valve with cap and chain, at base of drained tee fitting.

G. Individual flues that penetrate the roof shall terminate a minimum of 4 ft. apart, or as per the manufacturer's recommendations.

H. Horizontal runs of a flue gas venting system shall be installed at a slope of not less than 1/4 in. per foot, to allow for proper drainage of condensate back to the boiler or water heater condensate disposal system.

END OF SECTION

SECTION 23 52 16
CONDENSING BOILERS

PART 1 - GENERAL

1.01 SUMMARY

A. This Section includes packaged, factory fabricated and assembled, wall mountable, gas fired, water-jacketed, condensing boilers, trim, and accessories.

1.02 SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Shall be submitted to the Engineer for approval and shall consist of:

1. General assembly drawing of the boiler including product description, model number, dimensions, clearances, weights, service sizes, etc.
2. Schematic flow diagram of gas valve trains.
3. 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.

C. Installation Instructions: Manufacturer's printed instructions for installation shall be submitted to the Engineer for approval.

D. Boiler Inspector's Certifications: As specified hereinafter, shall be submitted in writing prior to final acceptance by the Engineer.

E. Factory Test Reports: Factory test reports, as specified hereinafter, shall be submitted prior to final acceptance by the Engineer.

F. Field Test Reports: Field test reports, as specified hereinafter, shall be submitted prior to final acceptance by the Engineer.

G. 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.

H. 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.

1.03 WARRANTIES

A. Heat exchanger and fuel burner shall be warranted for a period of five (5) years from date of shipment.

1.04 CLOSEOUT SUBMITTALS

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

1.05 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements".

D. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers".

E. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment". Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURER'S

A. Basis of Design Product: Subject to compliance with these requirements, provide Harsco P.K. Mach Boilers or comparable product as manufactured by:

1. Lochinvar
2. DeDetrich
3. Triad Triumph
4. Equivalent.

2.02 GENERAL

A. Provide knight Series factory "packaged" low pressure hot water boilers as manufactured by Lochinvar or as approved and accepted by the Engineer. 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.

2.03 PERFORMANCE CRITERIA

A. The minimum boiler combustion efficiencies allowed, per the below chart:

	140°F Return Water	**120°F Return Water**	**100°F Return Water**	**80°F Return Water**
100% Input	89.3%	89.4%	92.6%	95.9%
80% Input	89.7%	89.9%	93.6%	96.9%
60% Input	89.9%	90.7%	94.5%	98.0%
40% Input	90.0%	91.6%	95.6%	98.0%
20% Input	90.1%	93.0%	96.6%	99.1%

B. Low NOx burner shall be certified by SCAQMD. NOx levels not to exceed the following when O2 corrected to 3%: 20-50% firing rate - 9.9 PPM, 75-100% firing rate - 10.4 PPM.

C. CO to be no more than 4% at all firing rates.

D. Boiler noise ratings to be less than: 48 dBA @ 100% firing rate, 42 dBA @ 60% firing rate and 35 dBA @ <50% firing rate.

E. Boiler shall comply with ASME Section IV for 125 PSIG (max 250°F).

F. Fuel shall be natural gas with an assumed higher heating value of 1,000 Btu./cu. ft. and an assumed specific gravity of 0.60 (relative to air). Natural gas shall be supplied at a pressure of no less than 3.5 in. wc to the inlet gas valve. Maximum inlet gas pressure shall not exceed 14 in. wc.

2.04 BOILER DESIGN

A. The BOILER shall bear the ASME "H" stamp for 80 psi working pressure and shall be National Board listed. The BOILER shall have a fully welded, stainless

steel, fire tube heat exchanger. There shall be no banding material, bolts, gaskets or "O" rings in the pressure vessel construction. The heat exchanger shall be designed for a single-pass water flow to limit the water side pressure drop. The condensate collection basin shall be constructed of welded stainless steel. The complete heat exchanger assembly shall carry a fifteen (15) year limited warranty

B. The heat exchanger shall have a volume of water no less than:

Model	Water Content
KHB285 / WHB285	4.9 gallons

C. The BOILER shall be certified and listed by C.S.A. International under the latest edition of the harmonized ANSI Z21.13 test standard. The BOILER shall operate at a minimum of 95% AFUE Efficiency (KHB/WHB055-285) and 94.4% THERMAL Efficiency (WHB399) as registered with AHRI. The BOILER shall be certified for indoor installation.

D. The BOILER shall be constructed with a heavy gauge steel jacket assembly, primed and pre-painted on both sides. The combustion chamber shall be sealed and completely enclosed, independent of the outer jacket assembly, so that integrity of the outer jacket does not affect a proper seal. A burner/flame observation port shall be provided for observing the burner flame and combustion chamber. The burner shall be a premix design constructed of high temperature stainless steel with a woven Fecralloy outer covering to provide smooth operation at all modulating firing rates. The BOILER shall be supplied with a negative pressure regulation gas valve and be equipped with a pulse width modulation blower system to precisely control the fuel/air mixture to the burner. The BOILER shall operate in a safe condition with gas supply pressures as low as 4 inches of water column. The burner flame shall be ignited by direct spark ignition with flame monitoring via a flame sensor.

E. The BOILER shall utilize a 24 VAC control circuit and components. The control system shall have a factory installed display for boiler set-up, boiler status, and boiler diagnostics. All components shall be easily accessed and serviceable from the front and top of the jacket. The BOILER shall be equipped with a temperature/pressure gauge; high limit temperature control with manual reset; ASME certified pressure relief valve set for 30 psi (standard); outlet water temperature sensor with a dual thermistor to verify accuracy; system supply water temperature sensor; outdoor air sensor, flue temperature sensor with dual thermistor to verify accuracy; low water cut off with manual reset, blocked drain switch and a condensate trap for the heat exchanger condensate drain.

F. The BOILER shall feature the “SMART SYSTEM™” control which is standard and factory installed with 128 x 128 resolution display, password security, outdoor air reset, pump delay with freeze protection, pump exercise, ramp delay featuring six steps, domestic hot water prioritization with limiting capabilities,

USB drive for simple uploading of parameters and a PC port connection for connection to a local computer for programming and trending. A secondary operating control that is field mounted outside or inside the appliance is not acceptable. The BOILER shall have alarm contacts for any failure, runtime contacts and data logging of runtime at given modulation rates, ignition attempts and ignition failures. The BOILER shall have a built-in "Cascade" with leader redundancy to sequence and rotate while maintaining modulation of up to eight boilers of different Btu inputs without utilization of an external controller. The internal "Cascade" function shall be capable of lead-lag, efficiency optimization, front-end loading, and rotation of lead boiler every 24 hours. The BOILER shall be capable of remote communication via optional CON-X-US™ Remote Connectivity with the capability of historical trending and sending text message or email alerts to notify the caretaker of a boiler alarm and remote programming of onboard boiler control. The control must have optional capability to communicate via Modbus protocol with a minimum of 46 readable points. The BOILER shall have an optional gateway device which will allow integration with LON or BacNet protocols.

