

DIVISION 230000 – HVAC

Latest Update: 04-23-2026 for formatting. See Underlined Text for Latest Edits from 10-24-2024

(Engineer shall edit specifications and blue text in header to meet project requirements. This includes but is not limited to updating Equipment and/or Material Model Numbers indicated in the specifications and adding any additional specifications that may be required by the project. Also turn off all “Underlines”)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SCOPE

- A. The mechanical contractor shall furnish all labor, material, tools, equipment and services necessary and incidental for installing all mechanical systems shown on the drawings, indicated in the specification, or necessary to provide a finished installation. The finished installation shall be in perfect working condition and be ready for continuous and satisfactory operation. The project area is located in

Note: Engineer to complete above paragraph.

1.3 CODES AND REGULATIONS

- A. All materials furnished and all work installed shall comply with the codes and regulations adapted by the State of Maryland and recommendations of the following bodies:
 1. International Building Code (IBC)
 2. International Mechanical Code (IMC)
 3. International Plumbing Code (IPC)
 4. National Electric Code (NEC)
 5. Maryland State Health Department
 6. Underwriters Laboratories (UL)

1.4 RESPONSIBILITY

- A. The Construction Manager/General Contractor (CM/GC) shall be responsible for all work included in this Division. The delegation of work to the contractors shall not relieve him of this responsibility. Contractors who perform work under this Division shall be responsible to the CM/GC.

1.5 SITE VISIT

- A. Prior to preparing the bid, the HVAC contractor shall visit the site and become familiar with all existing conditions. Make all necessary investigations as to locations of utilities

and existing field conditions that could affect the work. No additional compensation will be made to the contractor as a result of his failure to familiarize himself with the existing conditions under which the work must be performed.

1.6 OUTAGES

- A. For all work requiring an outage, the HVAC contractor shall submit an outage request to the UMB Project Manager, using the UMB Standard Request for Outage Form which is available through the UMB Design and Construction Web Site at: <https://www.umaryland.edu/designandconstruction/resources/contractors/>
- B. The existing mechanical/electrical/fire protection systems shall remain operational unless turned off by University personnel during the construction of the project.
- C. Unless otherwise specified, outages of any services required for the performance of this contract and affecting areas other than the immediate work area shall be scheduled at least ten business days (10) days in advance with the UMB Design and Construction Department. Outages shall be performed during normal duty hours. If necessary some outage work may be performed outside normal hours if approved by UMB.
- D. All HVAC outages which will interfere with the normal use of the building in any manner shall be done at such times as shall be mutually agreed upon by the contractor and the UMB Design and Construction Department.
- E. The HVAC contractor shall include in his price the cost of all premium time required for outages and other work which interferes with the normal use of the building, which will be performed, in most cases, during other than normal work time and at the convenience of the University.
- F. The operation of HVAC valves or switches; required to achieve an outage must be operated by University personnel only. Unauthorized operation of HVAC valves, power switches, by contractors and their personnel will result in extremely serious consequences for which the contractor will be held accountable.

1.7 SUBMITTALS

- A. General: For general requirements see Architectural Specification Division 01 Section "Submittal Procedures". Also comply with the following:
 - 1. UMB requires all that all submittals, which includes shop drawings, product data, related equipment maintenance manuals, warranty documentation and all other pertinent information be submitted electronically by the manufacturer, trade contractors, and construction manager as a "pdf" file for review as required by Division 01. Partial submittals are not acceptable and will be returned without review.

2. After contract award and before material is ordered submit electrically all product data, shop drawings and other such descriptive data as the Engineer may require to demonstrate compliance with the contract documents as required by the contract clauses for review and approval. All construction and administrative type submittals shall be transmitted through ebuilder to the A/E Team and UMB.
3. Submittals for products and/or equipment, shall include the manufacturer's name, submittal sheets, cataloged or computer-generated performance data sheets, product / equipment dimensions and access requirements, equipment operating weights, project specification and paragraph reference for each product and/or equipment the Contractor proposes to furnish.
4. Submittals will be reviewed for general compliance with design concept in accordance with contract documents, but dimensions, quantities, or other details will not be verified.
5. Product Submittals shall include the following items unless otherwise noted: **<Edit List for Project Requirements>**
 - a. Article 2.2, Fire Stops & Smoke Seals for Wall & Floor Sleeve Applications
 - b. Article 2.3, HVAC Piping Systems
 - c. Article 2.4, Pipe Sleeves
 - d. Article 2.5, Piping Specialties
 - e. Article 2.6, Flow Meter Stations
 - f. Article 2.7, Steam Traps
 - g. Article 2.8, HVAC Valves
 - h. Article 2.9, Hangers and Supports
 - i. Article 2.10, Identification System
 - j. Article 2.11, Exterior Supports
 - k. Article 2.12, HVAC Equipment
 - l. Article 2.13, HVAC Terminal Units
 - m. Article 2.14, HVAC A/C Equipment
 - n. Article 2.15, Ductwork and Accessories
 - o. Article 2.16, HVAC Insulation
 - p. Article 2.17, BAS
 - q. Article 2.18, BAS Energy / Flow Meters
 - r. Article 2.19 TAB Report
 - s. Article 2.20, O & M Manual
 - t. Article 2.21, Housekeeping Pad
 - u. Article 2.22, Grout
 - v. Warranties and maintenance instructions shall be included in the O & M Manual only. Do not include this data in the Product Submittals.
6. Additional Data: Subject to project requirements, in addition to the product data indicated in the paragraph above the following additional data may be required: **<Coordinate with UMB, delete if not required >**
 - a. Coordinated drawings
 - b. Samples
7. Submittal File Format: File formats and names for each submittal shall be electronically as follows:

- a. File Formats:
 - 1) Product Data: “pdf” file format.
 - 2) Design Shop Drawings: “pdf” and “dwg” file formats.
 - 3) Coordinated Drawings: “pdf” or “dwg” file formats.
 - 4) Schedules: “xl” file format.

1.8 SAMPLES

- A. Samples of materials to be used on the work shall be submitted when requested and shall be subject to approval by the A/E and the UMB Design and Construction Department.

1.9 IDENTIFICATION BADGES

- A. Contractors must obtain photo identification cards for all employees who will be at the construction site. The University will charge the contractor \$25.00 for each badge as a deposit of which \$20.00 will be returned when the badge is returned. Lost photo I.D. card will cost \$25.00 for another replacement card. (The above charges are subject to change without notice.)

1.10 HAZARDOUS MATERIALS

- A. Identification and removal of hazardous materials (asbestos, lead paint, PCBs) is not part of this contract. If questionable material is encountered, notify the University Project Manager and the University Environmental Health and Safety in writing immediately. The University shall then arrange for investigation and possible abatement of the material. Contractor shall schedule his work to accommodate hazardous material removal by the Owner.

1.11 FUNCTIONAL TESTING OF NEW HVAC SYSTEMS

<Coordinate with UMB, if full Cx is included in project, edit section for Commissioning instead of Functional Testing >

- A. Summary: This article includes the requirements for functional testing of new HVAC Systems, assemblies and equipment related to the project area.
- B. Functional Testing will be performed by UMB staff.
- C. Description: The following equipment and/or accessories shall be tested as part of this project:
 1. HVAC Systems:
 - a. Air Distribution Systems:
 - 1) Air Terminal Units.
 - a) Supply terminal units.
 - b) General exhaust terminal units.
 - c) Fume hood exhaust terminal units.

- b. HVAC Equipment:
 - 1) Supplemental A/C units.
 - 2) Fume hood exhaust fans.
 - 3) Fume hood and monitor.
- c. BAS:
 - 1) Local control components for installed equipment.
 - 2) Integration into campus system.
 - 3) Project graphics and programming.

1.12 MOTOR REQUIREMENTS

- A. Compliance: Comply with NEMA MG 1 unless otherwise indicated.
- B. Motor Requirements: Requirements below apply to motors covered by this Division except as otherwise indicated.
 - 1. Motors 1/2 HP and Larger: Three phase.
 - 2. Motors smaller than 1/2 HP: Single phase.
 - 3. Frequency Rating: 60 Hz.
 - 4. Voltage Rating: Determined by voltage of circuit to which motor is connected for the following motor voltage ratings (utilization voltages):
 - a. 120 V Circuit: 115 V - motor rating.
 - b. 208 V Circuit: 200 V - motor rating.
 - c. 240 V Circuit: 230 V - motor rating.
 - d. 480 V Circuit: 460 V - motor rating.
 - 5. Minimum service factor shall be 15% and shall apply at frequency and utilization voltage at which motor is connected. Provide motors which will not operate in service factor range when supply voltage is within 10% of motor voltage rating.
 - 6. Capacity: Sufficient to start and operate connected loads at designated speeds in indicated environment, and with indicated operating sequence, without exceeding nameplate ratings. Provide motors rated for continuous duty at 100% of rated capacity.
 - 7. Temperature Rise: Based on 40°C ambient except as otherwise indicated.
 - 8. Enclosure: Open drip proof, unless otherwise specified. Provide screen over slots, where slots will permit passage of human extremities.
 - 9. Provide adjustable motor slide base for belt driven equipment. Include adjusting bolts and locknuts.
 - 10. Motors without VFD's: Motors 5 HP and lower shall be variable speed ECM motors with combination starter, disconnect and auxiliary contacts to interface with the BAS.
 - 11. Motors with VFD's: Motors larger than 5HP shall be equipped with a VFD including required accessory to interface with the BAS. See Division 260000 article for Variable Frequency Drive requirements.
 - 12. Shaft Grounding Rings: Provide shaft grounding rings on all motors with VFD's.
 - 13. Ceramic Bearings: Provide ceramic bearings on both ends of the shaft in motors 100 hp and larger.

14. Winding Heaters: Provide winding heaters as indicated below:
 - a. Required for emergency backup fans of all sizes and in all locations not operated by lead/lag control sequence.
 - b. Required for motors 100 hp and larger.
 - c. Not required for motors operated by a lead/lag control sequence.
 - d. Not required for motors located outdoors if they are smaller than 100 hp.

C. Three Phase Motors:

1. Description: NEMA MG 1, Design B, medium induction motor.
2. Efficiency: Minimum motor efficiencies shall be as follows:

Table 1 Three Phase Motor Minimum Efficiency

HP	Percent Efficiency, Minimum
1 and less	82.5
1½	84.0
2	84.0
3	87.5
5	87.5
7½	89.5
10	89.5
15	91.0
20	91.0
25	92.4
30	92.4
40	93.0
50	93.0
60	93.6
75 and larger	94.1

3. Service Factor: 1.15.
4. Multispeed Motors: Variable torque.
 - a. For motors with 2:1 speed ratio, consequent pole, single winding.
 - b. For motors with other than 2:1 speed ratio, separate winding for each speed.
5. Rotor: Random-wound, squirrel cage.
6. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
7. Temperature Rise: Match insulation rating.
8. Insulation: [Class F] <Insert class>.
9. Code Letter Designation:
 - a. Motors 15 HP and Larger: NEMA starting Code F or Code G. <Edit Code>
 - b. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

10. Motor Frames: Motor frames constructed of aluminum will not be permitted. Motor frame sizes 184T and larger shall be constructed of cast iron. Motor frames sizes smaller than 184T shall be constructed of rolled steel.

D. Polyphase Motors with Additional Requirements:

1. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
2. Motors Used with Variable Frequency Controllers: Motor ratings, characteristics, and features shall be coordinated with and approved by controller manufacturer.
 - a. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - b. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - c. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

E. Single Phase Motors:

1. Motors larger than 1/20 hp shall be one (1) of the following, to suit starting torque and requirements of specific motor application:
 - a. Permanent-split capacitor.
 - b. Split phase.
 - c. Capacitor start, inductor run.
 - d. Capacitor start, capacitor run.
2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
3. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
4. Motors 1/20 HP and Smaller: Shaded-pole type.
5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

1.13 WARRANTY/GUARANTEE

- A. All materials, equipment, etc. provided by the general contractor and/or his subcontractors shall be warranted and guaranteed to be free from defects in workmanship and materials for a period of two (2) years from the date of substantial of completion and acceptance of work by UMB. Any defects in workmanship, materials, or performance which appear within the guarantee period shall be corrected by the contractor without cost to the owner, within a reasonable time, to be specified by UMB. In default thereof, owner may have such work done and charge the cost of same to the contractor. In addition

to the above statement the Warranty/Guarantee Period shall also include all labor cost related to all warranty work. For compressorized equipment include an additional three (3) year Warranty/Guarantee Period.

PART 2 - PRODUCTS:

2.1 LISTED MANUFACTURERS

- A. Listed Manufacturers: The manufacturers indicated in Part 2 represent the basis for design and identify the minimum level of quality for materials and equipment, specified in this Division, that are acceptable to UMB. Unless “or equal” is included as an option, substitutions are not allowed, except under the following condition. During bid phase, contractors may submit material and equipment by non-listed manufacturers provided said submittals meet the requirements of these specifications. All submitted materials and equipment are subject to approval by the A/E and UMB. Reference: Division 1 Substitution Section.

2.2 FIRE STOPS & SMOKE SEALS FOR WALL & FLOOR SLEEVE APPLICATIONS

- A. General: Provide fire stops, and smoke sealant materials for all HVAC services penetrating through rated assemblies. See Architectural Specification Division 07, Section “Penetration Firestopping” for sealant material requirements. Services include:
1. HVAC penetrations include piping systems and duct systems.
- B. New Construction: All new penetrations shall be provided with a pipe sleeve and sealant materials.
- C. Existing Construction: All new service penetrations through existing rated assemblies shall be provided with a pipe sleeve and sealant materials. All existing unsealed penetrations for services passing through existing rated assemblies within the project area shall be provided with sealant materials.
- D. Project Area: The project area shall include the finished spaces and related sections of the utility shafts within the project area footprint.
- E. Wall Pipe Sleeve Applications: Pipe sleeves shall be required for all new pipe penetrations through rated wall assemblies and non-rated CMU walls. Where pipe sleeves are installed in non-rated CMU walls fire rated sealant materials are not required. Provide acoustical caulking to seal the annular spaces between the sleeve and the bare pipe or pipe insulation on each end with one half (1/2) inch caulking all around the annular space.
- F. Floor Pipe Sleeves Applications: Pipe sleeves are required for all new pipe risers passing through floor slabs.

2.3 HVAC PIPING SYSTEMS

- A. General: Provide all piping systems indicated on the drawings and as specified below, including all labor materials and equipment necessary for a complete installation.
- B. HVAC Piping Systems: HVAC piping systems include steam, condensate and hydronic piping systems as follows:
1. Hydronic Water Piping Systems: Hydronic water piping systems include, Heating Hot Water, Condenser Water, Chilled Water, Process Cooling Water, and Energy Recovery (Glycol) Water Systems. Pipe, fittings and joints shall be as follows:
 - a. Solder Connection: Hydronic water piping two (2) inch and smaller shall be type 'L' copper tubing assembled with wrought copper fittings and 95-5 solder.
 - b. Press End Connection: Hydronic water piping two (2) inch and smaller shall be type 'L' copper tubing assembled with Viega ProPress copper fittings with EPDM seals and press connection with EPDM sealing. (Contractor Option)
 - c. Press End Connection: Hydronic water piping two and one half (2-1/2) inch to four (4) inch shall be type 'L' copper tubing assembled with Viega ProPress XL-C (press end) copper fittings with EPDM seals and press connection with EPDM sealing. (Contractor Option)
 - d. Welded Connections: Hydronic water piping two and one-half (2-1/2) inch and larger ATM A53, Grade B, Schedule 40 black steel pipe with ASTM A234 butt welded fittings, ANSI B 16.5 flanges with weld neck, raised face and gasket.
 - e. Victaulic Connections: Hydronic water piping two and one-half (2-1/2) inch and larger shall be Grade B, Schedule 40 black steel pipe, 150 lb. ANSI Class, ASTM F-1476 using Victaulic rolled grooved ends with fittings and joints as follows: (Contractor Option)
 - 1) Fittings: Ductile Iron Grooved End Fittings for Elbows, Tees, Increases, Reducers, 'Y' Fittings, conforming to ASTM A - 395, grade 65-45-15
 - 2) Joints: Vic Style 07 Zero - Flex Rigid Ductile Iron couplings with Grade 'E' EPDM gasket material, Carbon Steel Nuts and Bolts, conforming to ASTM A-395, Grade 65-45-15, ASTM A - 183. Vic Flange Adapters: Vic Style 743, Ductile Iron, conforming to ASTM A -536, grade 65-45-12.
 2. Steam and Condensate Piping Systems: Pipe, fittings and joints shall be as follows:
 - a. Threaded Connections: Steam piping two (2) inch and smaller shall be ATM A53, Grade B, Schedule 40 seamless black steel pipe with malleable iron, ANSI B 16.3, Class 150, fittings with threads per ANSI B.1.20.1.
 - b. Welded Connections: Steam piping two and one-half (2-1/2) inch and larger shall be ATM A53, Grade B, Schedule 40 seamless black steel pipe with ASTM A234 butt welded fittings, ANSI B 16.5 flanges with weld neck, raised face and gasket.

- c. Threaded Connections: Condensate piping two (2) inch and smaller shall be ATM A53, Grade B, Schedule 80 seamless black steel pipe with malleable iron, ANSI B 16.3, Class 150, fittings with threads per ANSI B.1.20.1.
 - d. Welded Connections: Condensate piping two and one-half (2-1/2) inch and larger shall be ATM A53, Grade B Schedule 80 seamless black steel pipe with ASTM A234 butt welded fittings, ANSI B 16.5 flanges with weld neck, raised face and gasket.
3. A/C Condensate Drain Piping:
 - a. A/C condensate drain piping shall be schedule 40 PVC pipe and fittings.
 - b. A/C condensate drain piping shall be type 'L' copper tubing assembled with wrought copper fittings and 95-5 solder. (Contractor's option)
 4. Refrigerant Piping: **<Delete if not required>**
 - a. Refrigerant Piping shall be Copper Tube: ASTM B280, Type 'ACR' Type 'L', Seamless, hard drawn soft annealed seamless, factory cleaned and capped prior to shipping. Fittings shall be wrought copper fittings conforming to ANSI B16.22. Joints shall be AWS A5.8 classification BCuP-3 brazed (Silver) filler material.

2.4 PIPE SLEEVES

- A. Steel Pipe Sleeves: Steel pipe sleeves shall be standard black steel pipe Type E, Grade B, with plain ends conforming to ASTM A53/A53M.
- B. Cast Iron Pipe Sleeves: Cast iron pipe sleeves shall be standard weight cast iron pipe with plain ends conforming to ASTM A74 and CISPI – 301.

2.5 PIPING SPECIALTIES

- A. General: Provide all piping specialties where indicated on the drawings, details, and as specified below complete with all supports, fittings, etc. for HVAC Piping Systems.
- B. Piping Specialties:
 1. Manual Air Vents: Crane # 2910H, one quarter (1/4) inch Brass Cock
 2. Pressure/Temperature Plugs: Provide one quarter (1/4) inch ball valve.
 3. Strainers:
 - a. Copper Piping (two (2) inch and smaller): Mueller Model 352M, 250 psig working pressure; cast bronze body with threaded ends, conforming to ASTM B 61, and perforated 20 mesh Type 304 stainless steel screen, blow-down drain with plugged valve and threaded hose connection.
 - b. Copper Piping (two and one-half (2-1/2) inch and larger): Mueller Model 758, 200 psig working pressure; cast iron body with flanged ends, conforming to ASTM A 126-B, and perforated Type 304 stainless steel screen, blow-down drain with plugged valve and threaded hose connection. Screens for four (4) inch strainers shall have 0.062 size perforated openings.

- Screens for five (5) inch and larger strainers shall have 0.125 perforated openings.
- c. Steel Piping two and one-half (2-1/2) inch and larger: Mueller Model 758, 200 psig working pressure; cast iron body with flanged ends, conforming to ASTM A 126-B, and perforated Type 304 stainless steel screen, blow-down drain with plugged valve and threaded hose connection. Screens for four (4) inch strainers shall have 0.062 size perforated openings. Screens for five (5) inch and larger strainers shall have 0.125 perforated openings.
4. Thermometers: Provide Standard or Digital thermometers as manufactured by Trerice - Basis of Design or approved equal.
 - a. General Requirements: Standard adjustable type thermometer with seven (7) inch aluminum case, glass window, blue or red organic fluid, and insertion stem. Insertion length shall suite installation.
 - b. Standard Thermometers – Service & Temperature Scales:
 - 1) HVAC Systems: <Edit for Project>
 - a) Heating Water: 30°F to 240°F, with two (2) degree scale divisions.
 - b) Condenser Water: 30°F to 180°F, with two (2) degree scale divisions.
 - c) Chilled Water: 0°F to 100°F, with two (2) degree scale divisions.
 - d) Steam and Condensate: 50°F to 400°F, with five (5) degree scale divisions.
 - e) Ice Storage Glycol: -40°F to 110°F, with two (2) degree scale divisions.
 - f) Heat recovery Glycol: 0°F to 160°F, with two (2) degree scale divisions.
 - g) Chilled Glycol: 0°F to 100°F, with two (2) degree scale divisions
 - c. Digital Thermometers – Hydronic Systems: Trerice Model SX9, seven (7) inch adjustable angle, Solar Threm light powered digital thermometer with large 9/16-inch LCD °F/°C display, cast aluminum case NEMA – 4X/IP 65, Range minus 40°F to 300°F. Stem style and length to suit project requirements.
 5. Pressure Gauges: Trerice Type 450 series, four and one half (4-1/2) inch diameter aluminum case, Glass, Acrylic or Lexan window, one quarter (1/4) inch brass socket, #735 – two (2) needle valve, pressure range suite system. Gauges shall have black letters on white background. On gauges used for steam service provide a Trerice #885-1 coil syphon for each gauge.
 - a. Service and Scale Range in pounds per square inch (PSI):
 - 1) HVAC Systems:
 - a) HVAC Water Systems: Zero (0) to two (2) times operating pressure.
 - b) Steam Systems: 0 to 100 psig, with ten (10) figure intervals with 1 psi scale divisions.
 6. Flexible Connections: Metraflex flexible pipe connectors with stainless steel hose and braid, and copper end tubes, or schedule 40 IPS pipe ends.