G. The "SMART SYSTEM™" control shall increase fan speed to boost flame signal when a weak flame signal is detected during normal operation. A 0-10 VDC output signal shall control a variable speed boiler pump (pump shall be supplied by manufacturer) to keep a fixed Delta T across the boiler regardless of the modulation rate. The BOILER shall have the capability to receive a 0-10 VDC input signal from a variable speed system pump to anticipate changes in system heat load in order to prevent flow related issues such as erratic temperature cycling.

H. The BOILER shall be equipped with two terminal strips for electrical connection. A low voltage connection board with 46 connection points for safety and operating controls, i.e., Alarm Contacts, Runtime Contacts, Low Water Cut Off, Louver Proving Switch, Tank Thermostat, Domestic Hot Water Building Recirculation Pump Contacts, Domestic Hot Water Building Recirculation Temperature Sensor Contacts, Remote Enable/Disable, System Supply Temperature Sensor, Outdoor Temperature Sensor, Tank Temperature Sensor, Modbus Building Management System Signal and Cascade Control Circuit. A high voltage terminal strip shall be provided for Supply voltage. Supply voltage shall be 120 volt / 60 hertz / single phase on all models. The high voltage terminal strip plus integral relays are provided for independent pump control of the System pump, the Boiler pump and the Domestic Hot Water pump.

2.05 BOILER CONNECTIONS

A. Each boiler shall be provided with all necessary inlet and outlet connections as shown on the Drawings.

2.06 BOILER TRIM

A. Each boiler shall be provided with all necessary trim. Boiler trim shall be as follows:

1. Safety relief valve shall be provided in compliance with the ASME code. Contractor to pipe to glycol feed tank.
2. Water pressure temperature gauge, minimum 3-1/2 in. diameter, normal operating range approx. 50% of full range.
3. Primary low water flow fuel cutoff (probe type with manual reset).
4. Manual reset high limit water temperature controller.
5. Operating temperature control to control the sequential operation of the burner.
6. Separate inlet and outlet water temperature sensors capable of monitoring flow.
7. Exhaust temperature sensor.
8. Drain valve, minimum 3/4 in. hose end ball valve.
9. Condensate neutralization kit with refillable media.

2.07 BOILER FUEL BURNING SYSTEM

A. The boiler manufacturer shall provide each boiler with an integral, power type, straight gas, 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 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 be of the radial-fired (down-fired) type and constructed of steel with a stainless steel inner and stainless steel mesh outer screen.

F. Each boiler shall be provided with a "Full Modulating" firing control system whereby the firing rate is infinitely proportional at any firing rate between 10% 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.

G. 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 in. x 6.25 in.) and tactile membrane keypad. Displayed at each boiler shall be complete boiler status, alarm and alarm histories with full text description of each.

H. The boiler controller 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 with 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. 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, 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 - 10 VDC remote external analog signal to control the firing rate.
16. Computer (PC) interface for programming and monitoring all functions.

2.08 MAIN GAS VALVE TRAIN

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:

1. One (1) manual shutoff valve.
2. Two (2) safety shutoff valves. Valves equipped with dual solenoids that can independently energized for leak testing.
3. Air - Gas ratio control (maximum inlet pressure 14 in. wc).
4. One (1) low gas pressure switch (manual reset).
5. One (1) high gas pressure switch (manual reset).
6. Two (2) pressure test ports.

2.09 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:

1. 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.
2. One (1) low airflow differential pressure switch to insure that combustion air is supplied.
3. Intake air damper and filter.
4. High exhaust back pressure switch.

2.11 BURNER CONTROL SYSTEM

A. The ENVI boiler control system shall be supplied with a 24 VAC transformer (120 VAC, single phase, 60 Hz primary). The 120/1/60 power supply to each boiler shall be protected by a circuit breaker. Refer to electrical drawings for information.

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. General:

1. Provide a complete control system to control the boilers and auxiliaries. Provide a supply and return header temperature and boiler sequencing controller to cascade boilers into service and properly modulate their firing rates in unison to maintain the desired hot water supply temperature in the header.
2. Each boiler shall be given a specific address identification parameter for that particular model boiler unit. This feature is utilized in a "True" Hybrid system design to provide protection of the return water temperature differentiation between condensing and non-condensing boilers.
    a. Individual temperature controlled modulation capability for each boiler as a standalone operation backup to the Master/Member Network system.
    b. Each boiler shall be provided with a local/remote manual operation that transfers both firing rate control and operating limits.
    c. Controller shall provide hot water supply temperature based on PID Control, header temperature setpoint, outside temperature reset, temperature setback and high and low hot water temperature limits.
3. Boilers shall have the ability to be started or stopped and modulate by a single 0 - 10V signal from any external control signal.
4. Arrange system components and wiring so that failure of a control and/or individual device, or field wiring short, for one boiler does not affect automatic and manual operation of other boilers.
5. All equipment shall be provided with necessary communication capabilities and hardware to allow integration with Mod-Bus Communications with Building Automation System.
6. A single component failure shall not affect the continued operation of the boiler to ensure continued operation in the event of a controller memory corruption or CPU failure.

B. Cascade Controller:

1. Enclosure:
    a. Each boiler shall have a factory-assembled module that is cabinet mounted with all operator displays, indicators, control switches, power supplies, communications components and field terminals required for complete plant operations.

b. All operator interface control switches, indicators and displays shall be password protected.

c. Field wiring shall consist of one (1) twisted pair from boiler to boiler in a "daisy chain" fashion to provide for all communications and operations.

d. Provide a twisted pair wire to each header sensor transmitters and controller outputs for pumps, isolations valves or dampers.

e. Each controller shall be field configurable via an integral front panel keypad. Configuration and calibration data shall be stored in a non-volatile EEPROM memory with a minimum of ten (10) year data retention if (powered down).

f. Controllers shall be of US manufacture, microprocessor-based design to assure system integrity.

g. The controller shall be capable of providing an isolated Modbus RS-485 interface to allow connection to a facility's Building Automation System. Any additional protocol will be provided by factory engineering and supporting hardware. This interface shall be via (RS-485 MODBUS RTU, LonWorks, BACnet, or MetasysN2,) protocol two-way communication to, control boiler on/off and firing rate and read boiler status and error messages.

h. Controllers shall be approved by Underwriters Laboratories or a Nationally Recognized Test Lab (NRTL) to meet UL 508 and CSA C22.2 No. 14-95 requirements.

2. Displays:

a. The controller shall have a minimum 4.75 in. high by 6.25 in. wide LCD graphic display for boiler sequence operator control, alarm listing, fault historical trending and boiler control setup functions.

b. The controller's display shall be controlled by a tactile feedback membrane keyboard. The keyboard shall include both dedicated keys and alpha numeric keys for boiler parameter entry.

3. Control Relay Switches, Alarms and Indicators:

a. Alarm and status shall be displayed in real English (no codes) with date time stamped for six (6) most resent errors stored in error menu.

b. All control switches and indications shall be clearly identified using black lettering on a permanent white background.

c. The master/member operating control and alarm/status indications shall be provided for each boiler. In one location the operator shall have a complete status and controllability of the entire boiler system.

4. Cascade Sequencer:
    a. Sequence up to 24 boilers Master/Member Network. Sequence boilers regardless of size, input/output characteristics, return water temperature (minimums), condensing or non-condensing hybrid and/or manufactures model.
    b. Parallel boiler modulation, PID controlled modulation, hydronic or domestic.
    c. Boilers controlled to maintain a supply or return water header temperature.
    d. Appliance selection, each appliance shall be assigned an identity address with a particular firing rate (input) to start next unit in sequence to optimize total system efficiency. Specific parameters for that particular model boiler operating characteristics will be pre-programmed.
    e. Configure "True" Hybrid systems using a single control, non-condensing boilers do not run if return temperature is too low. Condensing boilers are limited to (adjustable) low fire if return temperature is too high to prevent short cycling.
5. Faults:
    a. Errors displayed in text format making it easier and quicker to diagnose problems "No Error Codes" display faults and program in real English language descriptions, time and date stamped.
    b. Six (6) most recent errors are stored in the Error Menu.
    c. Easier and quicker troubleshooting, I/O switches/relays are individually annunciated.
    d. Optional software for advanced set-up and diagnostics.
    e. Software flexibility paired with hardware durability.
    f. Open Predictive PID Proportional, integral, derivative shall work as one or independent to each boiler to accurately control firing rate to the temperature of a variable load to pin-point accuracy.

2.13 SOURCE QUALITY CONTROL

A. Each factory "packaged" boiler shall be hydrostatically tested and bear the ASME "H" stamp.

B. 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

3.01 DELIVERY, STORAGE AND HANDLING

A. 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.

3.02 EXAMINATION

A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

1. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

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

3.03 INSTALLATION

A. The installation shall be provided by the Contractor in accordance with the requirements of the codes specified hereinbefore. All of the Contractor's work shall be performed in a workmanlike manner, by experienced workmen previously engaged in boiler plant construction and shall be under the supervision of a qualified installation supervisor.

B. Install equipment in strict compliance with manufacturer's installation instructions.

C. Install equipment in strict compliance with state and local codes and applicable NFPA standards.

D. Maintain manufacturer's recommended clearances around sides and over top of equipment.

E. Install components that were removed from equipment for shipping purposes.

F. Install components that were furnished loose with equipment for field installation.

G. Provide all electrical control and power interconnect wiring.

H. Provide all fuel gas vent and service piping.

I. Provide all piping for boiler pipe connections.

J. Install condensate neutralization kit per manufactures installation instructions. Pipe to floor drain.

K. Contractor must, when filling the system with treated water, verify that the pH level is maintained between 6.0 and 8.5.

L. Contractor must verify that 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.

3.04 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

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

B. Tests and Inspections:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
    a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature, steam pressure.
    b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Remove and replace malfunctioning units and retest as specified above.

D. Occupancy Adjustments: When requested within twelve (12) months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two (2) 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.
    a. Test for full capacity.
    b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.
4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
7. Notify Architect in advance of test dates.
8. Document test results in a report and submit to Architect.

3.05 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Video training sessions. Refer to Section 017900, "Demonstration and Training".

END OF SECTION

SECTION 23 62 13
AIR-COOLED CONDENSING UNITS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services as required for the complete installation designed in the Contract Documents.

1.02 SUBMITTALS

A. Air-cooled condensing unit, complete with accessories.

B. Complete wiring and piping diagrams showing all piping and control interconnection.

C. Installation Manuals.

1.03 GENERAL REQUIREMENTS

A. Equipment Manufacturer shall be responsible for the following:

1. Furnish complete installation Drawings, templates, wiring diagrams and instruction manuals for the equipment.
2. Provide additional copies of above data for O&M Manual.
3. Provide refrigerant piping diagram prior to installation showing exact location and arrangement of piping and all devices required: Sight glass, solenoid valves, thermal expansion valves, filter dryers, shut off valves, charging valves, etc.
4. Supervise and check installation for compliance with manufacturer's recommendations.
5. Furnish spring vibration mounting equipment to prevent transmission of machine vibration to the building structure.
6. Complete start-up for each unit shall be performed under the direction of the manufacturers authorized representative.

B. Contractor shall:

1. Provide piping, valves and accessories to connect the condensing units to their respective units, including miscellaneous devices to make a complete and operable refrigeration system.
2. Provide one (1) year, 24-hour service and guarantee from date of final acceptance.

C. Electrical Wiring:

1. Division 26 will provide power wiring to condensing unit.

2. Division 23 will provide control wiring interlocks at units and interlocks to air handling units as required.

D. Start-Up, Testing and Instructions:

1. Provide complete installation, testing, wiring, start-up, and instructions to Owner's Representative.

PART 2 - PRODUCTS

2.01 AIR-COOLED CONDENSING UNITS

A. GENERAL DESCRIPTION

1. Furnish as shown on plans, Condensing Unit(s) Unit performance and electrical characteristics shall be per the job schedule.
2. Configuration: Fabricate as detailed on prints and drawings.
3. The complete unit shall be ETL listed.
4. Units constructed in accordance with ANSI B9.1 and NEC.
5. Unit performance shall be certified in accordance with ARI Standard 460, latest edition.
6. Unit shall be completely factory assembled and shipped in one piece.
7. Unit to be shipped with a nitrogen holding charge only.
8. The unit shall undergo an operational test prior to shipment. The factory test shall include a refrigeration circuit check test, a unit safety control system operations checkout, and a final unit inspection.
9. All units shall have decals and tags to indicate caution areas and aid unit service. Unit nameplates shall be fixed to the main control panel door. Electrical wiring diagrams shall be attached to the control panels. Installation, operating and maintenance bulletins and start-up forms shall be supplied with each unit.
10. Performance: All scheduled capacities and face areas are the minimum accepted value. All scheduled amps, KW, and HP are maximum accepted values that allow scheduled capacity to be met.