7. Pipe Alignment Guides: Metraflex style one (1) pipe alignment guide. Anchor guides to building structure.
8. Pipe Anchors: Anchors shall be constructed of steel sections and plates, assembled by bolting or welding and secured to building structure.
9. Dielectric Connections: Provide dielectric connections where nonferrous metal is joined to ferrous metal as follows:
 - a. Piping Two (2) Inch and Smaller: Provide Schedule 40 unlined type 316 stainless steel nipples, four (4) inches long with thread ends.
 - b. Piping Two and One Half (2-1/2) Inch and Larger: Provide Type 'E' Full Flanged Isolation Gasket Kits with Dielectric Insulators for the pipe flanges. End connections to match piping systems.
 - 1) Pressure Ratings:
 - a) Hydronic Pressure Rating: 125 psig minimum at 180°F.
 - b) Steam Pressure Rating: 150 psig minimum at 225°F.
 - 2) Gasket: Neoprene or phenolic.
 - 3) Bolt Sleeves: Phenolic or polyethylene.
 - 4) Washers: Phenolic with steel backing washers.

2.6 FLOW METER STATIONS

A. Flow Metering Stations:

1. General: Provide Flow Metering Stations (FMS) and accessories, for balancing all Hydronic Systems where indicated on the drawings, Details, Diagrams, etc. Flow Metering Stations shall be either, the Venturi Type, Pitot Tube Type or a combination of both types as specified hereinafter. Each Metering Station shall be fully assembled and include a Polycarbonate Tag. Each tag shall include the Manufacturers Model Number, Serial Number and 'CV' Flow Rate. Include the manufacturer's pressure differential tables with indicated selections for each FMS. Select each FMS so the design flow rate is within a pressure differential range of ten (10) inch wg through one hundred ten (110) inches wg.
2. Piping Systems One Half (1/2) Inch Through Two (2) Inch: For connections to reheat coils, chilled beam units, fan coil units, and cabinet type heaters provide Venturi Type Flow Meter Stations and accessories as indicated. All components shall be by the same manufacturer with thread end connections by one (1) of the following:
 - a. Venturi/ Ball Valve: Venturi/Ball Valve Type Flow Meter Stations shall be of Brass Construction, with Female Threaded End Connections, one quarter (1/4) inch P & T Connections with Quick Connects, Integral Brass Full Port Ball Valve with Stainless Steel Ball and Stem, Memory Stop, Integral Union with 'O' Ring Seal on Inlet side, Teflon Seals, conforming to ASTM B283-06.B.
 - b. Strainer/Ball Valve: Strainer/Ball Valve shall be a one assembly with a strainer having a removable stainless steel strainer and hose end drain valve with a chain and cap, the ball valve shall be a full port valve with stainless steel ball and stem. Also include a brass P/T Port with a cap and chain.

- c. Union/PT Assembly: Union/PT assembly shall be forged brass with a P/T Port with a cap and chain.
 - d. Flexible Hose Assembly: Not permitted at UMB.
 - e. Basis of Design: The basis of design are products by NuTech Hydronic Specialties as follows:
 - 1) NuTech Hydronic Specialties:
 - a) Venturi/ Ball Valve: Model MB
 - b) Strainer/Ball Valve: Model SV
 - c) Union/PT Assembly: Model UB
 - f. Other Acceptable Manufactures: Subject to compliance products by one (1) of the following manufacturers are also acceptable:
 - 1) Flow Design Inc.:
 - a) Venturi/ Ball Valve: Model US-SBS
 - b) Strainer/Ball Valve: Model YC - SBS
 - c) Union/PT Assembly: Model UP w/ SS2511 P/T Port
 - 2) Griswold Quickset:
 - a) Venturi/ Ball Valve: Model QS0 through QS3
 - b) Strainer/Ball Valve: Model Isolator 'S'
 - c) Union/PT Assembly: Model Isolation Union w/ CPTA
 - 3) HCI Hydronic Components:
 - a) Venturi/ Ball Valve: Model Terminator B SS
 - b) Strainer/Ball Valve: Model Terminator Y SS
 - c) Union/PT Assembly: Model Terminator U
 - 4) PRO Hydronic Specialties L.L.C.:
 - a) Venturi/ Ball Valve: Model CBV050L & H through CBV 070L & H, and CBV 100 through CBV200
 - b) Strainer/Ball Valve: Model CBYU
 - c) Union/PT Assembly: Model AU
3. Flanged Piping Systems two and one-half (2-1/2) inch through twelve (12) inch: Venturi Type Flow Meter Stations shall be of Carbon Steel Construction with 150# Flanged Connections, one quarter (1/4) inch S/S P & T Connections with Quick Connects, Integral Cast Iron Full Port Lug Type Butterfly Valve with ten (10) Position Memory Stop Plate, PTFE Seats and Seals Teflon Seals. Each Metering Station shall be fully assembled and include a Polycarbonate Tag. Each tag shall include the Manufacturers Model Number, Serial Number and 'CV' Flow Rate. Flanged Flow Metering Stations shall be as follows: ~~Delete if not Required~~
- a. PRO Hydronic Specialties L.L.C. Models CBVF250H/L through CBVF400H/L and CBVF500 through CBVF 1200H.
 - b. Griswold Quickset Models 3QFM through 3QFU.
 - c. Preso CV Series, Models CVF – 250 through CVF – 600 and CVF - 800 through CVF - 1200.
 - d. Preso Type B-Plus, Models B+50N through B+200N.
4. Grooved Piping Systems two and one-half (2-1/2) inch through twelve (12) inch: Venturi Type Flow Meter Stations shall be of Carbon Steel Construction, with

- Groove End Connections, and one quarter (1/4) inch S/S P & T Connections with Quick Connects. Each Metering Station shall be fully assembled and include a Polycarbonate Tag. Each tag shall include the Manufacturers Model Number, Serial Number and ‘CV’ Flow Rate. Contractor must provide a Balancing Valve for each FMS, see Valve Specifications. Flow Metering Stations shall be as follows: **<Delete if not Required>**
- a. PRO Hydronic Specialties L.L.C. Models SGV250H/L through SGV400H/L and SGV500 through SGV1200.
 - b. Griswold Quickset Models 3QGM through 3QGU.
 - c. Preso Type B-Plus, Models B+50N through B+200N.
5. Welded Piping Systems two and one-half (2-1/2) inch through twelve (12) inch: Venturi Type Flow Meter Stations shall be of Carbon Steel Construction, with Weld End Connections, and one quarter (1/4) inch S/S P & T Connections with Quick Connects. Each Metering Station shall be fully assembled and include a Polycarbonate Tag. Each tag shall include the Manufacturers Model Number, Serial Number and ‘CV’ Flow Rate. Contractor must provide a Balancing Valve for each FMS, see Valve Specifications. Weld End Flow Metering Stations shall be as follows: **<Delete if not Required>**
- a. PRO Hydronic Specialties L.L.C. Models SWV250H/L through SWV400H/L and SWV500 through SWV1200.
 - b. Griswold Quickset Models 3QWM through 3QWU.
 - c. Preso CV Series, Models CVW – 250 through CVW – 600 and CVW - 800 through CVW - 1200.
6. Flanged, Grooved and/or Welded Piping Systems twelve (12) inch through twenty four (24) inch: **<Delete if not Required>**
- a. Preso Type BIN Round Model PBIN Pitot Tube Flow Meter with 316 S/S Probe, “Y” Type Brass Head, one quarter (1/4) inch SAE Brass Ball Type Instrument Valves, 3,000 lb. CS Thread-O-Let for pipe mounting and Maximum Temperature/Pressure Rating of 250°F/400 PSIG and be capable of Bi – directional Flow Measurement.
 - b. Dwyer Series DS-400 Averaging Flow Sensor with 0.75 inch diameter S/S Sensing Tube, quick acting ball valves, S/S nameplate size and model information, and A-160 three eights (3/8) inch NPT forged steel 3000 psi Thred-o-let.
7. All Piping Systems two and one-half (2-1/2) inch through ten (10) inch (Contractor Option): **<Delete if not Required>**
- a. Dwyer Series DS-300 Flow Sensor with 0.75 inch diameter S/S Sensing Tube, quick acting ball valves, S/S nameplate size and model information, A-160 three eights (3/8) inch NPT forged steel 3,000 psi Thred-o-let, A-161 Brass Bushing and flared adapters.

2.7 STEAM TRAPS

A. Steam Traps:

1. Float and Thermostatic Steam traps shall be Armstrong series 'A' traps with stainless steel lever, float valve, & seat, integral vacuum breaker, 175 PSI maximum working pressure, class 30 cast iron body non-asbestos gaskets & sized with a safety factor of 3:1.
2. Inverted bucket trap, steam traps shall be Armstrong series '800' with stainless steel valve, retainer, lever, guide pin assembly, and bucket etc., non-asbestos gaskets, and a class 30 cast iron body. Size the steam traps with a safety factor of 3:1.

2.8 HVAC HYDRONIC, STEAM AND CONDENSATE VALVES

- A. Shut Off, Drain and Specialty Valves: All Shut Off, Drain and Specialty Valves installed in HVAC Hydronic and Steam Piping Systems shall be as specified below. Gate Vales will not be permitted for installation in these systems. All valves used in hydronic systems shall be Lead Free Certified per NSF/ANSI 61 and NSF/ANSI 372. Only listed manufacturers and model numbers below are acceptable to UMB. **<Edit paragraphs 1 – 5 for project requirements>**

1. Shut Off Valves for Hydronic Solder Joint Piping Systems:
 - a. Shut Off Valves for Piping Systems One Half (1/2) Inch through Two (2) Inch: All valves used for shutoff duty shall be two (2) piece full port (FP) lead free ball valves with brass or bronze valve body with threaded end connections, solid tunnel bore 316 stainless steel ball and stem, RPTFE seats and seals, and valve lever type handle. Valve model numbers shall be as listed below:
 - 1) Apollo: 77FLF-140* Series, Brass Body.
 - 2) Milwaukee: UPBA400S* Series, Bronze Body.
 - 3) Watts: LFB6080G2-SS*, Brass Body.
 - b. Contractor Note: Branch piping and associated shut off valves for terminal unit reheat coils shall not be less than three quarter (3/4) piping.
 - c. *Provide stem extensions on valves where pipe insulation affects the operation of the valve handle.
2. Shut Off Valves for Hydronic ProPress (Press End) Piping Systems: (Contractor Option)
 - a. Shut Off Valves for Piping Systems One Half (1/2) Inch to Two (2) Inch All valves used for shutoff duty shall be two (2) piece full port lead free ball valves with brass or bronze valve body with smart end connections, solid tunnel bore 316 stainless steel ball and stem, EPDM or PTFE seats and seals, and valve lever type handle Valve model numbers shall be as listed below:
 - 1) Viega: 2971.3ZL, Bronze Body*
 - 2) Apolloxpress 77WLF-140*, Bronze Body
 - 3) Milwaukee: UPBA480S*, Brass Body
 - b. *Provide stem extensions on valves where pipe insulation affects the operation of the valve handle.
 - c. Shut Off Valves for Piping Systems Two and One Half (2-1/2) inch to Four (4) Inch: All butterfly valves in hydronic piping systems used for shut-off duty shall be bi-directional dead end service general purpose butterfly valves

- with a lugged ductile iron valve body with full threaded lug connections, Nylon – 11 coated ductile iron disk, 416 stainless steel stem, EPDM double seal seats and seals, for gear operator, hand wheel or chain operation. All valves shall be ANSI Class 150, MSS-SP68 face to face dimension. Valve model numbers shall be as listed below:
- 1) Bray/McCannalok - Series 31H with Trim 390*
 - 2) Milwaukee – HL Series*
- d. *Chain Operation: Provide chain operators in place of valve handles for shut off valves installed in piping systems ten (10) feet or higher above the finished floor of Mechanical Equipment Rooms. <Delete if not Required >
- e. *Extensions: Where necessary provide an extension for the wheel handle output shaft for the hand wheel to clear pipe insulation.
- Balancing Valves: Where valves on details are indicated to be used as balancing valves on details provide a memory stop for this valve duty.
3. Shut Off Valves for Hydronic Welded, and Victaulic Piping Systems: (Contractor Option - Victaulic)
- a. Shut Off Valves for Piping Systems Two and One Half (2-1/2) inch and Larger: All butterfly valves in hydronic piping systems used for shut-off duty shall be bi-directional dead end service general purpose butterfly valves with a lugged ductile iron valve body with full threaded lug connections, Nylon – 11 coated ductile iron disk, 416 stainless steel stem, EPDM double seal seats and seals, for gear operator, hand wheel or chain operation. All valves shall be ANSI Class 150, MSS-SP68 face to face dimension. Valve model numbers shall be as listed below:
 - 1) Bray/McCannalok - Series 31H with Trim 390*
 - 2) Milwaukee – HL Series*
 - b. *Chain Operation: Provide chain operators in place of valve handles for shut off valves installed in piping systems ten (10) feet or higher above the finished floor of Mechanical Equipment Rooms. <Delete if not Required >
 - c. *Extensions: where necessary provide shaft extensions to allow mounting of the valve operator outside of pipe insulation. <Delete if not Required >
 - d. Balancing Valves: Where valves on details are indicated to be used as balancing valves on details provide a memory stop for this valve duty.
4. Drain and Specialty Valves for Hydronic Piping Systems:
- a. Drain Valves for Piping Systems One Half (1/2) Inch to Two (2) Inch: All valves used as low point drains or for system drain down duty shall be three quarter (3/4) inch two (2) piece full port (FP) lead free ball valves with brass or bronze valve body with threaded end connections, solid tunnel bore 316 stainless steel ball and stem, RPTFE seats and seals, and valve lever type handle and three quarter (3/4) inch capped hosed connection. Valve model numbers shall be as listed below:
 - 1) Apollo: 77FLF-140* Series, Brass Body.
 - 2) Milwaukee: UPBA400S* Series, Bronze Body.
 - 3) Watts: LFB6080G2-SS*, Brass Body.

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- b. Drain Valves for Piping Systems two and One Half (2-1/2) Inch and Larger: All valves used as low point drains or for system drain down duty shall be two (2) inch two (2) piece full port (FP) lead free ball valves with brass or bronze valve body with threaded end connections, solid tunnel bore 316 stainless steel ball and stem, RPTFE seats and seals, and valve lever type handle and two and one half (2-1/2) inch capped hosed connection. Valve model numbers shall be as listed below:
- 1) Apollo: 77FLF-140* Series, Brass Body.
 - 2) Milwaukee: UPBA400S* Series, Bronze Body.
 - 3) Watts: LFB6080G2-SS*, Brass Body.
- c. Specialty Valves: All specialty valves used for Pressure Gages, P/T Plugs, and DP Switches shall be one quarter (1/4) inch two (2) piece full port (FP) lead free ball valves with brass or bronze valve body with threaded end connections, solid tunnel bore 316 stainless steel ball and stem, RPTFE seats and seals, and valve lever type handle. Valve model numbers shall be as listed below:
- 1) Apollo: 77FLF-140* Series, Brass Body.
 - 2) Milwaukee: UPBA400S* Series, Bronze Body.
 - 3) Watts: LFB6080G2-SS*, Brass Body.
5. Shut Off Valves for Steam and Condensate Threaded and Welded Piping Systems:
- a. Shut Off Valves for Piping Systems One Half (1/2) Inch to Two (2) Inch: All ball valves in steam and condensate piping systems used for shut-off duty shall be provided with carbon steel valve body with threaded end connections, solid tunnel bore 316 stainless steel vented ball and stem, RPTFE seats and seals, and valve lever type handle and valve handle. Valve model numbers shall be as listed below:
- 1) Apollo - 73-140-64*
 - 2) Watts - 7000-04-SS-XH*
 - 3) Milwaukee - 20CSOR-03-XH*
- b. *Provide stem extensions on valves where pipe insulation affects the operation of the valve handle.
- c. Shut Off Valves for Piping Systems Two and One Half (2-1/2) Inch through Four (4) Inch: All butterfly valves in steam and condensate piping systems used for shut-off duty shall be bi-directional dead end service high performance butterfly valves with a lugged carbon steel valve body with full threaded lug connections, 316 stainless steel disk, 7-14 PH stainless steel stem, RPTFE double seal seats and seals, for gear operator, hand wheel or chain operation. All valves shall be ANSI Class 150, MSS-SP68 face to face dimension. Valve model numbers shall be as listed below:
- 1) Bray /McCannalok - Series 41 with Trim 466*
 - 2) Milwaukee – HL Series*
- d. *Chain Operation: Provide chain operators in place of valve handles for valves installed in piping systems ten (10) feet or higher above the finished floor of Mechanical Equipment Rooms. <Delete if not required >

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- e. *Extensions: where necessary provide shaft extensions to allow mounting of the valve operator outside of pipe insulation. <Delete if not required >
 - 6. BAS Control Valves for HVAC Piping Systems: <Delete if not required >
 - a. Control Valves for HVAC Piping Systems Two and One Half (2-1/2) and Larger: All butterfly valves in hydronic piping systems used for control duty shall be bi-directional dead end service general purpose resilient seated butterfly valves with a lugged ductile iron valve body with full threaded lug connections, Nylon – 11 coated ductile iron disk, 416 stainless steel stem, EPDM double seal seats and seals and for actuation type operation. All valves shall be MSS-SP67 face to face dimension. Valve model numbers shall be as listed below:
 - 1) Bray - Series 3L with Trim 390* (Basis of Design & UMB Preferred)
 - 2) Milwaukee – HL Series*
 - b. *Extensions: where necessary provide shaft extensions to allow mounting of the valve operator outside of pipe insulation.
 - c. These valves shall be provided by the BAS contractor and installed in the piping systems by the mechanical contractor including isolation valves. All required connections to the BAS shall be by the BAS contractor.
 - B. Check Valves: Hydronic and Steam/Condensate Service: <Edit paragraphs 1 – 3 for project requirements>
 - 1. Swing Check Valves, two and one half (2-1/2) inches (DN65) and Smaller: MSS SP-80; Class 125, 200-psi (1380-kPa) CWP, or Class 150, 300-psi (2070-kPa) CWP; horizontal swing, Y-pattern, ASTM B 62 cast-bronze body and cap, rotating bronze disc with rubber seat or composition seat, threaded connections for 60 psig steam condensate service and hydronic service.
 - 2. Swing Check Valves, three (3) inches DN80) and Larger: MSS SP-71, Class 125, 200-psi (1380-kPa) CWP, ASTM A 126 cast-iron body and bolted cap, horizontal-swing bronze disc, flanged or grooved end connections.
 - 3. Lift Check Valves: Class 125, ASTM B 62 bronze body and cap (main components), horizontal or vertical pattern, lift-type, bronze disc or Buna N rubber disc with stainless-steel holder threaded or soldered end connections.
- 2.9 HANGERS & SUPPORTS
- A. General: Provide all supports, identification, and testing for all piping systems indicated on the drawings, details and as specified below.
 - B. Interior Pipe System Hangers & Supports:
 - 1. Hangers and supports shall be provided for all piping systems, as recommended by the hanger manufacturers for the existing structural elements. On piping systems requiring insulation, hangers and supports shall be installed external to the insulation material, and sheet metal saddles shall be provided. Hangers and supports shall be provided at all changes of direction and elevations on piping

- system. Spacing shall be as recommended by manufacturer, for each pipe size and material.
2. Hangers, Supports, and Components: Provide factory fabricated products according to MSS SP-58 as manufactured by B-Line, Fee and Mason, ITT Grinnell, Pipe Shields, Inc., Michigan Hanger, and Unistrut. Unless otherwise indicated, specified model numbers are manufactured by B-Line.
 3. Components include galvanized coatings were installed for piping and equipment that will not have a field-applied finish.
 4. Pipe attachments include nonmetallic coating for electrolytic protection where attachments are in direct contact with copper tubing.
 5. Thermal Hanger Shield Inserts: 100-psi (690kPa) average compressive strength, waterproofed calcium silicate or treated lumber inserts, encased with sheet metal shield. Insert and shield cover entire circumference of pipe and are of length indicated by manufacturer for pipe size and thickness of insulation.
 6. Insulated Horizontal Piping Hangers: Chilled Water, Condenser Water, Steam and Condensate Return, Reheat Water, Glycol Solution, Heating Hot Water:
 - a. Two (2) inch and smaller: Figure No. B3108, with metal shield, Figure No. B3151.
 - b. Two and one-half (2-1/2) inch and larger: Figure No. B3108, with metal shield, Figure No. B3151.
 7. Vertical Piping Riser Clamps:
 - a. Copper Pipe: Figure No. B3373CT.
 - b. Steel Pipe: Figure No. B3136 and B3137.