B. CABINET

1. Exterior surfaces shall be constructed of pre-painted galvanized steel for aesthetics and long term durability. Paint finish to include a base primer with a high quality, polyester resin topcoat of a neutral beige color. Finished surface to withstand a minimum 750-hour salt spray test in accordance with ASTM B117 standard for salt spray resistance.

2. The unit base frame shall be constructed of 13 gauge pre-painted galvanized steel.

3. Lifting brackets shall be provided on the unit base with lifting holes to accept cable or chain hooks.

C. ELECTRICAL

1. Unit wiring shall comply with NEC requirements and with all applicable UL standards. All electrical components shall be UL recognized where applicable. All wiring and electrical components provided with unit shall be number and color coded and labeled according to the electrical diagram provided for easy identification.

2. The unit shall be provided with a factory wired weatherproof control panel. Unit shall have a power terminal block for main power connection. A terminal board shall be provided for low voltage control wiring. Branch circuit short circuit protection, 115 volt control circuit transformer and fuse, system switches, and a high temperature sensor. Each compressor and condenser fan motor shall be furnished with contactors and inherent thermal overload protection. Knockouts shall be provided in the side of the main control panels for field wiring entrance.

3. All 115-600 volt internal and external wiring between control boxes and components shall be protected from damage by raceways or liquid tight conduit.

4. The receptacle shall be powered by a field supplied 115V source.

5. Single non-fused disconnect swtich shall be provided for connecting electrical power at the unit. Disconnect switches shall be mounted internal to the control panel and operated by an externally mounted handle. Externally mounted handle is designed to prohibit opening of the control panel door without the use of a service tool.

6. Unit SCCR rating to be 10 kAIC.

7. Phase failure and under voltage protection shall be provided to prevent damage from single phasing, phase reversal, and low voltage conditions.

8. Unit shall be provided with a 24 volt transformer and terminal strip for field supplied controls.

D. CONDENSING SECTION

1. Air Cooled Condenser

   a. The condensing section shall be open on the sides and bottom to provide access and to allow airflow through the coils. Condenser

coils shall be multi-row and fabricated from cast aluminum micro-channel coils. Each condenser coil shall be factory leak tested with high-pressure air under water. Coils are to be recessed so that the cabinet provides built in hail protection.

b. The fan casing or discharge attenuation shroud shall be made of heavy gauge steel with spun flanges and welded seams. Condenser fans shall consist of high pressure die cast aluminum airfoil blades, hub and clamp plate. The finish of the fan assembly shall consist of high pressure cleaning, application of one coat of primer and one coat of enamel paint. The fan RPM shall not exceed to allow 850 for quieter operation. All motors are totally enclosed air over design with a 1.15 service factor, Class F insulation with Class B rise, and 100,000 hour L10 bearings.

c. Units shall have at least one head pressure sensing condenser fan controlled to maintain positive head pressure. An ambient thermostat shall prevent the refrigeration system from operating below 45º F ambient. Condenser fan speed control shall be added to the last fan off on each refrigeration circuit to provide cooling operation to ambient temperatures down to 0° F. Fan speed control shall be field adjustable.

2. Scroll Compressors

a. Each unit shall have multiple, heavy-duty Copeland scroll compressors.

b. Each compressor shall be complete with gauge ports, crankcase heater, sight-glass, anti-slug protection, motor overload protection and a 5 minute time anti-cycling time delay.

c. Compressors shall be isolated with resilient rubber isolators to decrease noise transmission.

d. Safeties including low oil pressure and thermal cutoffs on each compressor.

3. Refrigeration Circuit

a. Each unit shall have two independent refrigeration circuits. Each circuit shall be complete with low pressure control, liquid line charging valve with a 3/8" charging port, a manual reset high pressure safety switch. Each Circuit shall be dehydrated, leak tested, and shipped with a Nitrogen holding charge.

b. Each compressor shall be complete with gauge, ports, crankcase heater, sight - glass, anti-slug protection, motor overload protection and a 5 minute time anti-cycling time delay.

4. Hot gas bypass capped T shall be factory installed on the discharge line of refrigerant circuits.

E. CONTROLS

1. Refrigeration capacity control shall be accomplished by staging of the unit's multiple compressors. Unit shall be equipped with a 120V terminal strip for field supplied and installed controls

2. Controls cabinet shall be separate from power cabinet and shall have gasketed door.

F. Casings:

1. Zinc-coated steel, phosphatized casings coated with epoxy resin primer and finished with baked enamel.
2. With full face louvers to protect coils from hail damage.
3. Equipped with unit mounting rails and drain holes.
4. Spring isolators between unit and roof supports.

G. Design Equipment: Daikin

H. Make: Carrier, Daikin Applied, Trane, York.

2.02 REFRIGERATION ACCESSORIES

A. Filter Dryers:

1. Liquid lines dryer ahead of solenoid valves in each system.
2. Replaceable cartridge type.
3. Make: Ansul, McIntire, Mueller, Sporlan.

B. Sight Glass:

1. In each liquid line close to evaporator, after filter dryer.
2. Make: Ansul Super Dry-Ey, Henry; with elements to act as moisture indicator; Sporlan.

C. Thermal Expansion Valve:

1. In each liquid line at evaporator coil.
2. Make: Sporlan, Henry, Parker.

D. Shut-Off Valves:

1. To isolate equipment components, packless type.

2. Make: Henry, Mueller, Superior.

E. Charging Valve:

1. Locate and install at a point to facilitate charging of the system.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Connect services to the unit where called for in complete accordance with the manufacturer's installation instructions. Furnish Division 26 with wiring diagrams and electrical data to permit power wiring connections to the unit. Provide control wiring serving air handling unit associated condensing unit, and the auxiliary control panel in accordance with Section "Electric Wiring". Charge system with refrigerant and proper quality of oil, after evacuating and leak testing, and in accordance with manufacturer's installation instructions. Provide roof equipment support rails.

END OF SECTION

SECTION 23 73 13
AIR HANDLING UNITS

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation as shown on the Contract Documents.

1.02 SUBMITTALS

A. Submit unit performance 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 service clearances. Indicate lift points and recommendations. Indicate unit shipping split locations, and split dimensions, installation and operating weights including dimensions.

D. Provide fan curves with specified operating point clearly plotted.

E. Submit data on electrical requirements. Include safety and start-up instructions.

F. Submit sound data certified to ARI 260.

1.03 DELIVERY STORAGE AND HANDLING

A. Units may be shipped fully assembled or disassembled to the minimum module size in accordance with shipping or jobsite requirements.

B. The units must be rigged and lifted in strict accordance with the manufacturer's recommendations.

C. All unit openings must be sealed to prevent the entrance of construction dust.

D. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters in place, bearings lubricated (if applicable), condensate properly trapped, piping connections verified and leak-tested, belts aligned and tensioned, all shipping braces removed, bearing set screws torqued, and fan has been test run under observation.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. The units shall consist of the AHU modules as shown on the plans.

B. Air handling units to fit intended use and location as called for. Capacity, size and arrangement, static pressure, brake horsepower, component parts and accessories as called for and as necessary to obtain required results and allow for proper maintenance. Ratings based on standard Test Code for Centrifugal Fans, adopted jointly by AMCA and ASHRAE. Each size fan to be supplied shall be tested in the manufacturer's laboratory under simulated installation conditions. Ratings based on test, not on interpolated or extrapolated calculation. Guaranteed full capacity delivery through duct systems finally installed and under conditions listed. Guaranteed sound power level ratings not exceeding those of design equipment or as scheduled.

C. Source Limitations: Obtain modular indoor air-handling units through one source from a single manufacturer.

D. ARI Certification: Air-handling units and their components shall be factory tested according to the applicable ARI Standard and shall be listed and labeled by ARI.

E. More than one manufacturer is listed as make, Contractor must be certain that equipment submitted fits properly into indicated space conditions, same as design equipment.

F. Motors shall conform to the requirements of Specification Section 230513, "Motors".

G. Drives:

1. All motors and drives shall be factory-installed and run tested. All fans shall be direct drives.

2.02 AIR HANDLING UNITS

A. Unit Base:

1. Indoor Units: Provide factory-installed external support kit on the base of the unit. External support kit shall be used for ceiling suspension, external isolation, or with housekeeping pad. The external support kit for a floor mounted unit shall be 6 in. (minimum) height factory base rail. Unit mounting devices not constructed of galvanized steel shall be chemically cleaned and coated with both a rust-inhibiting primer and finished coat of rust-inhibiting enamel.

B. Casing:

1. Indoor Units:

a. Unit shall be constructed of a complete structural frame with removable panels. Unit manufacturer shall ship separate segments so unit can be broken down for ease of installation in tight spaces. The entire air handler shall be constructed of 18 gauge G90 galvanized steel. Casing finished to meet ASTMB 117 250-hour salt-spray test. The removal of side panels shall not affect the

structural integrity of the unit. All removable panels shall be gasketed to minimize air leakage. All doors shall have gasketing around full perimeter to prevent air leakage. Contractor shall be responsible to provide connection flanges and all other framework that is needed to properly support the unit.

b. Panels shall be 2" thick.

c. Indoor Units: Construct casing sections capable of operating from -6 in. w.g. to +5 in. w.g.

d. Casing leakage shall not exceed 0.5 cfm per square foot of casing at -6 in w.g. to 5 in w.g.

e. Access panels and/or access doors shall be available on both sides of the unit in all sections to allow easy access to drain pan, coil(s), motor, drive components and bearings for cleaning, inspection, and maintenance. If panels are not removable, then manufacturer shall provide access sections with doors between all internal components to ensure access and cleanability of the air handler.

f. Access doors shall be double wall construction to prevent damage to insulation during routine maintenance.

g. Access panels and doors shall be fully removable without the use of specialized tools to allow complete access of all interior surfaces.

h. Door hardware shall be surface mounted to minimize penetrations in the door casing that could lead to air leakage paths.

i. All joints between exterior panels and structural frames, as well as joints between module frames, shall be properly sealed and gasketed to provide an air seal.

j. Insulation shall be encased in double-wall casing between exterior and interior solid panel such that no insulation can erode to the airstream. Foil facing on insulation is not an acceptable alternate to double wall construction. Insulation shall have a minimum R-Value of 13 and shall be UL listed. The installation shall comply with NFPA 90A and B requirements.

C. Fan Section(s):

1. Provide supply, return, exhaust fan section(s) as shown on the plans.

2. Provide self-aligning, grease lubricated pillow-block ball bearings selected for L-50 400,000 - for plug fans hour average life per ANSI/AFBMA 9. Extend both grease lubrication fittings to drive side of unit with plastic tubes and zerk fittings rigidly attached to drive-side bearing support.

3. Vibration levels shall be factory tested for VAV applications. Special balancing and structural components shall be provided to minimize harmonic vibrations.

4. Provide supply, return, exhaust fan sections with AF single width, single inlet centrifugal plug fans designed and suitable for class of service indicated on unit schedule. Fan shaft to be properly sized and protectively coated width lubricating oil. Fan shafts shall be solid and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. Fans shall be statically and dynamically tested as an assembly at the required RPM to meet design specifications. Key fan wheels to fan shaft to prevent slipping. Provide galvanized expanded metal access door guards to prevent unauthorized entry into fan sections when access doors are opened. Design access door guards for removal from outside of unit. On plug fan sections with vertical down discharge, a safety grate shall cover the entire discharge opening to prevent service personnel from falling into supply air ductwork.
5. Fans shall be tested and rated according to AMCA210.
6. Mount fans on isolation bases. Internally mount motors on same isolation bases and internally isolate fans and motors with 1 in. spring isolators. Install flexible canvas ducts between fan and casings to ensure complete isolation. Flexible canvas ducts shall comply with NFPA 90A.
7. Fan sections shall have full height, double wall, hinged doors on one side for inspection and maintenance of internal components.
8. For fan sections controlled by variable frequency drives, balance at speeds between 25% and 100% of design RPM.
9. Belts shall be enclosed as required by OSHA standard 29 CFR 1910 to protect worker from accidental contact with the belts and sheaves.

D. Filter Section:

1. Provide factory-fabricated filter section of the same construction and finish as unit casings. Filter section shall have filter guides and access doors extending the full height of the casing to facilitate filter removal. Provide filter block-offs as required to prevent air bypass around filters. Filters shall be removable from one side of filter sections.
2. Filter type, efficiency, and arrangement shall be provided as defined in project plans and schedule. Filters shall be removable from one side of filter section(s).
3. Provide 2 in. angled pre-filter sections with Merv 8 pleated filters.
4. Provide high efficiency final filter sections with 12 in. cartridge filters and 2 in. pleated pre-filters in order to provide proper filtration. High efficiency filters shall be Merv 13 and rated in accordance with ASHRAE 52 and UL Class 1.
5. Manufacturer shall provide one set of startup filters and an additional set of operational filters.
6. Provide magnehelic gauge across the filter banks.