2.10 IDENTIFICATION SYSTEM

- A. General Requirements: Do not use pipe labels or plastic tapes for bare pipes conveying fluids at temperatures of 125°F (52°C) or higher.
- B. Identification Products for Mechanical Systems: Identification products for Mechanical Systems shall include pipe markers, duct markers, valve tags and ceiling markers conforming to ANSI/ASME A 13.1 OSHA requirements for letter/color combinations and as follows:
 1. Pipe Labels: Provide pretensioned, preformed semi-rigid vinyl or plastic pipe labels with flow arrows to partially cover or cover full circumference of pipe and to attach to pipe without adhesive. Pipe labels shall be SETMARK System as manufactured by Seton Name Plate Corporation or approved equal.
 - a. Label Material: Comply with the following:
 - 1) Vinyl Formed Labels:
 - a) External diameters up to two (2) inches – 20 mil vinyl.
 - b) External diameters up to two and one half (2-1/2) inches – 30 mil vinyl.
 - 2) Plastic Formed Labels: per manufacturer's recommendations.
 - b. Label Contents: HVAC: Text with Field/Letter color as noted below: **<Edit for Project>**

- 1) “HEATINGWATERSUPPLY” – Yellow/Black
 - 2) “HEATING RETURN” – Yellow/Black
 - 3) “PROCESS COOLING WATER SUPPLY” – Yellow/Black
 - 4) “PROCESS COLING WATER RETURN” – Yellow/Black
 - 5) “REFERIGERANT LIQUID” – Yellow/Black
 - 6) “REFERIGERANT SUCTION” – Yellow/Black
 - 7) “GLYCOL SUPPLY” – Yellow/Black
 - 8) “GLYCOL RETURN” – Yellow/Black
2. Duct Stencil Labels: Provide duct stencil labels with the following designations and letter color:
- a. Supply Air Duct: “Supply Air Duct – STU – #”
 - b. General Exhaust Air Duct: “General Exhaust Air Duct – ETU – #”
 - c. Fume Hood Exhaust Air Duct: “Fume Hood Exhaust Air Duct – FH – #”
 - d. Fume Hood General Exhaust Air Duct: “Fume Hood General Exhaust Air Duct – FH – #”
 - e. Main Supply Air Duct: “Main Supply Air Duct – AHU – #”
 - f. General Exhaust Air Duct: “General Exhaust Air Duct – GEF – #”
3. Valve Tags:
- a. Description: Stamped or engraved with one quarter (1/4) inch letters for piping system abbreviation and one half (1/2) inch numbers with:
 - 1) Brass Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2) Fasteners: Brass wire-link chain.
 - 3) Asterisk ((*): Indicates the valve is part of a renovation project in the building.
 - b. HVAC: Service – Tag Data:
 - 1) Hot Water Reheat Water Supply – *HWRHS
 - 2) Hot Water Reheat Return – *HWRHR
 - 3) Secondary Hot Water Reheat Water Supply – *SRHS
 - 4) Secondary Hot Water Reheat Return – *SRHR
 - 5) Secondary Process Cooling Water Supply – *SPCWS
 - 6) Secondary Process Cooling Water Return – *SPCWR
4. Ceiling Markers: Ceiling Grid and Access Panel Markers: Provide Kroy type clear adhesive printed labels with three sixteenth (3/16) inch high letters to identify the location of concealed valves and equipment. **<Edit for Project>**
- a. Ceiling Marker Data: For HVAC Systems include:
 - 1) System Valves: Identify as follows:
 - a) Hot Water Reheat Supply – “HVAC Valve – HWRS”
 - b) Hot Water Reheat Return – “HVAC Valve – HWRR”
 - c) Process Cooling Water Supply – “HVAC Valve – PCLWS”
 - d) Process Cooling Water Return – “HVAC Valve – PCLWR”
 - e) HVAC Low Point Drains – “HVAC LPD – *”
 - f) (* = System ID)
 - 2) System Equipment: Identify as follows:
 - a) Supply Terminal Unit HVAC – STU

- b) General Exhaust Terminal Unit HVAC – GETU
- c) Fume Hood Exhaust Terminal Unit HVAC – FHETU

2.11 EXTERIOR PIPE, DUCT AND EQUIPMENT SUPPORTS

- A. General: Provide exterior pipe, duct, and equipment supports where indicated on the construction documents and as specified and as manufactured by The Pate Company or approved equal.
- B. Pipe Curbs and Caps: Provide Pate PCA Series curbs and PCC Series cap and boot packages as follows:
 - 1. PCA Series Curbs: Curb assembly shall consist of heavy gauge galvanized steel roof curb, unitized construction, with an integral base plate, one and one half (1-1/2) inch insulation and two (2) inch by two (2) inch treated wood nailer. Unit shall be furnished with an acrylic clad thermoplastic cover, fastening screws, graduated step boots with stainless steel clamps. Assembly height shall be eighteen (18) inches from the roof deck to the top of the counterflashing cap. Provide built in cant strips where indicated.
 - 2. PCC Series Cap and Boot: Caps shall be molded from acrylic clad ABS (Acrylonitrile Butadiene Styrene) to provide UV protection, gray in color, lightweight, and extremely durable with a temperature range of -40°F to 160°F. Pipe boots shall be made from PVC to accommodate various pipe sized through a single curb assembly.

<Engineer shall review pipe curb loads with a structural engineer and the Pate Certified Load Bearing Date before finalizing the design and type of assemblies required for the project. Coordinate with the project Architect for proper installation details for roof type and flashing requirements and anchoring the bases to the roof deck>

- C. Duct Roof Curbs: Provide Pate PC Series curbs for duct penetrations through the roof as follows:
 - 1. PC Series Duct Roof Curbs: Duct roof curbs shall be constructed of eighteen (18) gauge galvanized steel with unitized, full mitered corners, with continuous welded seams, one and one half (1-1/2) inch thick rigid fiberglass insulation, pressure treated wood nailer and a cant strip. Assembly height shall be eighteen (18) inches from the roof deck to the top of the curb.

<Engineer shall review duct curb loads with a structural engineer and the Pate Certified Load Bearing Date before finalizing the design and type of assemblies required for the project. Coordinate with the project Architect for proper installation details for roof type and flashing requirements and anchoring the bases to the roof deck>

- D. Support Bases: Provide Pate ES Series support bases for pipes, ducts and equipment as follows:
 - 1. ES Series Support Bases: Support bases shall be constructed of eighteen (18) gauge galvanized steel with continuous welded seams, pressure treated wood nailer,

counterflashing with galvanized screws and internally reinforced to conform to the Pate load bearing factors. Assembly height shall be 18 inches from the roof deck to the top of the counterflashing cap.

<Engineer shall review pipe, duct and equipment loads with a structural engineer and the Pate Certified Load Bearing Date before finalizing the design and type of assemblies required for the project. Coordinate with the project Architect for proper installation details for roof type and flashing requirements and anchoring the bases to the roof deck>

2.12 HVAC EQUIPMENT – MISCELLANEOUS EQUIPMENT

- A. General: Unless otherwise indicated provide all HVAC miscellaneous equipment indicated on the drawings and as specified below, including all labor materials and equipment necessary for a complete installation.
1. Miscellaneous equipment includes steam to water shell and tube heat exchangers, and hydronic pumps.
- B. Shell and Tube Heat Exchangers:
1. Description: Packaged assembly of tank, heat exchanger coils, and specialties.
 2. Construction:
 - a. Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code, Section VIII, "Pressure Vessels," Division 01.
 - b. Fabricate and label shell and tube heat exchangers to comply with "TEMA Standards."
 3. Configuration: [U tube with removable] [Straight tube with removable] [Straight tube with fixed] bundle. <Edit for project.>
 4. Shell Materials: Steel.
 5. Head:
 - a. Materials: Fabricated steel.
 - b. Flanged and bolted to shell.
 6. Tube:
 - a. Seamless copper tubes.
 - b. Tube diameter is determined by manufacturer based on service.
 7. Tube Sheet Materials: Steel.
 8. Baffles: Steel.
 9. Piping Connections: Factory fabricated of materials compatible with heat exchanger shell. Attach tappings to shell before testing and labeling.
 - a. NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
 - b. NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless steel flanges and according to ASME B16.24 for copper and copper alloy flanges.
 10. Support Saddles:
 - a. Fabricated of material similar to shell.
 - b. Fabricate foot mount with provision for anchoring to support.

- c. Fabricate attachment of saddle supports to pressure vessel with reinforcement strong enough to resist heat exchanger movement during seismic event when heat exchanger saddles are anchored to building structure.

C. Hydronic Pumps: <Engineer Insert Pump Spec Below>

2.13 HVAC EQUIPMENT – AIR TERMINAL UNITS

A. General: Unless otherwise indicated provide all HVAC equipment indicated on the drawings and as specified below, including all labor materials and equipment necessary for a complete installation.

1. Terminal Unit Configurations: Terminal unit configurations shall be either RH or LH when facing the unit's inlet duct as indicated on the drawings and details.

A. HVAC Equipment – Supply, General Exhaust, and Fume Hood Exhaust Units – University Supplied and Contractor and Installed: <Delete if not required>

1. The University will make arrangements with the contracted supplier to have the required terminal units delivered to UMB. The University will also provide the contractor with approved submittals.

B. HVAC Equipment – Supply, General Exhaust, and Fume Hood Exhaust Terminal Units – Contractor Supplied and Installed: <If University supplied delete paragraph 'C'>

1. General Requirements: Supply and Exhaust Terminal Units: Terminal Units: Supply and exhaust air terminal units shall be, pressure independent type units, certified under ANSI/AHRI Standard 880 - 2011 Certification Program and carry the AHRI seal. Units shall be factory fabricated and tested. Selection shall be based on performance characteristics that match or exceed those indicated on the drawings. Air terminal units include units used for supply air, general exhaust air and fume hood exhaust air.

2. Supply Terminal Units:

- a. Basis of Design: The basis of design for supply terminal units shall be products manufactured by Titus, for single duct, dual, duct, or fan power unit applications, as indicated in the supply terminal unit model number schedule below.
- b. Other Acceptable Manufacturers: Subject to compliance with requirements, provide terminal units of one (1) of the following:
 - 1) Price Industries
 - 2) MetalAire
 - 3) Kruger
 - 4) Environ Tech
 - 5) Nailor
- c. Supply Terminal Unit Model Number Schedule:

Table 2 Supply Terminal Unit Model Number Schedule

Manufacturer	Single Duct CV/VV	Dual Duct CV/VV	Fan Powered (FP) CV	Fan Powered (FP) VV
Titus	DESV	DEDV	DTFS-F	DTQP
Price	SDVQ	DDUQ	FDCGQ	FDV
Metal Aire	TH-500	DH-500	FCI-600	FVI-500
Krueger	LMHS	LMHD	KQFS	QFS
Environ Tech	SDR	N/A	N/A	N/A
Nailor	D3001/D30RW	D3230	D35S	D35N

- d. Construction and Sound Ratings:
- 1) Terminal Casing: 22 gauge galvanized steel.
 - 2) Internal Lining: Internal lining shall be a non - porous engineered polymer foam insulation closed foam fiber free (FF) cell insulation, 0.75 inch thick with a ‘R’ value three (3), fiberglass insulation will not be acceptable. Thermal conductivity shall meet or exceed 0.25 BTU - Inch / Hr. ft² @ 75°F. Insulation shall retain zero (0) moisture providing no support for bacterial or fungal growth and shall comply with the following: NFPA 90A, UL181 (Air Erosion), UL181 (Mold Growth and Humidity), UL723 (25/50 Flame and Smoke), ASTM E84 (25/50 Flame and Smoke), and CAN/ULC – 102.2-M88 (Flame and Smoke). Insulation shall be listed by Factory Mutual Research for compliance with all Codes, and Standards previously listed.
 - 3) Discharge Connection: Galvanized steel slip and drive connections for square and/or rectangular ducts.
 - 4) Casing Leakage: The unit casing shall be constructed to allow no more than 4 CFM while performing at one (1.0) inch inlet static pressure.
 - 5) Damper: Heavy gauge steel with two (2) mechanical stops to prevent over stroking.
 - 6) Damper Shaft: Solid steel with self-lubricating high density polyethylene bearings. Shaft shall be plainly marked to indicate damper position.
 - 7) Damper Blade Seal: Full sheet synthetic to limit leakage to values specified in casing leakage data and no damper deflection.
 - 8) Actuator: Factory mounted to the damper shaft and capable of providing a minimum of 35 lbs. of torque to the damper shaft. Refer to Automatic Temperature Controls for additional requirements.
 - 9) Minimum Unit Static Pressure: The minimum static pressure required to operate each unit shall not exceed 0.13 inch wg for the basic unit with an inlet velocity of 2,000 fpm.
 - 10) Integral Sound Attenuator (Except FP Terminal Units): Slip and drive discharge connection with 22 gauge galvanized steel casing with perforated metal liner and polymer enclosed acoustic media. The

- geometry of the silencer shall be designed for use with the Air Terminal to avoid added pressure drop and generated noise. Silencer/Air Terminal assembly shall be tested and performance certified in accordance with ASHRAE 130-2008 and AHRI 880-2011.
- 11) Sound Ratings: Include sound rating documentation in the submittal for each unit size. The maximum scheduled noise criteria (NC Level) is for discharge and radiated sound and shall not be exceeded in any of the 2nd through 7th octave bands at the scheduled inlet static pressure (min 1.50 inches, unless otherwise noted). For computation of the terminal unit NC values do not include manufacturer's standard cataloged attenuation credits. Include attenuation credits based solely on the actual design arrangement with respect to the layouts for ductwork and air devices served by each terminal as well as the actual room construction. Using the raw sound data from the terminal unit only, add credits based on the actual design, where the NC values exceed the scheduled noise criteria provide sound attenuators to meet the scheduled NC values.
- e. Accessories:
- 1) Control Enclosure: Provide a factory mounted 22 gauge galvanized steel control enclosure with a removal cover to access the actuator, damper assembly and control components.
 - 2) Coil Access: Provide a gasketed removable panel to access the air flow inlet side of reheat coil. Locate the access panel, for the reheat coil on the bottom of the terminal casing. Access panel shall not leak in excess of the posted rating under the casing leakage requirements listed above.
 - 3) Removable Air Flow Sensor: The air flow sensor shall be of a cross configuration located at the inlet of the assembly. The sensor shall have multi-point pressure sensing ports and a center averaging chamber designed to accurately average the flow across the inlet of the assembly. Sensor shall provide accuracy within 5% with a 90° sheet metal elbow directly at the inlet of the assembly so that straight lengths of duct are not required. Air flow sensor shall be removable for inspection and cleaning without disconnecting the inlet duct and/or the terminal unit as follows:
 - a) Titus Units: Sensor shall be removable from the bottom of the inlet connection regardless of unit's configuration.
 - b) Price Units: Sensor shall be removable from the side of the inlet connection depending on the unit's configuration.
 - c) Metal Aire Units: Sensor shall be removable from the side of the inlet connection depending on the unit's configuration.
 - d) Krueger Units: Sensor shall be removable from the side of the inlet connection depending on the unit's configuration.
 - e) Environ Tech Units: Sensor shall be removable from the side of the inlet connection depending on the unit's configuration.

- f) Nailor Units: Sensor shall be removable from the side of the inlet connection depending on the unit’s configuration.
- 4) Induced Return Air Filter (Fan Powered Box Only): Not Required.
- f. Hot Water Heating Coils:
 - 1) Casing: 20 gauge galvanized steel, factory mounted on terminal unit.
 - 2) Fins: Rippled and corrugated heavy gauge aluminum mechanically bonded to the tubes.
 - 3) Tubes: Tubes shall be constructed with a 0.016 wall thickness with male header and solder ends.
 - 4) Connections: Flanged or slip and drive.
 - 5) Testing: Leak test to 300 psi with minimum burst pressure of 2,000 psi.
 - 6) Performance: Meet scheduled capacity in accordance with ARI Standard 410.
 - 7) Rows: All coils shall be two (2) row, multi circuited coils.
- g. Control Components:
 - 1) All control components shall be furnished, and field installed by the BAS contractor, unless otherwise directed by UMB.
- 3. General Exhaust Terminal Units:
 - a. Basis of Design: The basis of design for exhaust terminal units shall be products manufactured by Titus for round duct and square/rectangular duct applications as indicated in the exhaust unit model number schedule below.
 - b. Other Acceptable Manufacturers: Subject to compliance with requirements, provide exhaust terminal units of one (1) of the following manufactures. See exhaust terminal unit model number schedule below for manufacturers model numbers.
 - 1) Price Industries
 - 2) Metal Aire
 - 3) Krueger
 - 4) Environ Tech
 - 5) Nailor
 - c. Exhaust Terminal Unit Model Number Schedule:

Table 3 Exhaust Terminal Unit Model Number Schedule

Manufacturer	Exhaust Unit Round CV/VV	Exhaust Unit Square CV/VV	Exhaust Unit Stainless Steel CV
Titus	DECV	DEXV	DECV- 316 SS
Price	RDVQ	SDEQ	LDVQ
Metal Aire	RT-500-EX	SR-502-EX	RT-500-SS
Krueger	RVE	LMHS	RVE-6
Environ Tech	SGX	N/A	N/A
Nailor	D36VRR	30X	D36VRR-S/S

<Engineer Note: For Exhaust Terminal Units serving more than one room consult with UMB Engineering Staff>

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- d. Construction and Sound Ratings:
- 1) Terminal Casing: DECV – 22 gauge galvanized steel with a minimum of three (3) concentric rolled beads to ensure units are round. DEXV – 22 gauge galvanized steel mechanically sealed and gasketed leak resistant casing.
 - 2) Duct Connections: Straight tube design for round ducts. Slip and drive connections for square/rectangular ducts.
 - 3) Casing Leakage: The casing leakage shall be equal to or less than 2% at three (3) inches wg during full airflow CCW to close.
 - 4) Damper: Heavy gauge steel with two metal stops to prevent over-stroking.
 - 5) Damper Shaft: Solid steel with self-lubricating polyethylene bearings. Shaft shall be plainly marked to indicate damper position.
 - 6) Damper Blade Seal: Full synthetic sheet to limit leakage to values specified in casing leakage data.
 - 7) Actuator: Factory mounted to the damper shaft and capable of providing a minimum of 35 lbs. of torque to the damper shaft. Refer to Automatic Temperature Controls for additional requirements.
 - 8) Minimum Unit Static Pressure: The minimum static pressure required to operate each unit shall not exceed 0.32 inch wg for the basic unit with an outlet velocity of 2,000 fpm.
- e. Sound Attenuator: Slip and drive discharge connection with 22 gauge galvanized steel casing with perforated metal liner and polymer enclosed acoustic media. The geometry of the silencer shall be designed for use with the Air Terminal to avoid added pressure drop and generated noise. Silencer/Air Terminal assembly shall be tested, and performance certified in accordance with ASHRAE 130-2008 and AHRI 880-2011. Provide sound attenuators as follows:
- 1) Round Exhaust Terminals: Non – integral sound attenuator for mounting in rectangular or square ducts.
 - 2) Square Exhaust Terminals: Integral sound attenuator.
 - 3) Sound Ratings: Include sound rating documentation in the submittal for each unit size. The maximum scheduled noise criteria (NC Level) are for discharge and radiated sound and shall not be exceeded in any of the 2nd through 7th octave bands at the scheduled inlet static pressure (min 1.50 inches, unless otherwise noted). For computation of the terminal unit NC values do not include manufacturer’s standard cataloged attenuation credits. Include attenuation credits based solely on the actual design arrangement with respect to the layouts for ductwork and air devices served by each terminal as well as the actual room construction. Using the raw sound data from the terminal unit only, add credits based on the actual design, where the NC values exceed the scheduled noise criteria provide sound attenuators to meet the scheduled NC values.

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- f. Accessories:
- 1) Control Enclosure: Provide a factory mounted 22 gage galvanized steel control enclosure with a removal cover to access the actuator, damper assembly and control components.
 - 2) Removable Air Flow Sensor: The air flow sensor shall be of a cross configuration located at the inlet of the assembly. The sensor shall have multi-point pressure sensing ports and a center averaging chamber designed to accurately average the flow across the inlet of the assembly. Sensor shall provide accuracy within 5% with a 90° sheet metal elbow directly at the inlet of the assembly so that straight lengths of duct are not required. Air flow sensor shall be removable for inspection and cleaning without disconnecting the inlet duct and/or the terminal unit as follows:
 - a) Titus Units: Sensor shall be removable from the bottom of the inlet connection regardless of unit's configuration.
 - b) Price Units: Sensor shall be removable from the side of the inlet connection depending on the unit's configuration.
 - c) Metal Aire Units: Sensor shall be removable from the side of the inlet connection depending on the unit's configuration.
 - d) Krueger Units; Sensor shall be removable from the side of the inlet connection depending on the unit's configuration.
 - e) Enviro Tech Units: Sensor shall be removable from the side of the inlet connection depending on the unit's configuration.
 - f) Nailor Units: Sensor shall be removable from the side of the inlet connection depending on the unit's configuration.
- g. Control Components:
- 1) All control components shall be furnished, and field installed by the BAS contractor, unless otherwise directed by UMB.
4. Fume Hood Exhaust Terminal Units:
- a. Construction and Sound Ratings:
 - 1) Terminal Casing: DECV – Type 316 stainless steel with a minimum of three (3) concentric rolled beads to ensure units are round.
 - 2) Duct Connections: Straight stainless steel tube design for round ducts.
 - 3) Casing Leakage: The casing leakage shall be equal to or less than 1% for welded stainless casing.
 - 4) Damper: Heavy gauge stainless steel with two (2) mechanical stops to prevent over stroking.
 - 5) Damper Shaft: Damper shaft shall solid 316 stainless steel construction with self-lubricating Teflon bearings. Shaft shall be plainly marked to indicate damper position.
 - 6) Damper Blade Seal: Seal material is also Teflon to limit leakage to values at zero and as specified in casing leakage data.
 - 7) Actuator: Factory mounted to the damper shaft and capable of providing a minimum of 35 lbs. of torque to the damper shaft. Refer to Automatic Temperature Controls for additional requirements.

- 8) Minimum Unit Static Pressure: The minimum static pressure required to operate each unit shall not exceed 0.13 inch wg for the basic unit with an outlet velocity of 2,000 fpm.
- b. Accessories:
 - 1) Control Enclosure: Provide a factory mounted 22 gage galvanized steel control enclosure with a removal cover to access the actuator, damper assembly and control components. Where the panel is attached to the terminal provide neoprene gaskets to separate galvanized material from stainless steel material.
 - 2) Removable Air Flow Sensor: The air flow sensor shall be a cross pattern type flow sensor constructed with type 316 stainless steel. Air flow sensor shall be removable for inspection and cleaning without disconnecting the inlet duct and/or the terminal unit as follows:
 - a) Titus Units: Sensor shall be removable from the bottom of the inlet connection regardless of unit's configuration.
 - b) Price Units: Sensor shall be removable from the side of the inlet connection depending on the unit's configuration.
 - c) Metal Aire Units: Sensor shall be removable from the side of the inlet connection depending on the unit's configuration.
 - d) Krueger Units: Sensor shall be removable from the side of the inlet connection depending on the unit's configuration.
 - e) Enviro Tech Units: N/A
 - f) Nailor Units: Sensor shall be removable from the side of the inlet connection depending on the unit's configuration.
 - 3) Control Components:
 - a) All control components shall be furnished, and field installed by the BAS contractor, unless otherwise directed by UMB.

2.14 HVAC EQUIPMENT – DX WATER COOLED A/C UNITS

A. HVAC Equipment – Supplemental A/C Units:

<Engineer to coordinate requirements with UMB and edit for project requirements>

1. Ceiling Mounted DX Water Cooled A/C Unit:
 - a. General: Furnish and install Model AWC ceiling mounted packaged water cooled A/C Units as manufactured by Above Air Technologies or approved equal Ceilair Model OHS as manufactured by Stultz Air Technology. Units shall be provided with factory furnished and installed microprocessor controls. Additionally, the unit shall be furnished with software communications interface capability for connectivity to the external Building Automation System through Bac Net IP Protocol connection for monitoring and control and comply with the points list in this specification. See the drawings for unit location and capacity.
 - b. Unit Configuration: Unit configuration shall be as follows:

<Edit for Project Requirements>

- 1) Ductless Configuration: Unit shall be designed for installation in a standard two (2) foot by four (4) foot ceiling grid with bottom supply grille and return filter grille. <Delete if not Required>
 - 2) Ducted Configuration: Unit shall be provided with one (1) inch flanged duct connections for supply and return ductwork. <Delete if not Required>
- c. Unit Construction:
- 1) Unit Casing: Unit casings shall be constructed with 0.062 inch aluminum panels and supported by internal three sixteenths (3/16) inch aluminum frames. Casing shall be lined with one half (1/2) inch thick, two (2) pound per cubic foot density insulation protected from erosion. The internal condensate drain pan shall be constructed of 20 gauge stainless steel with drain connection on the same end as the pipe connections for the water cooled condenser. Provide removable access panels for access to fans, filters, coils, compressors and refrigeration components.
 - 2) Fan Type (1-10 Tons): Fan type shall be as follows:

<Edit for Project Requirements>

- a) Non Ducted Units (1-3 Tons): Supply fan/motor shall be a standard ECM direct drive assembly with a double inlet, dynamically balanced fan with backward inclined blades, and motor. Fan and motor shall be mounted on vibration isolators. Fan and motor assemblies that are rigid mounted to the cabinet are acceptable provided the unit is provided with external isolation. Fans with forward curved blades and motor are acceptable. <Delete if not Required>
 - b) Ducted Units - High Static (1-10 Tons): Supply fan/motor shall be an ECM direct drive high efficient assembly with double inlet, dynamically balanced fan with backward inclined blades, and motor. Fan and motor shall be mounted on vibration isolators. Fan and motor assemblies that are rigid mounted to the cabinet are acceptable provided the unit is provided with external isolation. See unit schedule on drawings for external static pressure requirements. Fans with forward curved blades and motor are acceptable. <Delete if not Required> <Engineer Note: “High Static” means an ESP @ 0.30” and above + Unit PD>
- 3) Evaporator System: Evaporator system shall be configured for a draw through air pattern to provide uniform air distribution over the evaporator coil face. Coils shall be constructed of seamless drawn copper tubes, mechanically bonded to tempered aluminum fins with a raised lanced fin design for maximum heat transfer. Coil end plates

shall be hot dipped galvanized steel. The evaporator coil shall be mounted in a stainless steel condensate drain pan.

- 4) Filters: Filters shall be as follows:

<Edit for Project Requirements>

- a) Filter - Ductless Configuration: Filter shall be a drop out one (1) inch deep class 2 filter per U.L. Standard 900 and shall also have a rating of at least 80% average arrestance as measured by ASHRAE Standard 52-76 test method. Filter shall be easily accessed through the hinged return grille. <Delete if not Required>
 - b) Filter - Ducted Configuration: Filter shall be a one (1) inch deep class 2 filter per U.L. Standard 900 and shall also have a rating of at least 80% average arrestance as measured by ASHRAE Standard 52-76 test method. Filter shall be mounted inside the unit, in a filter rack, in front of the evaporator coil and shall be accessible through an access door in the side of the unit. <Delete if not Required>
- 5) Refrigeration System: The refrigeration system shall include dual compressors, mounted on vibration isolators, type 'L' copper refrigeration tubing with brazed fittings, sight glass, externally equalized expansion valve, and liquid line filter dryer. The refrigeration system shall be pre charged with HCFC – 407-C refrigerant. The water cooled condenser shall be a tube in tube counter flow condenser rated for 150 psi.
- 6) Adjustable Water Regulating Valve: Adjustable water regulating valve by manufacturer to maintain head pressure with process cooling water conditions of 70°F EWT/ 90°F LWT. Include GPM and unit pressure drop in feet in the submittal data.
- 7) Control Panel: Unit mounted pre-wired control panel shall include contactors, relays, control transformer, capacitors, high and low refrigerant pressure switches, compressor and fan automatic reset safety devices for a complete control system.
- 8) Unit Power Supply: Single Source power supply shall be as follows:

<Edit for Project Requirements>

- a) One (1) and One and One Half (1-1/2) Ton Units: 208/277 volt single phase. <Delete if not Required>
 - b) Two (2) and Three (3) Ton Units: 208/277 volt single phase. 208/460 volt three phase. <Delete if not Required>
 - c) Four (4) Tons and Larger: 208/460 volt three phase. <Delete if not Required>
- 9) Provide a [Stultz E2] [Above Air Technologies MC 2000 Advanced] Microprocessor, for each water cooled A/C unit, with a Bac Net IP serial card. Inputs and outputs shall be remotely monitored (address

- readable) through the BAS. At a minimum, the following I/O addressable points shall be included: <Edit for Project Requirements>
- a) Unit on/off
 - b) Compressor running Module1
 - c) Fan running Module1
 - d) Compressor low pressure alarm Module1
 - e) Compressor high pressure alarm Module1
 - f) Air flow alarm Module1
 - g) Water detector alarm Module1 (condensate pan)
 - h) Room temperature to high alarm
 - i) Room temperature to low alarm
 - j) Supply temperature to high alarm
 - k) Supply temperature to low alarm
 - l) Water temperature to high alarm (Process Cooling Water)
 - m) Water temperature to low alarm (Process Cooling Water)
 - n) Set point temperature
 - o) Set point supply air temperature
 - p) Actual return air temperature
 - q) Supply air temperature
- 10) Humidity Control: For systems requiring Humidity Control include the following points: <Delete if not Required>
- a) Humidity Sensor
 - b) Humidifier Active
 - c) Humidifier Failure Alarm
 - d) Room Humidity to High
 - e) Room Humidity to Low
- 11) Accessories: Accessories shall include the following:
- a) Over Flow Safety Switch: A condensate pan water level switch shall be incorporated to shut the system down if an overflow condition is sensed.
 - b) Supply Air Temperature Sensor/Monitor: Provide a supply air temperature sensor for field installation in the supply air grille and wired through the E2 controller to the BAS. Sensor shall only monitor the supply air temperature with a signal to BAS.
 - c) Condensate Pump: A Low Profile condensate pump shall be provided for automatic removal of condensate and humidifier flush water (if applicable). In addition to the standard condensate pan overflow safety float(s), the condensate pump shall include an internal overflow safety float switch. When wired to the A/C's remote stop/start terminals, the switch shall open the A/C's control circuit, thereby shutting the A/C down in the event of a condensate overflow. The condensate pump shall be specifically designed to operate with the higher condensate temperatures caused by the flush and drain cycle of the electrode canister humidifiers. <Delete if not Required>

- d) Remote Water/Leak Dector (Ducted Units Only): Where auxiliary drain pans are indicated provide a remote strip/cable type water/leak detector with a twenty (20) foot sensing cable for remote field installation. Also include a 24 volt water detector power module shall require field mounting and wiring to the factory provided terminal connection, providing a remote notification of water detection alarm. Upon sensing a water leak, the normally closed water detector control circuit shall open, thereby shutting down the unit's water producing components.
<Delete if not Required>

2. Floor Mounted Vertical DX Water Cooled A/C Unit:

<Edit for Project Requirements>

- a. General: Furnish and install Model MCW vertical floor mounted up flow packaged water cooled A/C Units as manufactured by Above Air Technologies or approved equal Cyber One Model COS as manufactured by Stultz Air Technology. Units shall be provided with factory furnished and installed microprocessor controls. Additionally, the unit shall be furnished with software communications interface capability for connectivity to the external Building Automation System through Bac Net IP Protocol connection for monitoring and control and comply with the points list in this specification. See the drawings for unit location and capacity.
- b. Unit Configuration: Unit configuration shall be as follows:

<Edit for Project Requirements>

- 1) Ductless Configuration: Unit shall be provided with a discharge plenum located on top of the unit with three (3) supply grilles. Return air grille shall be located on the front panel of the unit <Delete if not Required>
- 2) Ducted Configuration: Unit shall be provided with evaporator supply air flanged duct connection located on top of the unit. Return air grille shall be located on the front panel of the unit <Delete if not Required>
- c. Unit Construction:
- 1) Unit Casing and Condensate Drain Pan: Unit casings shall be constructed from 16 gauge galvanized steel panels and supported by internal three sixteenths (3/16) inch galvanized steel frames. Casing shall be lined with one half (1/2) inch thick, two (2) pound high density sound and thermal insulation sealed with self-extinguishing gasketing conforming to NFPA 90A and 90B. The internal condensate drain pan shall be constructed of 20 gauge stainless steel with drain connection on the same end as the pipe connections for the water cooled condenser. Unit Color shall be Charcoal Gray.
- 2) Fan Types (1-10 Tons): Fan type shall be as follows:

<Edit for Project Requirements>

- a) Non Ducted Units (1-10 Tons): Supply fan/motor shall be a standard ECM direct drive assembly with a double inlet, dynamically balanced fan with backward inclined blades, and motor. Fan and motor shall be mounted on vibration isolators. Fan and motor assemblies that are rigid mounted to the cabinet are acceptable provided the unit is provided with external isolation. Fans with forward curved blades and motor are acceptable. <Delete if not Required>
- b) Ducted Units - High Static (1-10 Tons): Supply fan/motor shall be an ECM direct drive high efficient assembly with double inlet, dynamically balanced fan with backward inclined blades, and motor. Fan and motor shall be mounted on vibration isolators. Fan and motor assemblies that are rigid mounted to the cabinet are acceptable provided the unit is provided with external isolation. See unit schedule on drawings for external static pressure requirements. Fans with forward curved blades and motor are acceptable. <Delete if not Required> <Engineer Note: “High Static” means an ESP @ 0.30” and above + Unit PD>
- 3) Evaporator Coil: Evaporator coil shall be designed to provide maximum coil surface area and minimum depth to provide a high sensible cooling capacity. Coils shall be constructed of seamless drawn copper tubes, mechanically bonded to tempered aluminum fins with a raised lanced fin design for maximum heat transfer. Coil end plates shall be hot dipped galvanized steel. The evaporator coil shall be mounted in a stainless steel condensate drain pan.
- 4) Filter Chamber and Filter: Filters chamber shall be an integral part of the unit, located within the cabinet. Filter shall be slide out type, (2) inch deep class 2 filter per UL Standard 900 and shall also have a rating of at least 80% average arrestance as measured by ASHRAE Standard 52-76 test method. Filter shall be accessible through front hinged access door.
- 5) Refrigeration System: The refrigeration system shall include dual scroll high efficiency, high reliability, low noise compressors, with hot gas bypass, mounted on vibration isolators, type ‘L’ copper refrigeration tubing with brazed fittings, sight glass, externally equalized expansion valve, liquid line filter dryer, and charging and service ports. The refrigeration system shall be pre charged with HCFC – 407-C refrigerant. The water cooled condenser shall be a tube in tube counter flow condenser rated for 150 psi.
- 6) Electric Reheat: Include a factory mounted and wired single stage electric reheat with 24 volt control circuit to provide an automatic reheating mode during the dehumidification cycle and automatic heating mode as required. Electric heaters shall be provided with thermal/magnetic circuit breakers which shall protect each conductor.

- Heaters shall use fast reacting nichrome wire heater elements, which cool quickly when turned off, eliminating residual heat issues. The heater elements shall be housed in within a stainless steel frame with mounted supports. Also include one (1) automatic resetting over temperature safety device (pilot duty) and a non- resettable over temperature safety device located in the main power line.
- 7) Humidifier: The humidifier shall be an electrode steam canister type and shall have an adjustable humidity output setting from 25 to 100% of the full rated humidifier capacity. The humidifier shall have an automatic flush cycle that senses the current consumption of the humidifier and controls mineral concentration of the water. A “Change Cylinder” light shall notify service personnel when the humidification output is below rated requirements and when maintenance is due.
<Delete if not required>
 - 8) Adjustable Water Regulating Valve: Adjustable water regulating valve by manufacturer to maintain head pressure with process cooling water conditions of 68°F EWT/ 90°F LWT. Include GPM and unit pressure drop in feet in the submittal data.
 - 9) Control Panel: Unit mounted pre-wired control panel shall include contactors, relays, control transformer, capacitors, high and low refrigerant pressure switches, compressor and fan automatic reset safety devices for a complete control system.
 - 10) Modular Motor Controllers: The systems shall incorporate modular motor controllers utilizing motor start protectors and circuit breakers to eliminate the need for fuses. The control circuit shall be a 24 VAC Class II low voltage circuit, including primary and secondary circuit protection. Low voltage, high voltage, and common wires shall be color-coded and shall be individually numbered at each end for ease of service tracing. All wiring shall be in accordance with the National Electric Code (NEC) and shall include:
 - a) Motor branch circuit short circuit protection
 - b) Motor load switching controllers (contactors)
 - c) Motor overload protection.
 - 11) Unit Power Supply: Single Source power supply shall include a unit mounted main power dust proof, non-fused type disconnect switch with a lockable handle for the following: <Edit for Project Requirements>
 - a) One (1) and One and One Half (1-1/2) Ton Units: 208/277 volt single phase. <Delete if not Required>
 - b) Two (2) and Three (3) Ton Units: 208/277 volt single phase. 208/460 volt three phase. <Delete if not Required>
 - c) Four (4) Tons and Larger: 208/460 volt three phase. <Delete if not Required>
 - 12) Microprocessor: Provide a [Stultz E2] [Above Air Technologies MC 2000 Advanced] Microprocessor, for each water cooled A/C unit, with a Bac Net IP serial card. Inputs and outputs shall be remotely monitored

- (address readable) through the BAS. At a minimum, the following I/O addressable points shall be included: <Edit for Project Requirements>
- a) Unit on/off
 - b) Compressor running Module1
 - c) Fan running Module1
 - d) Compressor low pressure alarm Module1
 - e) Compressor high pressure alarm Module1
 - f) Air flow alarm Module1
 - g) Water detector alarm Module1 (condensate pan)
 - h) Room temperature to high alarm
 - i) Room temperature to low alarm
 - j) Supply temperature to high alarm
 - k) Supply temperature to low alarm
 - l) Water temperature to high alarm (Process Cooling Water)
 - m) Water temperature to low alarm (Process Cooling Water)
 - n) Set point temperature
 - o) Set point supply air temperature
 - p) Actual return air temperature
 - q) Supply air temperature
- 13) Humidity Control: For systems requiring Humidity Control include the following points: <Delete if not Required>
- a) Humidity Sensor
 - b) Humidifier Active
 - c) Humidifier Failure Alarm
 - d) Room Humidity to High
 - e) Room Humidity to Low
- 14) Accessories: Accessories shall include the following:
- a) Over Flow Safety Switch: A condensate pan water level switch shall be incorporated to shut the system down if an overflow condition is sensed. <Delete if not Required>
 - b) Supply Air Temperature Sensor/Monitor: Provide a supply air temperature sensor for field installation in the unit and wired through the E2 controller to the BAS. Sensor shall only monitor the supply air temperature with a signal to BAS.
 - c) Capacity Assist Option: Where multiple units will condition the same room provide the capacity assist option. Program the vertical unit as the active unit and the ceiling unit as the assist unit. On a call for cooling the active unit, shall be energized, through its controller, to maintain the room set point (75). If the active unit cannot satisfy the room set point, the assist unit shall be energized through its unit controller to assist the active unit. When the room set point is satisfied the assist unit shall be de-energized, then the active unit shall be de-energized. Program the active unit for cooling, dehumidification, reheating and humidification. Program the assist unit for the same functions

- and include a 3°F, 3% RH differential between the active and assist units. <Delete if not Required>
3. Remote Drycooler System: <Delete if not Required>
 - a. Remote Outdoor Propeller Fan Drycooler: Drycooler casings shall be fabricated from heavy aluminum for corrosion protection and appearance. Structural components shall be fabricated from galvanized steel for support. Motors shall be permanently lubricated ball bearings and be internally protected. Fans shall be propeller type with blades made from aluminum and shall have zinc plated hubs for strength and corrosion protection. Drycooler shall have internal air baffles to prevent air bypass from one (1) fan section to another and to maximize air through each coil section. The drycooler shall be designed to have the scheduled capacities at 105°F ambient air temperature. Manufacturer of drycooler shall be Stulz, model series “FSS” or approved equal by Liebert, provided that the system can be monitored and controlled via the existing Siemens Building Automation System (BAS). Drycooler shall have support legs integral to the chassis/frame. Drycooler coils shall be copper, complying with ASTM B 75. Fins shall be aluminum. Fin and tube joint shall be mechanical bond. Headers shall be seamless copper tube with brazed joints, prime coated.
 - b. Drycooler/Fan Cycling Control Box: The drycooler control box shall be factory mounted in an outdoor rated enclosure. Each Drycooler/Fan Cycling Control Box shall electrically interface to the GPS pump package via a 24-volt low voltage connection. The drycooler control box shall include, but not be limited to:
 - 1) Fan Motor starter(s)/contactor(s)
 - 2) Fan Cycling Aquastat(s) to sense coolant temperature to maintain proper coolant temperature in DX mode, and Free Cooling Mode (if applicable).
 - 3) Main Power Non-Fused Disconnect Switch.
 - c. Terminal strip for external connectivity to A/C Unit or Building Automation System. The terminal strip shall have dry contact available which will allow for the following:
 - 1) Enable/disable drycooler
 - 2) Flow status
 4. Glycol Pump Package: <Delete if not Required>
 - a. Dual Pump Package: The Pump Package shall be provided with two redundant, equal horsepower pumps, with one operating continuously (primary) and the second pump to provide redundancy (backup) in the event of a failure of primary pump. A coolant sensing flow switch shall be provided for automatic switch-over of primary to backup pump operation in the event of coolant flow loss. The controls shall be mounted in a NEMA-3R enclosure at the end of the pump package. Each pump shall be mounted on a steel angle chassis and be protected by a removable aluminum cover. Manufacturer of glycol pump package shall be Stulz, model series “GPS” or approved equal by Liebert, provided that the system can be monitored and controlled via the

existing Siemens Building Automation System (BAS). Each pump package shall include, but not be limited to:

- 1) Pump starter(s)/contactor(s) with fusing per NEC;
 - 2) A fifteen (15) gallon expansion tank;
 - 3) An airtrol fitting (automatic air bleed valve)
- b. Dry Cooler and Pump Package – BAS Interface: **<Delete if not Required>**
- 1) Provide BAC Net IP Serial Cards and/or communication software with the following points to interface with the BAS:
 - a) Drycooler Enable/Disable—Digital Output
 - b) Drycooler Status (via flow switch)—Digital Input
 - c) Supply Water Temperature — Analog Output
 - d) Return Water Temperature — Analog Output
 - e) Pump Status —Digital Input

2.15 DUCTWORK AND ACCESSORIES

A. HVAC Material - Sheet Metal Ductwork and Accessories:

1. Sheet Metal Duct Work:
 - a. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
 - b. Seal Class: Except as otherwise indicated, All ductwork shall be constructed to meet the requirements of SMACNA Seal Class A. Conform to the requirements in the referenced construction for metal thickness, reinforcing types and intervals, tie rod applications, and joint types and intervals.
 - c. Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for the pressure classification as follows:
 - 1) Supply Ducts - Upstream of/Before Air Terminal Units: 6 inch wg. (Medium Pressure)
 - 2) Supply Ducts - Downstream of/After Air Terminal Units: 2-inch wg. (Low Pressure)
 - d. Provide materials that are free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.
 - e. Cross Breaking or Cross Beading: Cross break or bead duct sides that are nineteen (19) inches and larger and are 20 gauge or less, with more than ten (10) sq. ft. of unbraced panel area, as indicated in SMACNA "HVAC Duct Construction Standard," Figure 1-4, unless they are lined or are externally insulated.
 - f. Rectangular Duct Fittings: Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA "HVAC Metal Duct Construction Standard," Latest Edition.

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- g. Flexible duct work will be permitted at UMB provided the duct lengths do not exceed six (6) feet in length and are installed without sharp bends. Also Flex duct will be limited to connecting ceiling diffusers to branch ducts.
 - h. All sheet metal seams in new ductwork shall be sealed with mineral impregnated woven fiber tape as manufactured by Hardcast, Inc or other types of sealant materials.
 - i. Duct Connection Joint Sealant: Where new ductwork connects to existing ductwork provide the following material as a joint sealer between the new and existing duct surfaces:
 - 1) Permatite, Butyl gray non curing tape of sufficient width to seal the duct joints. Material can be purchased from the manufacturer or from Grainger using the either the manufacturers model number DS5285, or the Grainger item number 2EJR3. Seal the external joints as required by these specifications and the ductwork can be placed in service.
2. Factory Fabricated Round Duct – Medium Pressure:
- a. Manufacturers: Subject to compliance with requirements, provide products by one (1) of the manufacturers specified:
 - 1) McGill Air Flow Corporation.
 - 2) SEMCO Incorporated.
 - b. Round, Longitudinal- and Spiral Lock-Seam Ducts: Factory-fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards-Metal and Flexible." Fabricate ducts larger than seventy two (72) inches (1830 mm) in diameter with butt-welded longitudinal seams.
 - c. Duct Joints:
 - 1) Ducts up to twenty (20) Inches (500 mm) in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
 - d. Tees and Laterals: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards-Metal and Flexible," with metal thicknesses two gauge numbers heavier than specified for longitudinal-seam straight ducts.
 - e. Elbows: Use die-formed, gored, pleated, or mitered construction with bend radius of one and one half (1-1/2) times duct diameter. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards-Metal and Flexible," with metal thickness two (2) gauge numbers heavier than specified for longitudinal- seam straight ducts.
 - f. Branch Duct Connections: Provide branch duct connections for the following:
 - 1) Round Connections: Where round ducts connect to medium pressure mains provide conical connections.
 - 2) Non Round Connections: Where rectangular/square ducts connect to medium pressure mains provide connections with a 45 degree angle equal to the SMANCA “45 degree entry” fitting.