E. Coils:

1. Install coils such that headers and return bends are enclosed by unit casing to ensure that if condensate forms on the header or return bends, it is captured by the drain pan under the coil.
2. Coils shall be manufactured with plate fins to minimize water carryover and maximize airside thermal efficiency. Fin tube holes shall have drawn and belled collars to maintain consistent fin spacing to ensure performance and air pressure drop across the coil as scheduled. Tubes shall be mechanically expanded and bonded to fin collars for maximum thermal conductivity. Use of soldering or tinning during the fin-to-tube bonding process is not acceptable due to the inherent thermal stress and possible loss of bonding at that joint.
3. Construct coil casings of galvanized steel. End supports and tube sheets shall have belled tube holes to minimize wear of the tube wall during thermal expansion and contraction of the tube.
4. All coils shall be completely cleaned prior to installation into the air-handling unit. Complete fin bundle in direction of airflow shall be degreased and steam cleaned to remove any lubricants used in the manufacturing of the fins, or dirt that may have accumulated, in order to minimize the chance for water carryover.
5. On stacked cooling coils, intermediate drain pans shall be installed between the coils. Intermediate drain pans shall have drop tubes to guide condensate to the main drain pan, thus preventing flooding of lower coils that would result in moisture carryover.
6. Hydronic Coils:
    a. Supply and return header connections shall be clearly labeled on outside of units such that direction of coil water-flow is counter to direction of unit airflow.
    b. All coils shall be tested and rated in accordance with ARI 401.
    c. Coils shall be drainable.
    d. Fins shall be aluminum with minimum 0.01 inch thickness.
    e. Tubes shall seamless copper and 5/8" tube diameter and 0.25" tube wall thickness.
    f. Coils shall be proof tested to 450 psig and leak tested to 300 psig air pressure under water.
    g. Headers shall be constructed of round copper pipe or cast iron.
    h. Penetrations shall be sealed with gasket and sealed.
7. Refrigerant Cooling Coils:
    a. Refrigerant suction and liquid connections shall be clearly labeled on outside of units.

b. Coils shall be proof tested to 450 psig and leak tested to 300 psig air pressure under water. After testing, insides of tubes shall be air dried, charged with dry nitrogen, and sealed to prevent contamination.

c. Refrigerant suction and liquid headers shall be constructed of copper tubing. Suction and liquid connections shall penetrate unit casings to allow for sweat connections to refrigerant lines and shall be gasketed.

d. Tubes shall be copper. Fins shall be aluminum.

e. Coils shall have equalizing type vertical distributors sized in conjunction with capacities of coils.

f. Coils shall be tested and rated in accordance with ARI 410.

g. Fins shall be aluminum with minimum 0.01 inch thickness.

h. Tubes shall be seamless copper and 1/2" tube diameter and 0.25" tube wall thickness.

i. Penetrations of casing for coil connections shall be tightly gasketed and sealed to prevent air leakage.

F. IAQ Drain Pans:

1. Insulation shall be encased between 18 gauge G90 galvanized exterior and interior walls. Units with cooling coils shall have drain pans under complete cooling coil section that extend beyond the air-leaving side of the coil to ensure capture of all condensate in section. Cooling coil drain pans shall be sloped in 2 planes, pitched toward drain connections to ensure complete condensate drainage when unit is installed level and trapped per manufacturer's requirements. Drain pans shall have one drain connection on same side as floor drain.

2. All drain pan connections supplied by unit manufacturer including, piping, and piping connections extending from stainless steel drain pans shall be constructed of stainless steel. The contractor is responsible to ensure the unit is installed level, trapped in accordance with the manufacturer's requirements, and visually inspected to ensure proper drainage of condensate.

G. Dampers

1. All dampers shall be internally mounted. Dampers shall be premium ultra low leak and located as scheduled. Dampers shall be double-skin airfoil design for minimal air leakage and pressure drop. Leakage rate shall not exceed 5 CFM/square foot at one-inch water gauge and 9 CFM/square foot at 4 in. water gauge. All leakage testing and pressure ratings shall be based on AMCA Publication 500. Manufacturer shall submit brand and model of damper(s) being furnished.

2. Provide dampers to modulate the volume of outside air, return air, and exhaust air as shown. Configure the dampers as shown on the plans:

a. OA/RA Mixing Module.

b. Return fan economizer.

3. Provide a factory-mounted ASHRAE Standard 62 airflow monitoring and control station in the outdoor air opening of the mixing box. The monitor shall track a variable outside air quantity for ventilation demand flow control and ventilation flow documentation. The airflow monitoring station shall be factory-mounted, factory-calibrated, and installed per the airflow monitor manufacturer's recommendations. The air-handling unit mixing box shall also include a modulating outside air damper mounted in series with the airflow monitor. All linkages, crank arms, jackshafts and mounting hardware shall be provided. The airflow monitoring station shall be calibrated to measure a variable airflow from 15% of nominal air handler cfm up to 100% of design airflow, maintaining an accuracy of plus or minus five (5%) percent of actual cfm, for air measuring between -40F up to +158F. Monitoring station shall compensate for outside air temperature fluctuations that affect mass flow rate of air. The airflow monitoring station shall provide a proportional output velocity signal (2-10 vdc). The velocity sensor shall have an automatic zeroing function and shall be programmed to recalibrate the device's transducer a minimum of once per day to ensure continuous accuracy of airflow measurements. The monitor manufacturer shall provide to the Building Automation System (BAS) contractor a certified conversion table for the signal provided.

H. Miscellaneous Sections:

1. Turning and Discharge Plenum Modules: Shall be provided as shown to efficiently turn air and provide sound attenuation.

I. Design Equipment:

1. Indoor Style Units: Daikin.

2. Makes: Daikin Applied, Trane, York by Johnson Controls, Carrier.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide equipment in accordance with manufacturer's recommendations and compatible with intent of the respective system performance requirements.

B. Provide vibration isolators in accordance with manufacturer's recommendations, and as called for. Provide necessary steel supporting framework for equipment requiring same. Braced against swaying.

C. Provide 6 in. high concrete pads for all floor mounted air-handling units.

D. Install piping adjacent to machine to allow service and maintenance. Do not block access doors or coil pull-space with piping.

E. Pan Drains:

1. Connect condensate drain pans with full-size piping.

2. Construct trap with offset dimension and seal depth per manufacturer's recommendations. Install cleanouts at changes in direction.