- 3) Rectangular/Square Manual Dampers: Where rectangular/square manual volume dampers connect to low pressure ductwork provide with a 45 degree angle,
 - 4) Round Manual Dampers: Where round manual volume dampers connect to low pressure ductwork provide conical side tap connections.
 - 5) Round Manual Dampers: Where round manual volume dampers connect to low pressure ductwork provide conical side tap connections.
3. Contractor Fabricated Round Duct – Medium Pressure: (Contractors Option)
- a. Round, Longitudinal- and Spiral Lock-Seam Ducts: Field-fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards-Metal and Flexible." Fabricate ducts larger than seventy two (72) inches (1830 mm) in diameter with butt-welded longitudinal seams.
 - b. Duct Joints:
 - 1) Ducts up to twenty (20) Inches (500 mm) in Diameter: Interior, center-beaded slip coupling, sealed before and after fastening, attached with sheet metal screws.
 - c. Tees and Laterals: Fabricate to comply with SMACNA's "HVAC Duct Construction Standards-Metal and Flexible," with metal thicknesses two gauge numbers heavier than specified for longitudinal-seam straight ducts.
 - d. Elbows: Use die-formed, gored, pleated, or mitered construction with bend radius of one and one half (1-1/2) times duct diameter. Fabricate to comply with SMACNA's "HVAC Duct Construction Standards-Metal and Flexible," with metal thickness two gauge numbers heavier than specified for longitudinal- seam straight ducts.
4. Factory Fabricated Manual Volume Dampers:
- a. Rectangular/Square Manual Volume Dampers – Low Pressure Ductwork: Provide manual volume dampers in low pressure duct systems where the system pressure does not exceed 2” wg and the air velocity is less than 1,500 fpm where shown on drawings and/or where needed for system balancing. Dampers shall be single blade and/or opposed blade type dampers as specified below:
 - 1) Single Blade Dampers Ductwork Less Than Twelve (12) Inches High: Dampers shall be Ruskin Model MD25 single blade type manual damper with a 24 gauge galvanized steel frame, a 22 gauge galvanized steel blade, molded synthetic bearings, three eights (3/8) inch square axle shaft extending beyond the frame, factory supplied hand quadrant with wing nut, and a two (2) inch standoff bracket. Quadrant handle shall be inscribed with “closed”, “1/4 open”, “1/2 open”, “3/4 open” and “open”.
 - a) Size Range in Inches (W x H): 5 x 4 to 12 x10 or
 - 2) Opposed Blade Dampers Ductwork Twelve (12) Inches High and Higher: Dampers shall be Ruskin Model MD35 opposed blade type manual damper with a 24 gauge galvanized steel frame, a 22 gauge galvanized steel blade, molded synthetic bearings, three eights (3/8)

- inch square axle shaft extending beyond the frame, factory supplied hand quadrant with wing nut, and a two (2) inch standoff bracket. Quadrant handle shall be inscribed with “closed”, “1/4 open”, “1/2 open”, “3/4 open” and “open”. See example size range below and drawings for actual duct sizes and locations.
- a) Example Size Range in Inches (W x H): 12 x 12 to 36 x 12
 - b. Round Manual Volume Dampers – Low Pressure Ductwork: Provide manual volume dampers in low pressure duct systems where the system pressure does not exceed 2” wg and the air velocity is less than 1,500 fpm where shown on drawings and/or where needed for system balancing. Dampers shall be single blade type dampers as specified below:
 - 1) Single Blade Dampers Ductwork Twelve (12) Inches in Diameter or Less: Dampers shall be Ruskin Model MDRS25 single blade type manual damper with a 20 gauge galvanized steel frame, a 20 gauge galvanized steel blade, molded synthetic bearings, three eighths (3/8) inch square axle shaft extending beyond the frame, factory supplied hand quadrant with wing nut, and a two (2) inch standoff bracket. Quadrant handle shall be inscribed with “closed”, “1/4 open”, “1/2 open”, “3/4 open” and “open”. See example size range below and drawings for actual duct sizes and locations of runouts to diffusers.
 - a) Example Size Range in Inches (diameter): Four (4) inch to twelve (12) inch in diameter.
 - c. Flat Oval Manual Volume Dampers – Low Pressure Ductwork: Provide manual volume dampers in low pressure duct systems where the system pressure does not exceed 2” wg and the air velocity is less than 1,500 fpm where shown on drawings and/or where needed for system balancing. Dampers shall be single blade type dampers as specified below:
 - 1) Single Blade Dampers Ductwork Twelve (12) Inches in Diameter or Less: Dampers shall be Ruskin Model CDO25 single blade type manual damper with a 20 gauge galvanized steel frame, a 20 gauge galvanized steel blade, molded synthetic bearings, three eighths (3/8) inch square axle shaft extending beyond the frame, factory supplied hand quadrant with wing nut, and a two (2) inch standoff bracket. Quadrant handle shall be inscribed with “closed”, “1/4 open”, “1/2 open”, “3/4 open” and “open”. See example size range below and drawings for actual duct sizes and locations of runouts to diffusers.
 - a) Example Size Range in Inches (diameter): Four (4) inch to twelve (12) inch in diameter.
5. Contractor Shop Fabricated Manual Volume Dampers: (Contractors Option)
 - a. Shop fabricated manual volume dampers must adhere to the same material and performance requirements specified for factory fabricated manual dampers.
 6. Remote Manual Volume Damper Operator: Provide remote volume dampers where required and/or where indicated on the drawings and details. Remote volume damper operators shall be Model 1200 Worm Gear Operator with Flex Shaft and

Termination Mounting Bracket as manufactured by young regulator company or approved equal complying with the following:

<Delete if not required>

- a. Operator: Self-locking regulator designed for one half (1/2) inch round or three eighths (3/8) inch damper shafts. Optional Model 1200- 1/4 is available for five sixteenths (5/16) inch round and one quarter (1/4) inch square damper shafts. Contractor to coordinate with manual damper types provided.
 - b. Flex Shaft: Flex steel shaft shall be a single wire wrapped with multi stranded layers of wire. Assembly shall be 0.250 inches in diameter with a brass finish and capable of delivering more than 50 lbs. of torque without damage. Shafts are available in one (1) foot, three (3) foot, six (6) foot and eight (8) foot lengths. Contractor shall include required lengths on the product submittal.
 - c. Termination PLBR: The flexible steel shaft shall be coupled to the worm gear operating shaft and terminated to the PLBR mounting bracket. Damper operation shall be by turning a Phillips head screw on the bracket.
7. Fume Hood Exhaust Ducts: New fume hood exhaust duct work shall be 20 gauge stainless steel round spiral duct work and fittings. All connections shall be welded with rods compatible with the duct material and all welds shall be continuous. Contractor has the option to hard cast each joint.
8. Duct Sound Lining – Return Air Grilles with Sound Boots and Transfer Ducts Only:
- a. Duct sound lining shall be a minimum one (1) inch (25 mm) thick (unless otherwise noted), 1.5 pcf density fiberglass, minimum R-value of 4.2 (k-value 0.24 or better), complying with ASTM C 1071, ASTM G 21, ASTM G 22, NFPA 90A, NFPA 90B and UL 181. Duct lining shall contain an EPA registered antimicrobial agent which resists the growth of bacteria and fungi as proven by tests in accordance with ASTM G21 and G22. Liner noise reduction coefficient (NRC) shall be 0.70 or better. Surface of liner shall have water repellent properties. Duct liner shall be Certainteed Toughgard Product Type 150 or equivalent by Johns Manville, Knauf or Owens Corning. All duct sizes shown are clear inside dimensions.
 - b. Duct Liner Adhesive: Comply with Adhesive and Sealant Council, Inc. (ASC) and ASTM C916.
 - c. Duct Liner Fasteners: Comply with SMACNA Standards. Fasteners shall not compress liner by more than one eighth (1/8) inch.
9. Duct Fire Dampers:
- a. General: Furnish and install Ruskin Model DIBD20 Curtain Type Dynamic Fire Damper or approved equal, where indicated on the drawings. Dynamic fire dampers shall be tested, constructed, and labeled in accordance with the latest edition of UL Standard 555. Each damper shall include a 165°F (74°C) fusible link (specifier select) and shall be labeled for use in dynamic systems. Dampers shall have a fire rating of one and one half (1 1/2) hours and shall meet the requirements of the latest edition of NFPA90A. Fire dampers shall be produced in an ISO 9001 certified factory. See floor plans for duct sizes.

- b. Construction: Damper frame and blades shall be galvanized steel in gauges required by UL listing R-5531 installed in a factory mounted sleeve and shipped loose mounting angle. Damper blades shall be steel interlock to provide fire shield in gauges required by UL listing R-5531. Closure spring dampers shall be of 301 stainless steel and shall be constant force or spring clip type. Each damper shall include a 165°F fusible link and shall be labeled for use in dynamic systems. Dampers labeled for use in static systems only are not permitted.
 - c. Accessories: Each dynamic fire damper shall include a twelve (12) inch long integral rolled formed steel sleeve and mounting angles furnished by the damper manufacturer to ensure appropriate installation.
 - d. Submittals: Submittal information shall include the fire protection rating, maximum velocity/pressure ratings and the manufacturer's UL installation instructions.
 - e. Damper Ratings: The damper shall be rated for dynamic closure at 2,000 fpm (10.16 m/s) and 4 inches wg static pressure and shall be rated to close with airflow in either direction.
10. Duct Access Doors:
- a. For Access to Terminal Unit Velocity Sensors provide Duct Mate Sandwich Type Access Doors. Access Doors shall be constructed of hot dipped galvanized steel panels with closed cell neoprene gasket bonded to the inside of the door. Gasket Material shall be rated for a service temperature range of -20°F to 200°F (ASTM D746) and shall be UL Listed (UL94HF1). Metal Panels shall be secured in place with zinc coated threaded bolts clinched and sealed to the inner panel and zinc coated springs between the inner and outer panels, and Red Molded Polypropylene Knobs with threaded metal inserts. Access Doors installed in the inlet duct to Terminal Reheat Units shall be insulated with High Density Fiberglass Insulation. Access Doors installed in the inlet duct to Exhaust Terminal Units do not require insulation. See Terminal Unit Details on Drawings for size and model numbers. <where removable velocity sensors are provided with air terminal units delete this paragraph>
 - b. Provide access doors in ductwork for Fire Dampers and ATC Dampers. For access door construction and air tightness, see SMACNA standard figure 2-12. See drawings for required door size. <Delete if not required>
- B. HVAC Material - Diffusers and Grilles: <Engineer Edit for Project>
- 1. Diffusers: Supply air diffusers shall be Titus, type [TDCA] [PAS] 22-gauge steel or aluminum diffuser with adjustable discharge, square or round neck, border type 3 twenty-four (24) x twenty-four (24) lay in module. and standard #26 white baked enamel finish. See drawings for diffuser size and capacities.
 - 2. Return / Exhaust Grilles: Return and/or exhaust grilles shall be TITUS, type [25RL] [PAR] 22-gauge steel or aluminum grilles, with square or rectangular neck, and

border type 3 twenty-four (24) x twenty-four (24) lay in module. and standard #26 white baked enamel finish. See drawings for grille size and capacities.

C. Filter Media: < Delete if not Required >

1. Return Air Grilles (RAG) with Sound Boots: Where return air grilles with sound boots are used in plenum ceilings with Fan Powered Boxes provide two (2) inch MERV 1 filter media for each RAG.
2. Return Air Grilles (RAG) with Fan Coil Units (FCU): Where return air grilles are used with ducted returns to recessed FCU provide two (2) inch MERV 1 filter media for each RAG.

2.16 INSULATION – PIPE AND DUCT SYSTEMS

A. General:

1. All pipe and duct systems shall be insulated with Owens Corning Insulation Products or approved equal by John Manville, Knauf Inc. or Pittsburgh Corning Corp. Foamglas.
2. Provide Tapes, Adhesives, Mastics and Sealants that are compatible with and approved by the insulation manufacturer.
3. HVAC Piping Systems include the following:
 - a. Hydronic Piping Systems: Includes Heating Hot Water Systems.
4. HVAC Duct Systems include the following:
 - a. Supply Duct Systems: Medium Pressure and Low Pressure Duct Systems.

B. Piping Systems:

1. HVAC Heating Hot Water Piping Systems -100°F to 250°F:
 - a. Concealed and Exposed Interior Piping: Insulation for pipe sizes one half (1/2) inch to two (2) inches shall comply with the following:
 - 1) Material: Fiberglass, Cellular Glass
 - 2) Thickness: One (1) inch
 - 3) Vapor Barrier: No
 - 4) Field Applied Jacket – Concealed: None
 - 5) Field Applied Jacket – MER Exposed: Glass Cloth
 - 6) Field Applied jacket – Non MER Exposed: PVC
 - 7) Pipe Fittings: “Zeston” pre molded fittings
2. HVAC Chilled Water Piping Systems - 0°F to 100°F:
 - a. Concealed and Exposed HVAC Chilled Water Piping: Insulation for pipe sizes one half (1/2) inch to two (2) inches shall comply with the following:
 - 1) Material: Fiberglass, Cellular Glass
 - 2) Thickness: One (1) inch
 - 3) Vapor Barrier: Yes
 - 4) Field Applied Jacket – Concealed: None
 - 5) Field Applied Jacket – MER Exposed: Glass Cloth

- 6) Field Applied jacket – Non MER Exposed: PVC
- 7) Pipe Fittings: “Zeston” pre molded fittings
- b. Concealed and Exposed HVAC Chilled Water Piping: Insulation for pipe sizes two and one half (2-1/2) inch and larger shall comply with the following:
 - 1) Material: Fiberglass, Cellular Glass
 - 2) Thickness: One and one half (1-1/2) inch
 - 3) Vapor Barrier: Yes
 - 4) Field Applied Jacket – Concealed: None
 - 5) Field Applied Jacket – MER Exposed: Glass Cloth
 - 6) Field Applied jacket – Non MER Exposed: PVC
 - 7) Pipe Fittings: “Zeston” pre molded fittings

C. Duct Systems:

1. HVAC Supply Duct Systems:
 - a. Concealed Interior Supply Duct Systems: (Square, Rectangular, Round)
 - 1) Material: Fiberglass, Blanket
 - 2) Thickness: One and one half (1-1/2) inch
 - 3) Vapor Barrier: Yes
 - 4) Field Applied Jacket – Concealed: None
 - 5) Field Applied Jacket – MER Exposed: None
 - 6) Field Applied jacket – Non MER Exposed: None
 - b. Exposed Interior Supply Duct Systems – Finished Areas: (Square, Rectangular, Round)
 - 1) Insulation is not required on supply ducts.
 - c. Exposed Interior Supply Duct Systems – MER: (Square, Rectangular, Round)
 - 1) Material: Fiberglass, Board (Square and Rectangular)
 - 2) Thickness: One and one half (1-1/2) inch
 - 3) Vapor Barrier: Yes
 - 4) Field Applied Jacket – Concealed: None
 - 5) Field Applied Jacket – MER Exposed: None
 - 6) Field Applied jacket – Non MER Exposed: None

2.17 BAS – AUTOMATIC TEMPERATURE CONTROLS

- A. General: Unless otherwise directed by UMB all work associated with the Building Automation System (BAS), including required demolition work shall be furnished and installed by the BAS Contractor. The BAS Contractor for this project shall be Siemens Bldg. Tech. Inc. No other manufacturers will be acceptable.
- B. Communication with third party products or products other than Siemens Apogee System: All products and/or devices that require software communication with the Siemens BAS shall be accomplished using BAC Net IP Communication Protocol.

C. Air Handling Unit Control Valves:

1. All control valves shall be electronic type valves designed for quiet operation and 100% tight shut off against the system operating pressure. Provide a bypass around the control valve.

D. Terminal Unit Control Valves: Terminal units include Supply Terminal Units, Fan Coil Units, Unit Heaters, Cabinet Heaters, Convectors and Chilled Beams:

1. Control Valves: All control valves shall be electronic type valves designed for quiet operation and 100% tight shut off against the system operating pressure. Valves concealed above suspended ceilings or in unit casings shall be packless type with bellows seals requiring no packing maintenance.
2. Hydronic control valves (1/2 inch to 1 inch) for terminal units shall be globe type valves with bronze or forged brass body, NPT threaded ends, brass trim, type 303 stainless steel stem, metal to metal seat, ethylene propylene 'O' ring packing, ANSI Class 250, and selected to provide the scheduled gpm flow rate @ a maximum pressure drop of ten (10) feet. See equipment schedules for design flow rates. Valve type shall be one (1) of the following as selected by ATC:
 - a. Valve Sizes 1/2 inch to 1 inch: Siemens Powermite MT Series valves for hydronic service.
 - b. Valve Sizes 1/2 inch to 2 inch: Siemens Flowrite Series valves for hydronic service.
3. Steam control valves for terminal units shall be globe type valves with bronze or forged brass body, NPT threaded ends, stainless steel trim, type 303 stainless steel stem, metal to metal seat, ethylene propylene 'O' ring packing, ANSI Class 250, ANSI Leakage Class IV and selected to provide the scheduled steam flow rate @ a maximum pressure drop of ten (10) feet. See equipment schedules for design flow rates. Valve type shall be one (1) of the following as selected by ATC:

<Delete if not required>

- a. Valve Sizes 1/2 inch to 1 inch: Siemens Powermite MT Series valves for LPS steam supply (15 psi maximum).
- b. Valve Sizes 1/2 inch to 2 inch: Siemens Flowrite Series valves for MPS steam supply (50 psi maximum).
4. Valve Fail Safe Position: Control valves fail safe position shall comply with the following:
 - a. Heating Valves Vivarium Areas – Fail Closed: Upon a loss of a signal or power control valves and actuators used as reheat valves for terminal units shall fail in the closed position.
 - b. Heating Valves Non Vivarium Areas – Fail Last Position: Upon a loss of a signal or power control valves and actuators used as reheat valves for terminal units shall fail in the last position.
 - c. Chilled Water Valves Non Vivarium Areas – Fail Last Position: Upon a loss of a signal or power control valves and actuators used as chilled water valves for fan coil/chilled beam terminal units shall fail in the last position.

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- d. Steam Control Valves - Fail Closed: Upon a loss of a signal or power control valves and actuators used as steam valves for terminal units shall fail in the closed position. <Delete if not required>
- E. ATC Valve Actuators: Valve actuators shall be mounted on the valve body and shall provide complete modulating control of the valve. The actuator motor shall de-energize when the valve has reached the operator or system determined position. Each actuator shall be removable without removing the valve from service or draining the system. Actuators shall be electronic.
- F. Current Sensor: All motors serving HVAC fans and pumps shall be provided with a current sensor for “on/off” status to the BAS.
- G. Moisture Sensor: Provide DiversiTech Model WS-1 moisture sensors in A/C condensate drain pans in fan coil units and fan powered boxes. When high water level is detected, the sensor shall send an alarm to the BAS and shut off the unit. The BAS alarm shall also remotely notify the client via [email], [or text] [or all three (3)] types of notification methods. <Engineer coordinate with UMB and edit for project>
- H. Terminal Unit Fans: Verification of air flow for fans, which are part of terminal heating and cooling units such as fan coil units, fan powered boxes, unit heaters, cabinets, shall be by a current sensing device unless indicated otherwise on the point schedule. All fans serving fan coil units, cabinet heaters, and unit heaters shall be provided with current sensors for “on/off” status to the BAS.
- I. Fume Hood Controller Assembly: Where fume hoods are indicated on the construction documents provide a Siemens Fume Hood Controller Assembly for control of laboratory fume hoods as manufactured by Siemens. Power source shall be through a 24 Vac power trunk. The controller shall include the following components:
1. Fume Hood Controller: The Fume Hood Controller shall consist of a control circuit board and metal enclosure. The controller circuit board shall be a snap in type circuit board mounted inside the enclosure. Provide all wiring terminations for input and output points, 24 Vac power, FLN trunk, and the Operator Display Panel. The controller shall maintain a constant face velocity as the fume hood sash is raised and lowered and includes the following:
 - a. Communicates using BACnet MS/TP protocol for open communications on BACnet MS/TP networks.
 - b. BTL listed as a B-ASC device.
 - c. Programmable using PPCL.
 - d. Plenum rated controller.
 - e. Constant face velocity fume hood operation.
 - f. Maintains programmed minimum exhaust flow.
 - g. True exhaust flow measurement used to monitor safe operation and provide fine flow control.
 - h. Modular components, easy to install and service.

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- i. Program and calibration parameters are user defined or modified via the Laptop Terminal.
 - j. PID closed loop control for all control devices.
 - k. Electrically Erasable Programmable Read Only Memory (EEPROM) memory for setpoint and control parameters; no battery is needed.
 - l. Supports multiple hood sash inputs.
 2. Offboard Air Module: The Offboard Air Module shall contain the air velocity sensor (a specialized differential pressure transducer), V/F conversion circuitry and solenoid for auto-zero function and advanced digital signal processing to produce a highly accurate reading of even the noisiest flow signals. The auto-zero solenoid shall be connected to the air velocity pressure transducer's inlet ports to enable automatic periodic re-calibration. This re-calibration ensures accurate, drift-free airflow measurement. Automatic re-calibration of the differential pressure transducers occurs upon system power-up and when airflows are stable with frequency selectable from one (1) to six (6) times a day.
 3. Operator Display Panel II: The Operator Display Panel shall provide the fume hood user with the face velocity readout, operating status of the hood, alarm horn, alarm silence and an emergency purge function and include the following:
 - a. Continuous display of hood operating parameters using a large alpha-numeric display.
 - b. Colored hood status lights for normal (green), marginal (yellow), and alarm (red) conditions. Purge push-button for activation of emergency operation mode. Alarm horn for high and low face velocity and emergency purge indication.
 - c. Easy to install and connect to the controller via a single cable and telephone type connectors.
 - d. “Greenleaf” turns red to indicate unsustainable operation, such as keeping sash open when not in use. Animated graphics to encourage safe use.
 - e. Communicates using BACnet MS/TP protocol for open communications on BACnet MS/TP networks.
 - f. BTL listed as a B-ASC device.
 - g. Programmable using PPCL.
 - h. Auto-discovery and Auto-addressing over entire MS/TP network. (WCIS 4.0 or later)
 - i. RJ-11 type connectors to provide termination to the Fume Hood Controller and for the Portable Operator’s Terminal.
 4. Power Module and Cable: Siemens Product Number AQM2200.
 5. Sash Sensor Kits (Vertical/ Horizontal): Siemens Product Number 149-269.
 6. Airflow Measurement and Control Options:
 - a. [Application 6740] [Application 6741]
 - J. Temperature Sensors (DDC):
 1. General: Provide temperature sensors for controllers performing space temperature control. Sensors shall be wired thermistor type, with the following features:

- a. Accuracy: + .5°F.
- b. Operating Range: 35°F to 115°F.
- c. Set Point Adjustment Range: 55°F to 95°F.
- d. Calibration Adjustments: None required.
- e. Installation: Up to one hundred (100) ft. from controller.
- f. Auxiliary Communications Port: As required.
- g. Set Point Adjustment Dial: As required.
- h. Occupancy Override Switch: As required.
- i. Terminal Jack: As required.
- j. Cover: Blank cover, no display.
2. Set Point Modes: Provide the following set point modes:
 - a. Independent Heating, Cooling.
 - b. Night Setback-Heating.
 - c. Night Setback-Cooling.
3. Auxiliary Communication Port: Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. RS-232 communications port shall allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator's terminal.
4. Set Point Adjustment Dial: The set point adjustment dial shall allow for modification of the temperature by the building operators. Set point adjustment may be locked out, overridden, or limited as to time or temperature through software by an authorized operator at any central workstation, Building Controller, room sensor two (2) line display, or via the portable operator's terminal.
5. Override Switch: An override switch shall initiate override of the night setback mode to normal (day) operation when activated by the occupant and enabled by building operators. The override shall be limited to two (2) hours (adjustable.) The override function may be locked out, overridden, or limited through software by an authorized operator at the operator interface, Building Controller, room sensor two (2) line display or via the portable operator's terminal.
6. Room Sensors and Monitors: The following sensors for space control and/or space monitoring were indicated on the drawings and as required for proper control for the project:
 - a. Room Mounted Temperature Control Sensor: Room sensor shall come with a wall plate suitable for surface mounting in the room. The local setpoint adjustment shall be capable of being locked out by the BAS. The sensors shall be wired to the TEC by a cable which transmits the temperature signal to BAS.
 - b. Duct Mounted Space Temperature Control: For duct mounted space temperature control provide a surface mounted duct thermistor for the space TRU TEC. Thermistor shall be 10,000 Ohm with a set point adjustment range of 55°F to 95°F and be accurate to within $\pm 5^\circ\text{F}$ at mid range. The sensors shall be suitable for mounting on either a round or rectangular ductwork with self drilling screws and a gasket. The sensors shall be wired to the TEC by a

- cable which transmits the temperature signal to BAS. Mount the thermistor were indicated on the drawings in the exhaust duct serving room.
- c. Duct Mounted Supply & Exhaust Air Temperature Monitor: For each supply and exhaust terminal unit serving a space, provide a duct mounted temperature sensor to monitor the supply and exhaust air temperature. The sensors shall provide an input for temperature monitoring range of 32°F to 122°F and be accurate to within $\pm 5^\circ\text{F}$ at mid range. The sensors shall be suitable for mounting on either a round or rectangular ductwork with self drilling screws and a gasket. The sensors shall be wired to the TEC by a cable which transmits the temperature signal to BAS.
- K. ATC Dampers: Dampers shall be airfoil type, low leak dampers with 16 gauge galvanized steel channel frame reinforced with corner braces equal to 13 gauge galvanized steel blades shall be 14 gauge equivalent thickness galvanized steel roll formed airfoil type with extruded vinyl edge seals mechanically locked into blade edge & suitable for -50°F to $+250^\circ\text{F}$ operating temperature range. Jamb seals shall be flexible metal compression type. Bearings shall be corrosion resistant permanently lubricated stainless steel type turning in an extruded hole in the damper frame. Axles shall be positively locked into the damper blade. Linkages shall be concealed out of the airstream within the damper frame. Damper leakage rating shall be less than 6.2 CFM per sq. ft. thru a forty-eight (48) inch x forty-eight (48) inch damper at four (4) inches W.G. pressure difference. Damper shall be Ruskin model CD 60 or approved equal. All ATC Dampers shall be provided with end switches. <Delete if not required>
- L. ATC Wiring & Conduit:
1. Wiring and conduit necessary for all control work shall be provided by the ATC Contractor. All electrical work shall be in accordance with the National Electric Code latest edition. All control cabling between the TEC and each room sensor shall be provided by the ATC Contractor. Electrical Contractor shall provide a one half (1/2) inch EMT between each TEC and room sensor.
 2. All 110V power wiring for the control transformer shall be provided by the Division 26 Electrical Contractor from the circuit breaker to a junction box located near the control transformer. All 110V power wiring between the junction box and the control transformer shall be provided by the ATC Contractor.
- M. Graphics and Programing – Existing Siemens System:
1. Graphics: For campus renovation projects, the BAS Contractor shall provide a graphics package as follows:
 - a. Existing Graphics: Where graphics exist in the Siemens System for the project, the BAS contractor shall either modify the existing graphics or replace the existing graphics with new graphics indicating the architectural changes to the project area and the locations of air terminal units or HVAC equipment and BAS sensors.

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- b. New Graphics: Where the Siemens System does not include graphics for the project, the BAS contractor shall provide a new graphics package for the project area indicating the architectural changes to the project area and the locations of air terminal units or HVAC equipment and BAS sensors.
 - c. New Graphics Background: Where new backgrounds are created by the BAS contractor these backgrounds must reside on and be compatible the Siemens Front End System and software. The BAS contractor can either create the background or utilize a CAD dwg file from the consultant or UMB as the background.
 - d. BAS Sensors: Where BAS Sensors are installed in HVAC Systems show the sensor locations on the mechanical graphics diagrams and the floor plan graphics. The locations on the mechanical graphics diagram shall include the nearest room number as a location reference. Identify each sensor by sensor type, floor number and numerical number. Types of sensors include but may not limited to the following:
 - 1) Hydronic Systems: Differential pressure sensors in hydronic piping systems. (DPS – 2 – 1, 2...)
 - 2) Air Systems: Static pressure sensors in air distribution systems. (SPS – 1 – 1, 2...)
2. Programing: For campus renovation projects, the BAS Contractor shall provide the required programing as follows:
 - a. Existing Programing: Where programing exists in the Siemens System for the existing air terminal units or HVAC equipment that is either relocated, or removed and replaced, the existing building automation system programming shall be either modified or deleted, and a new program written by the BAS contractor to identify the air terminal units with the rooms they serve as part of the ATC work for the project.
 - b. New Programing: Where programing does not exist in the Siemens System for the existing air terminal units or HVAC equipment that is either relocated, or removed and replaced, the BAS contractor shall provide new programming to identify the air terminal units with the rooms they serve as part of the ATC work for the project. The new programing must reside on and be compatible the Siemens Front End System and software.
 - c. Miscellaneous: Programming modifications shall also include the occupied and unoccupied modes of control for each terminal unit or lead/lag operation for HVAC equipment.

N. Uninterruptible Power Supplies (UPS):

1. All Building Automation System field panels and application specific controllers shall be provided with Uninterruptible Power Supplies (UPS). Provide a single UPS, if possible, at each central field panel location, sized for total load of connected equipment. Provide external battery cabinets, if required to meet load requirements.

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2. Provide constant on line 1500 kVA minimum UPS with Ethernet card to feed back to IP based UMB monitoring system APC Model # SMX1500RM2UNC, 120V 1.5 kVA UPS and a UPS bypass Eaton hot swap Model # MBP-115 or approved equal for seamless serving. When a larger UPS is required, increase the kVA capacity as needed. Line interactive UPS's will not be acceptable.
- O. BAC Net IP Interface to the BAS:
1. Provide a patch panel and all required wiring as needed to connect the BAC Net IP based HVAC equipment to the BAS. Coordinate with UMB for the location of the panel in the building.
- P. Air Terminal Units - Sequence of Operation (DDC): <Edit for Project >
1. Supply Terminal Reheat Units: The pressure independent [constant volume] [variable volume] supply terminal reheat units (STU) shall be controlled by an application specific DDC controller using electric actuation. Provide an auto zero module for each STU for periodic calibration of the controller's air velocity transducer. For supply terminal units serving non Laboratory, Animal or Vivarium areas the calibration of the controller shall be programmed for the unoccupied mode. The space served by each STU is controlled in occupied and unoccupied modes as follows:
 - a. Occupied: The STU supplies a [constant volume] [variable volume] of supply air to the space. The controller monitors the air velocity sensor and modulates the supply air damper to maintain the supply air volume at the occupied set point. The controller monitors the room temperature sensor and modulates the reheat valve to maintain the space temperature at set point.
 - b. Unoccupied: The STU is controlled using the unoccupied temperature and volume set point. The controller may reset to the occupied mode for a predetermined time period upon a signal from the control system.
 2. Exhaust Terminal Unit: The pressure independent [constant volume] [variable volume] exhaust terminal unit (ETU) shall be controlled by an application specific DDC controller using electric actuation. Provide an auto zero module for each STU for periodic calibration of the controller's air velocity transducer. For exhaust terminal units serving non Laboratory, Animal or Vivarium areas the calibration of the controller shall be programmed for the Unoccupied Mode. The space served by the ETU is controlled in occupied and unoccupied modes as follows:
 - a. Occupied: The ETU exhausts a [constant volume] [variable volume] of air from the space. The controller monitors the air velocity sensor and modulates the exhaust air damper to maintain the exhaust air volume at the occupied set point.
 - b. Unoccupied: The ETU is controlled using the unoccupied volume set point. The controller may reset to the occupied mode for a predetermined time period upon a signal from the control system.
 3. Fume Hood Exhaust Terminal Unit: The pressure independent fume hood exhaust terminal unit (FHETU) shall be controlled by an application specific DDC

controller using electric actuation. This sequence is for constant volume fume hoods that incorporate an integral hood bypass. Provide an auto zero module for each STU for periodic calibration of the controller's air velocity transducer. The hood served by the FHETU is controlled in occupied and unoccupied modes as follows:

- a. Occupied: The FHETU exhausts a constant volume of air from the space through the fume hood. The controller monitors the air velocity sensor and modulates the exhaust air damper to maintain the exhaust air volume at the occupied set point.
- b. Unoccupied: The FHETU is controlled using the volume set point. The controller may reset to the occupied mode for a pre-determined time period upon a signal from the control system.

Q. Description – Input/Output Point Summary: For points not listed below and for software association, see sequence of operation. Points shall be able to integrate to trends and totalizations, as applicable. Additional points not specifically called for herein but required to perform the sequences as specified shall be provided at no additional cost to the Owner. Points labeled with * shall be trended.

<Engineer to edit Summary for Project Requirements >

1. Laboratory Supply Air Terminals: (CV)
 - a. Analog Inputs Measured:
 - 1) Space Temperature *
 - 2) Supply Air Temperature *
 - 3) Supply Air Flow – CFM *
 - 4) [Terminal Humidifier]
 - 5) [Space RH] *
 - 6) Exhaust to Track Supply or Supply to Track Exhaust for Room Pressurization *
 - 7) Differential Pressure Monitors (DPM)
 - b. Analog Inputs Calculated:
 - 1) Differential Flow *
 - 2) Valve Position *
 - 3) Damper Position – Supply & Exhaust *
 - 4) Per cent (%) Flow – Supply & Exhaust *
 - c. Digital Outputs:
 - 1) Auto - Zero Module
 - 2) [Fin Tube Radiation Valve] *
 - 3) [Alarms – Temp, Flow and Pressure]
 - d. Analog Outputs:
 - 1) Damper Control – Supply & Exhaust *
 - 2) Reheat Valve Control *
 - 3) Space Set Point Adjustment *
 - 4) [Fin Tube Radiation Valve] *
 - 5) [Humidifier Output]

-
- e. System Features - Programs:
 - 1) Alarm Instruction *
 - 2) Occupied/Unoccupied
 - 3) Trend *
 - 2. Laboratory General Exhaust Air Terminals: (CV)
 - a. Analog Inputs Measured:
 - 1) Exhaust Air Temperature *
 - 2) Exhaust Air Flow – CFM *
 - 3) Exhaust to Track Supply or Supply to Track Exhaust for Room Pressurization *
 - 4) Differential Pressure Monitors (DPM)
 - b. Analog Inputs Calculated:
 - 1) Differential Flow *
 - 2) Damper Position – Exhaust *
 - 3) Per cent (%) Flow – Exhaust *
 - c. Digital Outputs:
 - 1) Auto - Zero Module
 - 2) [Alarms – Temp, Flow and Pressure]
 - d. Analog Outputs:
 - 1) Damper Control – Exhaust *
 - e. System Features - Programs:
 - 1) Alarm Instruction *
 - 2) Occupied/Unoccupied
 - 3) Trend *
 - 3. Laboratory Supply Air Terminals: (VAV)
 - a. Analog Inputs Measured:
 - 1) Space Temperature *
 - 2) Supply Air Temperature *
 - 3) Supply Air Flow – CFM *
 - 4) Terminal Humidifier – When Required
 - 5) Space RH – When Required *
 - 6) Supply Air Flow Min/Max Cooling and Heating *
 - 7) Exhaust to Track Supply or Supply to Track Exhaust for Room Pressurization *
 - 8) Differential Pressure Monitors (DPM)
 - b. Analog Inputs Calculated:
 - 1) Differential Flow*
 - 2) Valve Position *
 - 3) Damper Position – Supply & Exhaust *
 - 4) Per cent (%) Flow – Supply & Exhaust *
 - c. Digital Outputs:
 - 1) Auto - Zero Module
 - 2) [Fin Tube Radiation] *
 - 3) [Alarms – Temp, Flow and Pressure]
 - d. Analog Outputs:

-
- 1) Damper Control – Supply & Exhaust *
 - 2) Reheat Valve Control *
 - 3) Space Set Point Adjustment *
 - 4) [Fin Tube Radiation Valve] *
 - e. System Features - Programs:
 - 1) Alarm Instruction
 - 2) Occupied/Unoccupied
 - 3) Trend *
4. Laboratory General Exhaust Air Terminals: (VAV)
 - a. Analog Inputs Measured:
 - 1) Exhaust Air Temperature *
 - 2) Exhaust Air Flow – CFM *
 - 3) Exhaust Air Flow Min/Max *
 - 4) Exhaust to Track Supply or Supply to Track Exhaust for Room Pressurization *
 - 5) Differential Pressure Monitors (DPM)
 - b. Analog Inputs Calculated:
 - 1) Differential Flow*
 - 2) Damper Position – Exhaust *
 - 3) Per cent (%) Flow – Exhaust *
 - c. Digital Outputs:
 - 1) Auto - Zero Module
 - 2) [Alarms – Temp, Flow and Pressure]
 - d. Analog Outputs:
 - 1) Damper Control – Supply & Exhaust *
 - e. System Features - Programs:
 - 1) Alarm Instruction
 - 2) Occupied/Unoccupied
 - 3) Trend *
 5. Office Environment – Supply Air Terminals: (CV)
 - a. Analog Inputs - Measured:
 - 1) Space Temperature *
 - 2) Supply Air Temperature *
 - 3) Supply Air Flow – CFM *
 - b. Analog Inputs Calculated:
 - 1) Differential Flow *
 - 2) Valve Position *
 - 3) Damper Position – Supply & Exhaust *
 - 4) Per cent (%) Flow – Supply & Exhaust *
 - c. Digital Outputs:
 - 1) [Fin Tube Radiation Valve] *
 - 2) [Alarms – Temp, Flow and Pressure]
 - d. Analog Outputs:
 - 1) Damper Control *
 - 2) Reheat Valve Control *

-
- 3) Space Set Point Adjustment *
 - 4) [Fin Tube Radiation Valve] *
 - e. System Features - Programs:
 - 1) Night Setback
 - 2) Occupied/Unoccupied
 - 3) Trend *
 - 6. Office Environment – General Exhaust Air Terminals: (CV)
 - a. Analog Inputs - Measured:
 - 1) Exhaust Air Temperature *
 - 2) Exhaust Air Flow – CFM *
 - b. Analog Inputs Calculated:
 - 1) Differential Flow *
 - 2) Damper Position – Exhaust *
 - 3) Per cent (%) Flow – Exhaust *
 - c. Digital Outputs:
 - 1) [Alarms – Temp, Flow and Pressure]
 - d. Analog Outputs:
 - 1) Damper Control *
 - e. System Features - Programs:
 - 1) Night Setback
 - 2) Occupied/Unoccupied
 - 3) Trend *
 - 7. Office Environment – Supply Air Terminals: (VAV)
 - a. Analog Inputs - Measured:
 - 1) Space Temperature *
 - 2) Supply Air Temperature *
 - 3) Supply Air Flow – CFM *
 - 4) Supply Air Flow Min/Max Cooling and Heating *
 - 5) Exhaust to Track Supply or Supply to Track Exhaust for Room Pressurization *
 - b. Analog Inputs Calculated:
 - 1) Differential Flow *
 - 2) Valve Position *
 - 3) Damper Position – Supply *
 - 4) Per cent (%) Flow – Supply *
 - c. Digital Outputs:
 - 1) [Fin Tube Radiation Valve] *
 - 2) [Alarms – Temp, Flow and Pressure]
 - d. Analog Outputs:
 - 1) Damper Control *
 - 2) Reheat Valve Control *
 - 3) Space Set Point Adjustment *
 - 4) [Fin Tube Radiation Valve] *
 - e. System Features - Programs:
 - 1) Night Setback

-
- 2) Occupied/Unoccupied
 - 3) Trend *
 8. Office Environment – General Exhaust Air Terminals: (VAV)
 - a. Analog Inputs - Measured:
 - 1) Exhaust Air Temperature *
 - 2) Exhaust Air Flow – CFM *
 - 3) Exhaust Air Flow Min/Max *
 - 4) Exhaust to Track Supply or Supply to Track Exhaust for Room Pressurization *
 - b. Analog Inputs Calculated:
 - 1) Differential Flow *
 - 2) Valve Position *
 - 3) Damper Position – Exhaust *
 - 4) Per cent (%) Flow – Exhaust *
 - c. Digital Outputs:
 - 1) [Alarms – Temp, Flow and Pressure]
 - d. Analog Outputs:
 - 1) Damper Control *
 - e. System Features - Programs:
 - 1) Night Setback
 - 2) Occupied/Unoccupied
 - 3) Trend *
 9. Laboratory Fume Hoods (LFH):
 - a. Analog Inputs Measured:
 - 1) Fume Hood Controller Air Flow – CFM *
 - 2) Fume Hood Safety Monitor Air Flow – FPM *
 - b. Analog Inputs Calculated:
 - 1) Damper Position – Exhaust *
 - 2) [Sash Height]
 - c. Analog Binary Input:
 - 1) Safety Monitor – Status Alarm
 - d. Digital Outputs:
 - 1) Auto - Zero Module
 - e. Analog Outputs:
 - 1) Damper Control – Supply & Exhaust
 - f. System Features - Programs:
 - 1) Fume Hood Controller – High Analog Alarm
 - 2) Fume Hood Controller – Low Analog Alarm
 - 3) Fume Hood Safety Monitor – Low Analog Alarm
 - 4) Trend *
 10. [General Exhaust Fans] [Hot Lab Exhaust Fans] [Fume Hood Exhaust Fans]:
 - a. Analog Inputs - Measured:
 - 1) Air Flow CFM *
 - b. Digital Output:
 - 1) On – Off *

-
- c. Digital Input:
 - 1) Current Sensor for Fan Status*
 - d. Analog Output:
 - 1) VFD
 - e. System Features:
 - 1) Alarm *
 - 2) Proof *
 - 3) LAN device for VFD to BAS
 - 4) Trend *
11. [ATC Isolation Dampers:]
- a. Analog Binary Input:
 - 1) Status
 - b. Digital Output:
 - 1) On – Off
 - c. System Features:
 - 1) Alarm
 - 2) Proof
12. [Filter Housing Assembly:]
- a. Analog Measured:
 - 1) Duct Pressure
 - b. Digital Output:
 - 1) Pressure Differential Across Each Filter
 - 2) Duct DP Sensor to BAS
 - c. System Features:
 - 1) Graphics and Programming
13. [Fan Coil Units], [Unit Heaters], [Cabinet Heaters]:
- a. Analog Inputs Measured:
 - 1) Space Temperature *
 - b. Analog Inputs Calculated:
 - 1) Valve Position *
 - c. Digital Output:
 - 1) On – Off *
 - 2) Heating Valve *
 - d. Digital Input:
 - 1) Current Sensor for Fan Status*
 - 2) FCU Drain Pan Moisture Sensor*
 - e. Analog Outputs:
 - 1) Reheat Valve Control *
 - 2) Space Set Point Adjustment *
 - f. System Features:
 - 1) Proof *
 - 2) Trend *
14. [Fan Powered Box:]
- a. Analog Inputs - Measured:
 - 1) Space Temperature *

- 2) Supply Air Temperature *
 - 3) Supply Air Flow – CFM *
 - b. Analog Inputs Calculated:
 - 1) Heating Valve Position *
 - 2) Cooling Valve Position *
 - 3) Damper Position – Return & Ventilation *
 - c. Digital Outputs:
 - 1) [Fin Tube Radiation Valve] *
 - 2) [Alarms – Temp and Flow]
 - d. Digital Input:
 - 1) Current Sensor for Fan Status*
 - 2) Drain Pan Moisture Sensor*
 - e. Analog Outputs:
 - 1) Damper Control *
 - 2) Reheat Valve Control *
 - 3) Cooling Valve Control *
 - 4) Space Set Point Adjustment *
 - 5) [Fin Tube Radiation Valve] *
 - f. System Features - Programs:
 - 1) Night Setback
 - 2) Occupied/Unoccupied
 - 1) Trend *
15. [Convectors]
- a. Analog Inputs Measured:
 - 1) Space Temperature *
 - b. Analog Inputs Calculated:
 - 1) Valve Position *
 - c. Digital Output:
 - 1) Heating Valve *
 - d. Analog Outputs:
 - 1) Heating Valve Control *
 - 2) Space Set Point Adjustment *
 - e. System Features:
 - 1) Trend *
16. [Chilled Beams]
- a. Analog Inputs Measured:
 - 1) Space Temperature *
 - b. Analog Inputs Calculated:
 - 1) Valve Position *
 - c. Digital Output:
 - 1) Heating Valve *
 - d. Analog Outputs:
 - 1) Heat Valve Control *
 - 2) Space Set Point Adjustment *
 - e. System Features:

- 1) Trend *
17. [Walk In Cold Rooms:]
 - a. Analog Inputs - Measured:
 - 1) Space Temperature
 - b. Analog Binary Input:
 - 1) Status
 - c. System Features:
 - 1) Alarm – High Binary Alarm
 - 2) Alarm – High/Low Temp Alarm
18. [Server Rooms:]
 - a. Analog Inputs - Measured:
 - 1) Space Temperature
 - 2) Compressor status
 - 3) RH
 - b. System Features:
 - 1) Alarm – High Analog Alarm
 - 2) Compressor Failure
 - 3) Safety Trip
 - 4) Com Error
 - 5) General Alarm
 - 6) Water Alarm
 - 7) Trend
 - 8) Alarm Instruction
 - 9) BACnet IP interface if applicable
19. Hydronic Pumps:
 - a. Analog Inputs - Measured:
 - 1) Water Temperature *
 - 2) Water Flow GPM *
 - b. Digital Output:
 - 1) On – Off *
 - c. Digital Input:
 - 1) Current Sensor for Pump Status *
 - 2) Alarms – Hx Control Valves *
 - d. Analog Output:
 - 1) VFD
 - e. System Features:
 - 1) Alarm *
 - 2) Proof *
 - 3) LAN device for VFD to BAS
 - 4) Trend *
20. Shell and Tube Heat Exchanges:
 - a. Analog Inputs - Measured:
 - 1) Water Temperature *
 - 2) Water Flow – GPM *
 - b. Analog Inputs Calculated:

-
- 1) Valve Position – 1/3 Steam Valve *
 - 2) Valve Position – 2/3 Steam Valve *
 - 3) Valve Position – BAS Valve *
 - c. Digital Outputs:
 - 1) Alarm – High Water Temp *
 - 2) Alarm – Low Water Temp *
 - 3) Alarms – Control Valves *
 - d. Analog Outputs:
 - 1) Damper Control *
 - e. System Features - Programs:
 - 1) Alarms *
 - 2) Valve Proof *
 - 3) Trend *
21. System Features (Typical for ‘1’ through ‘20’ above):
- a. General:
 - 1) Color Graphics
 - 2) DDC Control
 - 3) Programming
 - 4) Trend
 - b. For points related to supplemental A/C equipment see points list specified elsewhere.
 - c. For points related to HVAC Systems coordinate with UMB and insert as directed.
22. BAS Networking and Point Identification: BAS contractor shall use the UMB Standard BAS Networking and Point Identification information and naming conventions for all project required networking and points. Include these requirements in the BAS Submittal. Contact UMB Building Automation Manager for additional requirements.