3. Indoor Units: Extend to nearest equipment or floor drain.

F. Start-Test-Check:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

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

3. Verify that shipping, blocking, and bracing are removed.

4. Verify that unit is secure on mountings and supporting devices and that connection to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.

5. Leak Test: After installation, fill water and steam coils with water and test coils and connections for leaks. Repair leaks and retest until no leaks exist.

6. Charge refrigerant coils with refrigerant and test for leaks. Repair leaks and retest until no leaks exist.

7. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

8. Verify that specified filters are installed. Check for leakage around filters.

9. Verify that cooling coil drain pans have a positive slope to drain.

10. Verify that the cooling coil condensate drain trap maintains an air seal.

11. Clean air-handling units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils entering air face.

12. After completing system installation and testing, adjusting, and balancing modular indoor air handling and air-distribution systems, clean filter housings and install new filters.

END OF SECTION

SECTION 23 81 26.11
DUCTLESS SPLIT SYSTEM AIR CONDITIONER

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide all labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.02 SUBMITTALS

A. Submit product data for split system ductless air conditioner, including condensing unit, refrigerant piping diagrams, O & M manual, and control and wiring schematics.

1.03 GENERAL REQUIREMENTS

A. Provide units to fit intended use and location as indicated:

1. Capacity, size and arrangement, component parts and accessories as scheduled and/or as necessary to obtain required results and allow for proper maintenance.
2. Unit capacities to be ARI 210 rated.
3. Unit to meet or exceed minimum SEER Requirements of New York State Energy Code and Department of Energy (DOE).

PART 2 - PRODUCTS

2.01 AIR HANDLING UNIT(WALL MOUNTED TYPE)

A. Units shall be completely factory assembled including coil, condensate drain pan, fan, motor, filters and controls in an insulated casing. Units shall be UL listed and C.S.A. certified. Forward curved, dynamically and statically balanced fan with 3 speed direct drive. Fan motor bearing shall be permanently lubricated.

B. Units shall have sheet metal and steel frame construction and shall be painted with an enamel finish. Casing shall be insulated and knockouts shall be provided for electrical power and control wiring.

C. Unit shall have a single refrigerant circuit controlled by a flow control check valve (FCCV). Aluminum fin surface shall be mechanically bonded to 3/8 in. OD copper tubing. Coils shall be factory pressure and leak tested.

2.02 CONDENSING UNIT

A. The condensing unit shall be fully charged from the factory for up to 100 ft. of piping. The unit must be designed to operate at outdoor ambient temperatures as high as 115°F and as low as -20°F, with low-ambient kit. The unit shall be UL

listed. Unit casing shall be constructed of heavy gauge, galvanized steel and painted with a weather-resistant powder paint finish.

B. Refrigeration system controls include condenser fan and compressor contactor. High and low pressure controls shall be inherent to the compressor. A factory installed liquid line dryer shall be standard. The compressor shall feature internal over temperature and pressure protection, total epoxy dipped hermetic motor windings, thermostatically controlled sump heater, centrifugal oil pump, and internal spring mounts to reduce vibration and noise. The coil shall be continuously wrapped, corrosion resistant all aluminum glued with minimized brazed joints. The coil shall be 3/8 in. O.D. seamless aluminum glued to a continuous aluminum fin. The coil shall be protected on all four sides by louvered panels.

2.03 ACCESSORIES

A. Wall Mounted Microprocessor Controller:

1. Liquid crystal digital display indicating: Operating mode, setpoint temperature, room temperature, timer setting, fan speed and airflow direction.
2. Self diagnostic fault indication.
3. 24 hour on-off timer.
4. Previous setpoint memory feature.

B. Low ambient protection kit with wind baffle. Allow unit operation down to -20°F.

C. Auto restart following power failure.

D. Pre-charged uninsulated refrigerant piping lines.

2.04 DESIGN EQUIPMENT

A. LG.

2.05 ACCEPTABLE MAKE

A. LG, Sanyo, Mitsubishi, EMI, Carrier.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install equipment in strict accordance with manufacturer's instructions and so as to be compatible with intent of the respective system performance requirements.

B. Connect condensate drain indicated on drawings and route to room G004.

C. Provide refrigerant piping and control wiring.

D. Provide any and all necessary control wiring.

END OF SECTION

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SECTION 23 82 16.11
COILS

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.02 SUBMITTALS

A. Submit product data for on coils

1.03 GENERAL REQUIREMENTS

A. Provide coils of proper size and rows to fit intended use and capacity as scheduled and specified. Location as shown on Plans. Designed for 125 psi. Same end or opposite end connections as required to fit installation shown on Plans. Vertical mounted coils shall have bottom drain headers. Duct mounted coils shall be equipped with flanges. Tag each coil at factory giving number and location. Coils completely drainable with auxiliary drain headers, if necessary. Minimum 1/2 in. drain and vent connections. Aluminum fins shall be a minimum of .0075 in. thick unless otherwise noted. Coils shall have brazed return "U" bends; bent tubes are not acceptable. Performance certified in accordance with ARI Standard 410.

PART 2 - PRODUCTS

2.01 REHEAT COILS

A. Tubing shall be .025 in. thick copper and shall have a minimum outside diameter of 5/8 in. Fins shall be of aluminum and wound on tubing individually. Steel headers and galvanized steel casings. Coils shall be tested by subjecting each coil to a minimum air pressure of 250 psig with the coil submerged in water.

B. Design Equipment: Trane.

C. Make: Aerofin, Carrier, Daikin Applied, Trane, Heatcraft, Marlo

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install equipment in strict accordance with manufacturer's instructions and so as to be compatible with intent of the respective system performance requirements. Provide supporting ironwork and sheet metal safing to assure proper installation without any bypass air around coil.

B. Provide ample space during installation to allow for the removal of the coil. Provide all necessary unions, isolation valves, flexible connectors and accessories to allow for the removal and service of the coil.

C. Provide an access door upstream of all coils for inspection. Access door shall be minimum 16 x 12.

END OF SECTION 23 82 16.11

SECTION 23 82 35
GRAVITY HEATING EQUIPMENT (HYDRONIC)

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation designed in Contract Documents.