2.18 BAS ENERGY / FLOW METERS

A. General Product Requirements:

1. Equipment Design and Selection: Meters used to measure energy and flow, or flow only shall be designed and selected, for the intended use, in accordance with the requirements of this specification. For this specification meters used to measure energy and flow are identified as “energy meters” and meters used to measure flow only are identified as “flow meters”.
2. Ultrasonic Energy Meters and Flow Meters: Subject to compliance with requirements, provide energy flow meters and flow meters for liquids by one (1) of the following:
 - a. Flexim Meters. (Basis of Design & UMB Preferred)
 - b. Katronic_Meters.

- B. Meter Types: Provide clamp on type ultrasonic energy flow meters and accessories specified in the Summary Chart and were indicated on the drawings and diagrams and as follows:
1. Flexim: Meters: Models F721 – Flow, F721 TE – Energy / Flow (BTU) or Model F532 – Flow while available.
 2. Katronic Meters: Models Kat 100 – Flow, Kat 150 – Energy / Flow (BTU).
 3. See Summary Chart for meter functions and applications.
- C. Meter Units of Measurement: Meters used as either Energy Meters or Flow Meters shall include the units of measurement as follows:
1. Energy Meters - Units of Measurement: The energy meter shall provide the following data both locally and remotely, from each system, via direct Ethernet communications capability as follows: **<Edit or Project>**
 - a. HVAC Hydronic System - Hot Water Heating Systems:
 - 1) Total Energy: In Btu.
 - 2) Energy Rate/Demand: Btu/h.
 - 3) Total Volume: In Gallons (Gal)
 - 4) Volume Flow Rate: In Gallons per Minute (GPM)
 - 5) Supply Temperature: In °F.
 - 6) Return Temperature: In °F.
 - 7) All readings must have a minimum accuracy of +/- 0.4%.
 - b. HVAC Hydronic Systems: Include Chilled Water, Process Cooling Water, Condenser Water, And Energy Recovery Systems:
 - 1) Total Energy: In Btu, kWh, and ton-hours.
 - 2) Energy Rate/Demand – Btu/hr, kW, and tons.
 - 3) Total Volume: In Gallons (Gal).
 - 4) Volume Flow Rate: In Gallons per Minute (GPM).
 - 5) Supply Temperature: In °F.
 - 6) Return Temperature: In °F.
 - 7) All readings must have a minimum accuracy of +/- 0.4%.

< Edit Paragraphs a – c above to meet project requirements>

 - 2. Flow Only Meters - Units of Measurement: The flow only meters shall provide the following data both locally and remotely, from each system, via direct Ethernet communications capability as follows:
 - a. HVAC Hydronic Systems: Include Hot Water Heating, Chilled Water, Process Cooling Water, Condenser Water, And Energy Recovery Systems:
 - 1) Total Volume: In Gallons (Gal).
 - 2) Volume Flow Rate: In Gallons per Minute (GPM).
 - 3) All readings must have a minimum accuracy of +/- 0.4%.
 - b. HVAC Drain and Fill Systems:
 - 1) Drain Meters – Condenser Water Drain Systems:
 - a) Volume Flow Rate: In Cubic Feet (CF) and Gallons (GAL).
 - b) All readings must have a minimum accuracy of +/- 0.4.

- 2) HVAC Fill – Make Up Water Systems:
 - a) Volume Flow Rate: In Gallons per Minute (GPM).
 - b) All readings must have a minimum accuracy of +/- 0.4%.
- c. Domestic Water System – Building Service:
 - 1) Total Volume: In Gallons (Gal), and Hundred Cubic Feet (CCF).
 - 2) Volume Flow Rate: Gallons per Minute (GPM); Gallons per hour (GPH)
 - 3) All readings must have a minimum accuracy of +/- 0.4%.

< Edit Paragraphs a – c above to meet project requirements >

D. Meter Data Outputs and Software: Data outputs and software shall be as follows:

1. Data Outputs: Data outputs shall be as follows:
 - a. Native: 4-20ma; 12-bit resolution, internally powered, can span negative to positive flow/energy rates; test function allows simulated flow output to verify proper installation and span settings on receiving equipment.
 - b. Required Outputs: Modbus TCP/IP or BACnet®/IP protocols. See Summary Charts for meter and protocol applications.

<UMB will select protocol based on project requirements >

2. PC Software Utility: PC software utility shall be included to configure calibrate, backup and conduct diagnostics on the flow meter. The software shall be compatible with Windows 7 and 10 operating systems.

E. Components: Components shall include the following:

1. Transmitters and Transducers: Unit shall be comprised of two (2) transducers for the transmission and reception of ultrasonic signals, a digital signal processor module to integrate raw measurement data and compute volumetric flow and/or energy rate and total, and an LCD display. Data can be output to a SCADA system, PLC or BAS (building automation system) using various analog, digital, serial, and/or IP outputs.
2. Temperature Sensors: Sensors used to measure temperature by correlating the resistance of the RTD element with temperature. Set consists of one to measure liquid in the inlet pipe, and one to measure the liquid in the outlet pipe.
3. Mounting Hardware: Stainless steel mounting straps and two types of acoustic coupling medium for proper mounting of the transducers in either short term or long term applications.
4. PC Software Utility: PC software utility shall be included to configure calibrate, backup and conduct diagnostics on the flow meter. The software shall be compatible with Windows 7 and 10 operating systems.
5. Calibration: Flow meter calibration data shall be performed by the factory prior to use. Calibrate to NIST standards to ensure between $\pm 1\%$ accuracy of reading for transit time.

- F. Ultrasonic Energy and Flow Meter Summary Chart: See flow meter summary chart on the next page. <Edit or Project>

Table 4- Ultrasonic Energy and Flow Measurement Meters Summary Chart

Building System	Meter Type	Function	LAN	Flow Meter	Components
HVAC Hydronic Water Meters	Strap On	Flow	Ethernet Modbus TCP or Bacnet IP	Flexum – F721 Katronic – Kat100	Flow Sensors Transmitter
HVAC Make up Water and / or Drain and Fill Water Meters	Strap On	Flow	Ethernet Modbus TCP or Bacnet IP	Flexum – F721 Katronic – Kat100	Flow Sensors Transmitter
HVAC Hydronic	Strap On	Energy & Flow (BTU)	Ethernet Modbus TCP or Bacnet IP	Flexum – F721TE Katronic – Kat150	Flow Sensors Transmitter Temp Sensors
HVAC Steam	Strap On	Energy & Flow (BTU)	Ethernet Modbus TCP or Bacnet IP	Flexum – F721TE Katronic – Kat150	Flow Sensors Transmitter Temp Sensors
Building Water Service Meters	Strap On	Flow	Ethernet Modbus TCP or Bacnet IP	Flexum – F721 Katronic – Kat100	Flow Sensors Transmitter

2.19 TESTING AND BALANCING

A. Testing and Balancing (TAB):

1. General: All TAB work shall be accomplished by an air balancing agency certified by AABC only. NEBB certified balancing companies will not be permitted.

2. Scope of Work: Balance the HVAC systems in the project area for air quantities and/or GPM flow rates indicated on the CD's. Acceptable results are where the actual measured values (cfm and/or gpm) are with-in +/- 10% of the design values.
3. TAB Report – Rough Draft: Identify the following:
 - a. Actual CFM and/or GPM results and compare them to the design requirements.
 - b. Identify any deficiencies and problems found in systems being tested and balanced.
 - c. Provide a list of deficiencies and problems to the CM along with any suggested corrections.
 - a. Where actual results are more than 10% below the design values submit an RFI.
 - b. When the deficiencies have been corrected rebalance the systems.
 - c. If the results are not acceptable repeat 'c' through 'e' until the results are acceptable, then see 'g'.
 - d. When the results are acceptable prepare a final TAB Report.
4. Final TAB Report: The TAB contractor shall submit one (1) electronic "pdf" file of the TAB report to engineer for review. TAB report shall bear the seal and signature of Test and Balance Engineer.

2.20 PROJECT OPERATION AND MAINTENANCE MANUAL – ELECTRONIC FILES

- A. Project O & M Manual File: The project OM Manual shall include one (1) electronic copy of each approved submittal and any manufacturer's maintenance manuals, and all warranty certificates included in this Division. Also include the address, phone number and contact person for each supplier. Using the UMB Standard O&M Manual Template referenced in Division 01 Closeout Procedures insert the submittal files include both a bookmark and tree structure for accessing each submittal file in the manual.

2.21 CONCRETE HOUSEKEEPING PADS <Delete if nor Required>

- A. Provide concrete required for housekeeping pads under Division 22 unless otherwise noted.
- B. Concrete shall be 3,500 psi twenty-eight (28) day compressive strength concrete and reinforcement bars as specified in the architectural specifications.

2.22 GROUT <Delete if nor Required>

- A. Grout shall be non-shrink, high strength type, free of iron or chlorides and suitable for use in contact with all metals, without caps or other protective finishes complying with ASTM C 1107, Grade B and the following:

1. Characteristics: Post hardening, volume adjusting, dry, hydraulic cement grout, non-staining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5,000 psi (34.50MPa), twenty eight (28) day compressive strength.
3. Packaging: Premixed and factory packaged.

2.23 DUCT AND PIPE LEAK TESTING

A. Duct System Leak Test:

1. General: The Contractor conducting the test shall use this Test Procedure for all new duct systems. All new pressurized duct systems (positive and negative) shall be leak tested prior to the duct insulation being installed and/or the duct systems being concealed in shafts and/or above hard ceilings where indicated on the drawings. Where duct systems are indicated to be concealed, these duct systems shall not be enclosed until each system as successfully passed its leak test. Test each duct system as a whole or in segments as required by progress of the work.
2. Duct Construction and Seal Class: All ductwork will be constructed to meet the requirements of SMACNA Seal Class A and shall be leak tested to meet the requirements of SMACNA Leak Class 2.
3. Leak Test Requirements: Unless otherwise directed by UMB, 100% of each non welded duct system shall be leak tested following the outlines and classifications in “The SMACNA HVAC Air Duct Leakage Test Manual” 2012 or latest edition or 1% duct leakage, whichever is greater. The total allowable leakage shall not exceed SMACNA Leak Class 2 for all duct construction. This UMB requirement exceeds standard SMACNA requirements.
4. Pre Test Procedure:
 - a. Prior to testing, the Sheet Metal Contractor shall manually remove all debris from inside ductwork, plenums, and equipment. Do not use Fans to remove the debris. Verify that all duct mounted equipment, access doors, accessories, components are installed complete as specified. Set all Fire Dampers, Smoke Dampers, or Combination Fire/Smoke Dampers in their proper position with “Fire Links” or other devices required for operation, in place and set.
 - b. Provide test blank off plates between each segment to be tested and provide access doors as specified to permit the removal of the blank off plates when the testing has been completed and approved by UMB.
5. Leak Test Procedure:
 - a. Close off and seal all openings in the duct section to be tested. Connect the test apparatus to the duct by means of a section of flexible duct.
 - b. Calculate the allowable leakage rate for the duct system or duct segment to be tested using the specified allowable leakage rate and the air volume
 - c. Start the blower with its inlet control damper closed.
 - d. Gradually open the inlet control damper until the pressure in the duct reaches the design duct operating pressure/class. Read and record the test pressure indicated on manometer (#1). Read and record the pressure differential across the orifice indicated on manometer (#2). Read and record the duct leakage

rate in CFM from the appropriate calibration curve. If there is no leakage, the pressure differential will be zero (0).

- e. If the test results indicate a leakage rate that exceeds the specified leakage rate the contractor and UMB Personnel shall survey all joints for audible leaks. Mark each location and repair the joints after shutting down the blower. After the sealant has set for at least twenty four (24) to thirty six (36) hours the contractor shall reschedule the test with all appropriate parties. Follow the procedures outlined in paragraphs 1, 2, 3 and 4 above. If the pressure test fails again the contractor shall repeat the entire process until the tested section passes the leak test.

B. Pipe System Hydrostatic/Leak Test:

1. HVAC Piping Systems: The following Pipe Systems shall be Hydrostatically Leak Tested by the contractor. All piping systems shall be proven tight in the presence of UMB Project Engineer prior to installation of insulation, and connection to exist piping systems. Provide all equipment and labor necessary for hydrostatically testing each system for one (1) hour at the minimum pressures as specified herein unless otherwise noted:
 - a. Heating supply/return piping 100 psig
 - b. Chilled water piping 100 psig
 - c. Cooling water piping 100 psig
 - d. Condenser water piping 100 psig
 - e. Steam & condensate piping 100 psig
 - f. Non - lab natural gas piping 50 psig minimum *
 - g. Refrigerant piping Psig as noted below
 - h. *Cap and fill each system, with oil-free, dry nitrogen, to pressure of one and one half (1-1/2) times the system operating pressure, but not less than fifty (50) psig. Isolate the test source and let stand for four (4) hours to equalize temperature. Refill system, if required, to test pressure and hold pressure for one (1) hour with no allowable drop in pressure.

<Delete Pipe Systems Not Applicable to Project>

2. Systems using Pro-Press piping connectors shall perform a pre-test at 30 psi for ten (10) minutes. After the hydrostatic test pressure has been applied for ten (10) minutes and with no allowable drop in pressure, the tested system or segment has passed the Pro-Press leak pretest. If after the ten (10) minute test period there is a loss in pressure below the initial test pressure, the test has failed, and the contractor shall examine piping, joints, and connections for leakage. After all leaks have been corrected by tightening, repairing, and/or replacing components as appropriate, the hydrostatic test shall be rescheduled with the University. The test procedure shall be repeated as specified above until there are no leaks and there is no loss in pressure.
3. Refrigerant Piping System: The Contractor conducting the test shall use this Test Procedure for Refrigerant Piping Systems. Test each pipe system as a complete system. Testing this piping system in segments is not permitted. Test shall include

both the high- and low-pressure sides of each system. Inspect, test and perform corrective action of refrigerant piping in accordance with ASME Code B31.5, Chapter VI and as follows: ~~<Delete if not required>~~

- a. All refrigerant tubing shall be tested before tube insulation is applied.
- b. Tests shall be performed with dry nitrogen. Oxygen, air, combustible gasses and mixtures containing such gases shall not be used.
- c. Refrigerant relief valves, if installed, shall be removed prior to pressure testing and shell openings plugged. After system is tested and found to be completely tight, relief valves shall be reinstalled prior to system evacuation.
- d. Each tubing system shall be pressure tested with dry nitrogen. Leaks shall be repaired by removing and remaking the defective joint. No caulking will be permitted. After repair of leaks, system shall be retested and proved tight.
- e. Refrigerant pipe tests shall include both the high- and low-pressure sides of each system at not less than the lower of the design pressures or the setting of the pressure relief device(s) for four (4) hours. The design pressures for testing shall be those listed on the condensing unit, compressor or compressor unit nameplate as required by ASHRAE 15.
- f. Test apparatus. The means used to build up the test pressure shall have either a pressure-limiting device or a pressure-reducing device and a gauge on the outlet side.
- g. Declaration. A certificate of test shall be provided for all systems tested under this requirement. The certificate shall give the name of the refrigerant and the field test pressure applied to the high side and low side of the system. The certification of test shall be signed by the installer and be made part of the project documentation.

C. Hydrostatic/Leak Test Forms:

1. Contractors shall use the UMB Standard Leak Test Summary Forms for recording the leak test results for all duct and pipe systems tested on this Project as follows:
 - a. UMB Standard Air Duct Leak Test Summary Form.
 - b. UMB Standard Pipe System Hydrostatic/Leak Test Summary Form.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS – EXECUTION

- A. All construction work that creates excessive noise will not be permitted during normal business hours. See Division 01 Specification Section “Cutting and Patching” for requirements.

3.2 CONNECTIONS AND ALTERATIONS TO EXISTING WORK

- A. When existing mechanical work is removed, all pipes, valves, ducts, etc. shall be removed back to the active pipe and duct mains and capped.

- B. Removal and/or relocation of existing services shall be closely coordinated with Facilities
- C. Management if they impact adjacent areas which shall remain operational.
- D. While performing connections and alterations to existing mechanical work, the contractor shall take extreme care to protect all existing materials, equipment, casework etc. from dirt, debris, and damage. Any damage caused by the contractor to existing materials, equipment, casework, etc. shall be repaired to UMB's satisfaction and specifications at the contractor's expense.

3.3 CUTTING AND PATCHING

- A. Cutting and patching associated with the work in the existing structure shall be performed a neat and workmanlike manner. Existing surfaces that are damaged by the contractor shall be repaired or provided with new materials to match existing.
- B. Structural members shall not be cut or penetrated. Holes cut through concrete and/or masonry to accommodate new work shall be cut by reciprocating or rotary, non-percussive methods.
- C. Patching of areas disturbed by installation of new work and/or required demolition shall match existing adjacent surfaces as to material, texture and color.

3.4 CUTTING, WELDING, BURNING

- A. Before the contractor and/or any sub-contractor commences any cutting, welding, burning or other type of hot work at UMB, the contractor must request a Hot Work Permit from the UMB Office of the Fire Marshal. Hot Work Permits must be requested online at <https://www.umaryland.edu/fire-marshal/hot-work-permits/> at least one (1) day before beginning hot work.
- B. The hot work permit copy shall remain on the job site at the hot work location until such work is completed.

3.5 INSTALLATION – HVAC PIPING SYSTEMS

- A. Install all piping systems level and parallel to the building walls, and partitions. Diagonal runs are prohibited unless specifically indicated otherwise.
- B. Where horizontal piping offsets to clear obstructions such as ductwork, structural members and work installed by other trades provide drain valves and air vents in locations where they can be accessed.
- C. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- D. Install piping in concealed locations unless otherwise indicated.

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- E. Install piping exposed in equipment rooms and service areas unless otherwise noted.
 - F. Pipe Joints: Comply with the following:
 - 1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
 - 2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
 - 3. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
 - 4. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook."
 - G. HVAC Branch Pipe Connections: Install branch pipe connections off the top of the main pipe or on a 45-degree upward angle. Branch connections off the bottom of the main pipes are not acceptable.

3.6 PIPING SPECIALTIES

- A. Dielectric Connections:
 - 1. Install dielectric connections where piping of dissimilar metals and tubing are joined.
 - 2. Dielectric Connections for NPS 2 and Smaller: Use stainless steel threaded nipples.
 - 3. Dielectric Connections for NPS 2-1/2 and Larger: Use dielectric flange kits.

3.7 INSTALLATION – REFRIGERANT PIPING SYSTEMS

- A. Install refrigerant piping according to ASHRAE 15.
- B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping adjacent to machines to allow service and maintenance.
- F. Install piping free of sags and bends.
- G. Install fittings for changes in direction and branch connections.
- H. Slope refrigerant piping as follows:

1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
2. Install horizontal suction lines with a uniform slope downward to compressor.
3. Use double-suction riser for maximum compressor efficiencies if load variation is expected.
4. Install traps and double risers to entrain oil in vertical runs.
5. Liquid lines may be installed level.

I. Pipe Joints: Comply with the following:

1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
3. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
4. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - a. Use Type BCuP (copper-phosphorus) alloy for joining copper socket fittings with copper pipe.
 - b. Use Type BAg (cadmium-free silver) alloy for joining copper with bronze or steel.

3.8 INSTALLATION – PIPE SLEEVES

A. Fire Rated Walls: Where new and/or existing plumbing piping passes through rated walls provide pipe sleeves with required fire sealant materials to maintain the rating of the wall assembly.

1. Use standard weight steel pipe or service weight cast iron pipe for pipe sleeves. Where sleeves are installed in floors and load bearing walls, use only standard weight steel pipe for pipe sleeves.
2. Provide a minimum of one half (1/2) inch annular space clearance around the entire circumference of the pipe and/or insulation on cold piping passing through the sleeve and between the pipe sleeve and the surface of the core drilled hole.
3. Center pipe passing through sleeve.
4. Except for cold piping, do not continue insulation through sleeve.
5. The entire annular spaces must be sealed with fire and waterproof sealant. Seal ends of pipe insulation and butt insulation ends up to fire stopping sealant in sleeve.
6. Sleeves in walls must be installed flush with both finished wall surfaces.
7. In finished areas provide an escutcheon plate around the bare pipe or insulated pipe passing through the assemblies to conceal the sleeve and sealant.

<Engineer Note: Where openings in walls for pipe sleeves are large enough to require additional structural supports such as lintels the A/E team shall coordinate the additional wall supports with structural engineer>

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- B. Fire Rated Floors: Where new and/or existing plumbing piping passes through rated walls provide pipe sleeves with required fire sealant materials to maintain the rating of the wall assembly.
1. Use standard weight steel pipe or service weight cast iron pipe for pipe sleeves.
 2. Provide a minimum of one half (1/2) inch annular space clearance around the entire circumference of the pipe and/or insulation on cold piping passing through the sleeve and between the pipe sleeve and the surface of the core drilled hole.
 3. Center pipe passing through sleeve.
 4. Except for cold piping, do not continue insulation through sleeve.
 5. The entire annular spaces must be sealed with fire and waterproof sealant.
 6. Seal ends of pipe insulation and butt insulation ends up to waterproof sealant in sleeve.
 7. Sleeves must be installed with top of sleeve one (1) inch above the finished floor surface. The bottom of the sleeve must be flush with the finished surface of the underside of the floor assembly.
 8. In finished areas provide an escutcheon plate around the bare pipe or insulated pipe passing through the assemblies to conceal the sleeve and sealant. If a riser clamp is in place, omit the escutcheon.
- C. Non-Fire-Rated Soundproof Partition Penetrations: Where pipes pass through interior partitions with sound proofing provide a pipe sleeve. Seal the annular spaces between construction openings, the sleeve, the pipe and/or pipe insulation with soundproof insulation material equal to the width of the opening. The soundproof insulation shall match the insulation in the partition. <Delete if not required>
- D. Sealant Requirements: Comply with requirements for sealants specified in Part 2.
- E. Fire-Barrier Penetrations: Comply with requirements for firestopping specified in Part 2.