1.02 SUBMITTALS

A. Submit product data on gravity heating equipment with color selection chart. Clearly indicate which equipment is being submitted.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. All equipment shall be free from expansion, noises and strains. Exposed parts to be cleaned and parkerized or phosphate coated before prime coating or baked enameling. Finish colors as selected from manufacturer's standard colors during the submittal process. Factory-boxed and tagged by room numbers. Access doors shall be provided in cabinet at locations of valves, flow balancers and air vents. Verify at site, the space available for each piece of equipment. Top of heating unit enclosures shall be at least 1 in. below top of windowsill. Bottom of heating unit enclosures, unless otherwise called for, approximately 6 in. above floor and above the base molding. Refer to Architect at once, any correction, discrepancy or suggested change in size or location.

B. Ratings of elements shall be in accordance with approved I=B=R test methods.

2.02 FIN RADIATION

A. General Requirements:

1. Complete enclosure, continuous supporting channel backplate, heating element, hangers and accessories, as specified and shown on the Contract Drawings.
2. Enclosures to run from wall-to-wall unless otherwise called. Provide necessary corner pieces, end caps, column enclosures, butt trims, wall sleeves, with access doors. Do not leave any enclosure installed without an end trim piece.

B. Heating Element:

1. Hot Water System: Seamless copper tube with non ferrous fins, 125 lbs. minimum hydrostatic test pressure. .020 in. tube wall thickness, minimum. .020 in. fin thickness, minimum.

2. Tube mechanically expanded to fin collars for permanent metal to metal contact.

3. Properly support with pitch adjustment. Silent element and pipe support. Locate a maximum of 2 ft. 0 in. apart. Support shall allow for lateral movement for expansion and contraction of heating equipment.

C. Enclosures:

1. Enclosure fronts, 18 gauge furniture steel.

a. Sloping top with stamped grille as scheduled on drawings.

b. Edges and corners rounded. Individual sections not over 6 ft. No exposed areas shall have sharp edges.

c. Mechanically fastened to wall bracket.

d. Continuous interlocking slip joint fit between adjoining covers. Finish shall match enclosure fronts along entire male and female sides.

e. Enclosure accessories shall fit tight to wall at sides, in back plate at top and extend back and mechanically screw to wall at bottom.

2. Support channel full backplate and supports:

a. 20 gauge securely fasten to wall.

b. Enclosure front braced by internal channel braces. Minimum on either side of joint seam.

c. No sheet metal screws or other fastening devices shall be visible.

d. Provide wall brackets or stiffening supports adjacent to each joint and at least every 16 in., maximum 24 in. O.C.

3. Top of cover rest on backplate only and not between wall and backplate.

4. Accessories:

a. Pedestal brackets or bottom panel when required for style.

b. With worm gear driven damper control and knurled aluminum knob, where automatic control is not specified.

D. Design Equipment: Rittling.

E. Make: Rosemex, Sterling, Rittling, Vulcan.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Each unit isolated with shut-off ball valves to permit servicing. Provide flow balancer for each unit as detailed. Contractor responsible for correct end connections and arrangements. Arrange piping accessories and valving fully accessible for servicing. Enclosures fastened to structure with screws or bolts, no

nailing allowed. Fasten at 6 in. O.C. Provide air collecting chamber and manual vent on return end of each heating unit on all upfeed hot water installation.

END OF SECTION

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SECTION 23 82 39
UNIT HEATERS AND CABINET UNIT HEATERS (HYDRONIC AND ELECTRIC)

PART 1 - GENERAL

1.01 DESCRIPTION

A. Provide labor, materials, equipment and services as required for the complete installation and related work as shown on the Contract Documents.

1.02 SUBMITTALS

A. Submit product data for unit heaters and cabinet unit heaters.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Free from expansion and contraction noises and strains. Fan speed shown on Schedule shall not be exceeded. Each piece of equipment shall be factory-boxed and tagged by room number. Cabinet unit heaters and unit heaters shall have baked enamel finish with color selected by the Architect from manufacturer's standard colors. Rating in accordance with standard test codes adopted jointly by IUGA and ASHRAE.

2.02 UNIT HEATERS

A. General:

1. Wall hung or ceiling suspended.
2. Access for servicing the heating element, motors, and controls.
3. Horizontal discharge units with adjustable horizontal and/or vertical outlet vanes.
4. Vertical units with adjustable outlet louvers or diffusers.

B. Fan and Motor:

1. Statically and dynamically balanced.
2. Motor shall be totally enclosed and designed for continuous operation. Lubrication shall be sealed-in, permanent type.
3. Wall Mounted line voltage thermostat.

C. Heating Element (Hydronic):

1. Serpentine coil, copper tube, aluminum fins, back or side connections to fit headroom requirements.

D. Accessories:

1. Finger proof fan guard.

2. Unit mounted disconnect switch.

E. Hydronic:

1. Design Equipment: Modine.
2. Acceptable Makes: Daikin Applied, Airtherm, Dunham-Bush, McQuay, Sterling, Trane, Vulcan.

2.03 CABINET UNIT HEATERS

A. General:

1. Rough-in dimensions must not exceed those of design equipment.

B. Cabinet:

1. Front and exposed parts, 16-gauge metal with baked enamel finish, all others, 18 gauge steel. Architect shall select color from mano factures standard colors
2. Fronts shall be removable for access to interior parts.
3. Recessed or semi-recessed equipment to have four-side overlap, trim strips not acceptable.

C. Fan And Motor:

1. Fans, forward curved, centrifugal type, direct drive from motor shafts.
2. Driven by totally enclosed motor with overload protection and lifetime lubrication.
    a. Integral manual motor starter.
3. Shall be quiet in operation, not to exceed 45 db measured 5 ft. away, at high speed.
4. Throwaway filter.
5. Key lock control access door(s).

D. Heating Element (Hydronic):

1. Nonferrous construction, copper tube, aluminum fins.
2. Multipass serpentine design for high temperature drop.
3. Manual air vent. Automatic air vent is not acceptable.

E. Control and Piping Accessories:

1. Wall mounted line voltage thermostat.
2. Unit mount fan speed switch.

F. Hydronic:

1. Design Equipment: Trane.
2. Acceptable Makes: Airtherm, Dunham-Bush, McQuay, Sterling, Trane, Vulcan.

PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL

A. Provide equipment in accordance with manufacturer's printed instructions. Report untrue walls before installation. Report cases where clearance below suspended heaters is less than 7-1/2 ft. Provide clearance for piping and conduit. Support units independent of piping. Support units from building structure, with screws or bolts, no nailing allowed. Be responsible for proper location and size of recesses. Coordinate installation of recessed or semi-recessed equipment in recesses. Provide framing in recess and shims. Use sponge rubber gasket air-seal between front enclosure and wall.

3.02 INSTALLATION - HYDRONIC

A. Provide valves and accessories and arrange to permit servicing. Coordinate correct end connections and coil arrangements.

END OF SECTION