3.9 INSTALLATION – VALVES

- A. Valves shall be placed in such manner as to be easily accessible for smooth and easy hand wheel operation and packing maintenance.
- B. Install valves in piping systems were shown on drawings, diagrams and details and where indicated below:
1. To Isolate:
 - a. Motorized flow control valves.
 - b. Equipment.
 - c. Pipe risers.
 - d. Branch piping.
 2. To Drain:
 - a. Low points in piping systems.
 - b. Pipe risers.

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- c. Equipment.
 - d. Trapped sections in the piping system.
 - 3. To Balance:
 - a. Flow to equipment and coils.
 - C. Where piping or equipment may be subsequently removed, provide valves with bodies having integral flanges or full lugs drilled and tapped to hold valve in place so that downstream piping or equipment can be disconnected and replaced with blank-off plate while valve is still in service.
 - D. Shut off valves serving equipment and/or control valves shall be installed full size at the equipment connection.
 - E. Where there is no interference, shut-off valves shall be installed with hand wheel located up on the horizontal runs of pipe to prevent accumulation of foreign matter in working parts of valves.
 - F. On valves, strainers, etc., installed in copper piping, provide a union on the discharge side of each valve, and threaded adapters where copper piping connects to valves, strainers, etc.
 - G. Where valves are installed in piping systems for pressure gauges, P/T plugs, DP Switches etc, for each device provide a three quarter (3/4) inch tap in piping systems one (1) inch and larger and provide a one half (1/2) inch tap in piping systems less than one inch.
 - H. Install drain valves at low points of risers and at trapped/low points in mains, branch lines, and everywhere else required to permit drainage of the entire piping system.
 - I. Where threaded ball valves are installed in brazed copper piping systems braze each threaded adapter on to the piping. After each adapter has cooled to the touch install the threaded ball valve. Do not connect the threaded adapter to the valve and then braze the adapter and valve to the piping as this will result in damage to the valve seals. If any valve, in the brazed piping systems are damaged due to faulty installation the damaged valves shall be replaced by the contractor at no cost to the University.
 - J. Where butterfly valves are installed in copper piping systems provide companion flanges and dielectric gasket kits for each flange. When valves and/or fittings are installed in piping where electrolysis may occur provide dielectric flange kits at each connection. In heating hot water systems where dielectric connections are required, provide connections rated for an operating temperature of at least 200°F minimum.
- 3.10 INSTALLATION – INTERIOR HANGERS AND SUPPORTS
- A. Piping Systems: Hangers and supports shall be provided for all piping systems, as recommended by the hanger manufacturers for the existing structural elements. Additional requirements are as follows:

1. On piping systems requiring insulation, hangers and supports shall be installed external to the insulation material, and sheet metal saddles shall be provided.
 2. Hangers and supports shall be provided at all changes of direction and elevations on piping system.
 3. Spacing shall be as recommended by manufacturer, for each pipe size and material type.
- B. Duct Systems: Hangers and supports shall be provided for all duct systems, as recommended by SMACNA for the existing structural elements. Additional requirements are as follows:
1. Spacing shall be as recommended by SMACNA, for each duct size and material type.
 2. Support horizontal ducts within two (2) feet of each elbow and within four (4) feet of each branch intersection.

3.11 INSTALLATION – DUCT WORK

- A. Install all rigid ducts with support systems indicated in SMACNA “HVAC Duct Construction Standards,” Tables 4-1 through 4-3 and Figures 4-1 through 4-9.
- B. Install all ducts with the fewest possible joints.
- C. Locate ducts, except as otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs. Install duct systems in shortest route that does not obstruct useable space or block access for servicing building and its equipment.
- D. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- E. Install louvers and accessories complete with mounting frames as indicated on the drawings. Coordinate all rough opening requirements with all trades prior to fabrication or procurement of any penetrations. <Delete if not required>
- F. Horizontal Ducts: In finished spaces with suspended ceilings conceal the horizontal ducts above suspended ceilings. In finished spaces without suspended ceilings install as shown on drawings and details.
- G. Vertical Ducts: Conceal vertical ducts in hollow wall construction in finished spaces or in utility shafts as indicated on the drawings and details.
- H. Non-Fire-Rated Partition Penetrations: Where ducts pass interior partitions and are exposed to view, conceal space between construction opening and duct and/or duct insulation with sheet metal flanges of same gauge as duct. Overlap opening on four (4) sides by at least one and one-half (1-1/2) inches.

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- I. Non-Fire-Rated Soundproof Partition Penetrations: Where ducts pass through interior partitions with sound proofing seal the annular spaces between construction openings, the sleeve, the duct and/or duct insulation with soundproof insulation material equal to the width of the opening. The soundproof insulation shall match the insulation in the partition. <Delete if not required>
 - J. Fan Powered Equipment Connections: Connect ducts to fan powered equipment with flexible connections. Comply with SMACNA “HVAC Duct Construction Standards,” for requirements.
 - K. Branch Connections: Comply with SMACNA “HVAC Duct Construction Standards,” Figures 2-5, 2-6, 2-14 and 2-15.
 - L. Seam and Joint Sealing: Seal duct seams and joints as follows:
 - 1. Seal all transverse joints, longitudinal seams, and duct penetrations.
 - 2. Seal externally insulated ducts prior to insulation installation.
- 3.12 INSTALLATION – PIPE AND DUCT INSULATION
- A. Fiberglass Pipe Insulation:
 - 1. All insulation shall be installed by a qualified insulation contractor. Insulation installed on cold surfaces shall have a vapor barrier and exposed ends shall be sealed. All insulation shall be installed and all seams, sealed, with Benjamin Foster sealant, according to manufacturer’s recommendations.
 - 2. Bond insulation to pipe with lagging adhesive.
 - 3. Seal exposed ends with lagging adhesive.
 - 4. Seal seams and joints with vapor barrier compound.
 - 5. Where existing pipe insulation is disturbed for demolition work, and piping is capped, repair and seal damaged insulation.
 - 6. Where existing pipe insulation is disturbed for demolition work, and new piping is connected at that location, butt new insulation up to the existing insulation and seal the joints as specified herein.
 - 7. On new piping systems requiring insulation all pipe insulation shall be continuous through point of support. Provide sheet metal saddles between insulation and pipe hangers.
 - 8. Where new piping connects to existing piping the new insulation shall match the thickness of the existing insulation.
 - B. Fiberglass Duct Insulation:
 - 1. Install insulation tight and smooth to the duct surface.
 - 2. Secure to ducts having long sides or diameters as follows:
 - a. Smaller than twenty four (24) inches: Apply bonding adhesive in six (6) inch wide transverse strips on twelve (12) inch centers.

- b. Twenty four (24) inch and larger: install anchor pins spaced twelve (12) inches apart each way. Apply bonding adhesive to prevent the insulation from sagging.
- c. Overlap the joints three (3) inches.
- d. Seal joints, breaks, tears, and punctures with vapor barrier compound.
- e. Where existing duct insulation is disturbed for demolition work, and duct is capped, repair and seal damaged insulation.
- f. Where existing duct insulation is disturbed for demolition work, and new ductwork is connected at that location, butt new insulation up to the existing insulation and seal the joints as specified herein.

3.13 INSTALLATION – PIPE LABELS

- A. General: Provide pipe labels with directional arrows every twenty five (25) feet on straight runs of horizontal and vertical pipes exposed in equipment rooms, utility shafts and above ceilings. In addition to the referenced spacing above comply with the following:
 1. Where pipes pass through floors, walls and partitions provide pipe labels on each side of the penetration.
- B. Exposed Piping: Install pipe labels in accessible locations on the piping systems so they are visible from the floor. Do not install pipe labels on sections of pipe that are not in a person's sight line.
- C. Concealed Piping: Install pipe labels in accessible locations on the piping systems so they are visible from the point of access through the ceiling tile or ceiling access door.
- D. Directional Arrows: Install directional arrows to indicate the correct flow direction.
- E. All pipe labels and flow arrows that are found to be incorrectly installed shall be replaced and corrected at no additional cost to the project.

3.14 INSTALLATION – DUCT LABELS

- A. General: Provide duct labels every twenty five (25) feet on straight runs of horizontal and vertical exposed ducts in equipment rooms, utility shafts and above ceilings. In addition to the referenced spacing above comply with the following:
 1. Where ducts pass through floors, walls and partitions provide duct labels on each side of the penetration.
- B. Exposed Ducts: Install duct labels in accessible locations on the duct systems so they are visible from the floor. Do not install duct labels on sections of duct that are not in a person's sight line.

- C. Concealed Ducts: Install duct labels in accessible locations on the duct systems so they are visible from the point of access through the ceiling tile or ceiling access door.
- D. Directional Arrows: Install directional arrows to indicate the correct flow direction.
- E. All duct labels and flow arrows that are found to be incorrectly installed shall be replaced and corrected at no additional cost to the project.

3.15 FUME HOOD CONTROLLER ASSEMBLY

- A. BACnet Fume Hood Controller: The enclosure may be mounted directly on the exterior of the fume hood or remotely on the laboratory wall or ceiling.
- B. Operator Display Panel II: The Operator Display Panel shall be field mounted on the fume hood were indicated on the fume hood submittal and shall fit over any unused hood electrical box or over predrilled holes.

3.16 INSTALLATION – BAS SENSORS <Edit for Project or Delete if not required>

A. Room Sensors:

1. Wall Mounting Height: Wall mount sensor with the centerline @ forty eight (48) inches AFF and to the right of the room light switch with a two (2) inch space between the devices.
2. Duct Mounted: When the space sensor cannot be wall mounted provide a duct mounted temperature sensor located in the rooms general exhaust duct.
<Coordinate with UMB> <Delete if not required>

B. Current Sensors: All motors serving HVAC fans and pumps shall be provided with a current sensor for “on/off” status to the BAS.

C. Moisture Sensors: All terminal A/C units shall be provided with moisture sensors in the unit’s condensate drain pan for “high water” alarm. When high water level is detected, the sensor shall send an alarm to the BAS and shut off the unit. The BAS alarm shall also remotely notify the client via [email], [or text] [or all three (3)] types of notification methods. <engineer coordinate with UMB and edit for project>

3.17 INSTALLATION – BAS ULTRASONIC ENERGY AND FLOW METERS

A. General:

1. Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of meters and gauges in the HVAC piping systems. So far as practical, install meters as indicated.
2. Accessibility: All meters shall be installed in accessible locations for maintenance.
3. Installation does not require system shut down and/or cutting into any piping.

4. Follow manufacturer's recommendation upstream and downstream straight pipe diameters and transducer orientation to achieve optimum performance.
 5. Enter pipe and liquid configuration information into the flow meter. The flow meter will calculate transducer separation from the data entered.
 6. Mechanical Requirements: See details on the mechanical and/or plumbing drawings for installation requirements.
 7. BAS Interface Wiring: All BAS interface wiring to the BAS and power wiring from a local junction box shall be provided and installed by the control contractor.
 8. Power Wiring: Power wiring from the electric panel to the local junction box shall be provided by the electrical contractor. All power wiring from a local junction box to the meter shall be provided and installed by the control contractor.
- B. Ultrasonic Energy Meter Display Unit: Install the ultrasonic meter display unit in an accessible location sixty (60) AFF on the nearest wall. Additional installation requirements are as follows:
1. Transducers w/ Caulking: Install the remote transducers and temperature sensors on the HVAC System piping in a location that will promote a clear reading and provide the minimum straight runs of pipe on both upstream and downstream piping sections of the transducers and temperature sensors. Where the transducers are located on the chilled water piping remove a section of pipe insulation and install the transducers per the manufacturer's installation instructions. After the transducers have been secured in place caulk all around the outer edge each transducer body with a non-cracking DOW 732 Silicone Sealant. When the sealant has cured insulate the piping up to and between the transducers. Connect the transducer leads to the remote meter.
 2. Transducers: Install the remote transducers and temperature sensors on the HVAC System piping in a location that will promote a clear reading and provide the minimum straight runs of pipe on both upstream and downstream piping sections of the transducers and temperature sensors. Where the transducers are located on the chilled water piping remove a section of pipe insulation and install the transducers per the manufacturer's installation instructions. Connect the transducer leads to the remote meter.
 3. Temperature Sensors: Mount the temperature sensors onto the supply and return pipes according to the direction provided in the instruction manual. Where the temperature sensors are located on the chilled water piping remove a section of pipe insulation and install the sensors around the pipe per the manufacturer's installation instructions. Cover each sensor with insulation and extend the sensor lead through the insulation. Place a bead of caulk around the lead where it passes through the insulation jacket. Connect the sensor leads to the remote meter.
 4. Provide supports for the wire leads between the meter and the transducers and sensors.
 5. Follow manufacturer's recommendation upstream and downstream straight pipe diameters and transducer orientation to achieve optimum performance.

6. Enter pipe and liquid configuration information into the flow meter. The flow meter will calculate transducer separation from the data entered.

3.18 INSTALLATION – SHELL AND TUBE HEAT EXCHANGERS

A. Equipment Mounting: <Edit for Project Requirements>

1. Install heat exchangers on cast in place concrete housekeeping pads. Comply with requirements for housekeeping pads [specified in Architectural Specification Sections "Cast in Place Concrete." and "Miscellaneous Cast in Place Concrete."]
[in this Division and detailed on the drawings.] <Edit for Project>

B. Install heat exchangers on saddle supports.

C. Heat Exchanger Supports: Use factory fabricated steel cradles and supports specifically designed for each heat exchanger.

3.19 INSTALLATION – HYDRONIC PUMPS <Insert Requirements Below>

3.20 INSTALLATION – EXTERIOR PIPE, DUCT AND EQUIPMENT SUPPORTS

A. General: Coordinate the location of the exterior pipe, duct and equipment supports with the existing structural system of the building. As required provide necessary structural framing to support the assemblies. Coordinate with all other related trades to ensure the complete assembly (curbs, supports, pipes ducts, and equipment) is weather tight.

3.21 CONCRETE HOUSEKEEPING PADS <Delete if not Required>

A. General: Construct concrete housekeeping pads to support mechanical equipment were indicated and as detailed on the drawings and as specified herein. Engage the services of the Structural or General Contractor, and pay for them, to provide the concrete housekeeping pads. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations.

B. Housekeeping Pads: Set all floor-mounted equipment on four (4) inch high concrete housekeeping pads, unless otherwise shown or specified.

1. Housekeeping Pads: Pads shall be a minimum of four (4) inches wider and longer than vibration isolation base or structural base of equipment being set on pad.

3.22 CLEANING AND FLUSHING

A. General Requirement: The contractor shall secure the services of the water treatment company that is under service contract to UMB, to clean, flush and add chemical treatment to new piping systems that are required to be connected to existing piping systems serving the building or campus. The cost for labor and material for this work

must be included in the contractors bid price. The contractor shall be responsible for the scope of work for the UMB water treatment company.

- B. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris; repair damaged finishes, including chips, scratches, and abrasions.
- C. Before adding chemicals to the system, isolate coils for heating and cooling equipment, and open bypasses.
- D. Flushing portions of the system:
 - 1. After a piping loop has been completed and prior to the installation of strainer baskets, flush that portion of the system. Connections shall be same size as piping being flushed, or one size smaller.
 - 2. When a major section of the building has been completed, repeat the same procedure, except that pipe connections shall be limited to one and one half (1-1/2) inch.
 - 3. Flushing shall remove sediment, scale, rust and other foreign substances.
 - 4. After flushing, install strainers and pressure test system and make it tight.
- E. Chemical cleaning: Fill system with sufficient detergent and dispersant to remove dirt, oil, and grease.
 - 1. Circulate for at least forty eight (48) hours.
 - 2. Open a drain valve at the lowest point and bleed while the system continues to circulate. Assure that the automatic make-up valve is operating.
 - 3. Continue until water runs clear and all chemicals are removed. Sample and test the water until pH is the same as pH of makeup water.
 - 4. After chemical cleaning, remove strainers, clean and reinstall them.
 - 5. Close bypasses and open valves to coils.
- F. Submit certificate and test results to the UMB Project Manager.

3.23 FUNCTIONAL TESTING OF NEW HVAC SYSTEMS

- A. Testing Preparation:
 - 1. Certify in writing to the UMB testing agent that new HVAC systems, subsystems, and equipment have been installed, calibrated and are operating according to the Contract Documents.
 - 2. Certify in writing to the UMB testing agent that new HVAC hydronic piping systems have been flushed and disinfected according to the Contract Documents.
 - 3. Certify in writing to the UMB testing agent that new HVAC instrumentation and control systems have been completed and calibrated, that they are operating

- according to the Contract Documents, and that pretest set points have been recorded.
4. Certify in writing that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
 5. Place new systems, subsystems, and equipment into operating mode to be tested (e.g., for supply and exhaust terminal units, and/or exhaust fans normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
 6. Inspect and verify the position of each device and interlock identified on checklists.
 7. Check safety cutouts, alarms, and interlocks for supplemental A/C equipment with the BAS.
 8. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the UMB testing agent.
- B. Tab Verification:
1. Notify the UMB testing agent at least ten (10) days in advance of testing and balancing Work and provide access for the UMB testing agent to witness testing and balancing Work.
 2. Provide technicians, instrumentation, and tools to verify testing and balancing of new HVAC systems at the direction of the UMB testing agent.
 - a. The UMB testing agent will coordinate with the CM and TAB contractor to determine the date of field verification. Notice will not include data points to be verified.
 - b. The TAB subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.
 - a. Failure of an item includes, other than sound, a deviation of more than +/- 10%.
 - c. Failure of more than 10% of selected items shall result in rejection of final TAB report.
 - d. TAB contractor shall remedy the deficiency and notify the UMB testing agent so verification of failed portions can be performed.
- C. General Testing Requirements:
1. Provide technicians, instrumentation, and tools to perform testing at the direction of the UMB testing agent.
 2. Scope of HVAC testing shall include new HVAC installation, from the existing building systems through the new distribution systems to the renovated spaces. Testing shall include measuring capacities and effectiveness of operational and control functions.
 3. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.

4. The UMB testing agent along with the HVAC contractor, TAB Subcontractor, and HVAC Instrumentation and Control Subcontractor shall prepare detailed testing plans, procedures, and checklists for new HVAC systems, subsystems, and equipment.
5. Tests will be performed using design conditions whenever possible.
6. If tests cannot be completed because of a deficiency outside the scope of the HVAC system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

D. New HVAC Systems, Subsystems, and Equipment Testing Procedures:

1. Procedures: Where applicable follow manufacturer's written procedures. If no procedures are prescribed by the manufacturer, proceed as follows:
 - a. HVAC Piping Distribution Systems: Includes new chilled water, hot water heating, natural gas, steam and condensate piping systems.
 - b. Verify that all new valves and accessories have been installed correctly, are accessible and operate as intended.
 - c. Verify that specified leak tests of piping systems are complete.
2. New HVAC Air Distribution Systems: Includes new supply, general exhaust, fume hood and miscellaneous exhaust duct systems.
 - a. Verify that all new ductwork, air devices, terminal units and accessories have been installed correctly, are accessible and operate as intended.
 - b. Verify that specified leak tests of duct systems are complete.
3. New HVAC Equipment: Includes new terminal units, new supplemental A/C units and exhaust fans.
 - a. Verify that all new equipment has been installed in accordance with the manufactures recommendations and all equipment can be easily accessed for maintenance.
 - b. Verify that all new valves, trim, fittings, controls, and accessories have been installed correctly and operates as intended.
 - c. Verify that all new required interfaces with the BAS have been installed correctly and operates as intended.
 - d. Operate new equipment as intended to ensure the design conditions can be obtained.
4. New HVAC Building Automation System Interface:
 - a. Verify that all new control hardware and software, sequences of operations, and integration of factory controls has been installed correctly and operates as intended.
 - b. Verify that all new control valves, trim, fittings, and accessories have been installed correctly and operates as intended.
 - c. Verify that all new equipment test, training, and startup procedures have been completed per the specifications.
 - d. Verify that all new required interfaces between the BAS and HVAC equipment have been installed correctly and operates as intended.

- e. Verify that all new control graphics and programming has been installed in accordance with the manufactures recommendations and operates as intended.
- f. Operate new equipment as intended to ensure the design conditions can be obtained.
- g. Where existing terminal equipment and/or exhaust fans are reused and/or relocated verify related control components are installed as indicated.

3.24 CLEAN – UP

- A. Excessive debris and dirt, such as occurs from cutting through masonry or plaster walls shall be cleaned up from the equipment and removed immediately after the work of cutting through the walls.
- B. Debris shall be removed from UMB property.
- C. Ceiling panels shall be replaced as soon as work is finished in the area and shall be kept free of dirty fingerprints. Where work is being done in corridors used by patients and ceiling panels shall be replaced at the close of the day's work even if work is at the particular location is incomplete.
- D. All areas shall be left broom-clean at the end of the work period.
- E. Remove all mechanical clipping, wiring, nuts, bolts, etc. left on top of ceilings and ceiling tiles.

3.25 WET TAP PROCESS <Delete if not Required>

- A. General: When existing HVAC hydronic systems cannot be shut off and drained for new connections the contractor shall coordinate with UMB to wet tap the system requiring new connections as follows:
 - 1. Piping Systems up to Four (4) Inches: Use an Apollo 77FLF-140 full port ball valve only as specified. Size the valve to match the new pipe connection.
 - 2. Piping Systems Six (6) Inches and Larger: Provide an appropriately sized gate valve for the wet tap process. Provide a specified butterfly valve downstream of the gate valve for shut off duty. Size the butterfly valve to match the new pipe connection. Lock the gate valve in the open position.

3.26 COMPLETED HYDROSTATIC/ LEAK TEST FORMS

- A. Upon completion of each hydrostatic/test, the contractor shall upload the signed leak test forms to the Project File, in ebuilder, in Folder 11.06 Test Reports.
- B. General: Contractors shall use the UMB Standard Forms for Recording the Hydrostatic/Leak Test Results for all Duct and Pipe Systems Tested on this Project.

1. Availability: The standard test summary form is available on the UMB Design and Construction Web Site.
2. Field Testing: For field testing download and copy the forms from the UMB web site.

END OF DIVISION 230000