

## **DIVISION 23 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

### **23 00 00 – HEATING, VENTILATING AND AIR CONDITIONING (HVAC)**

- A. All equipment shall be furnished with the manufacturer's installation directions and operating and maintenance instructions.
- B. Provide positive ventilation in equipment rooms to prevent damage from heat and humidity.
- C. Design conditions shall conform to ASHRAE/IESNA 90.1, codified version.
- D. Outside air intakes should be located so they will not be contaminated by fume hood exhaust, building exhausts, vents or motor exhausts.
- E. Do not use electric heating coils or electric heat without Owner approval.
- F. In general, systems shall provide heating and cooling year-round to accommodate the desired occupancy.
  - 1. Proposed systems require life cycle costing and compliance with the ASHRAE/IESNA 90.1, codified version.
    - a) The impact of central system zoning needs consideration. The cost analysis must include the operational costs as the building is operated and not be based on square footage costs alone. Zoning of the systems by occupant function, and the ability to shut down areas occupied only during regular university hours is strongly encouraged.
    - b) The impact of the mechanical selection should include the maintenance costing as well as the energy cost impact.
  - 2. Wherever possible, the sources of energy should be from the central heating plant.
    - a) The source of heat should be steam in all cases.
    - b) The source of humidification should be steam, unless the economies of operation dictate the use of another method (i.e., evaporative).
  - 3. When radiation systems are supplied, they must not be "string" type radiation. Each piece should be connected to the supply and return independently.

### **23 00 01 – MECHANICAL ROOM PLANNING AND EQUIPMENT ACCESS**

#### **GENERAL**

This section provides general standards for overall planning and design of Mechanical Rooms to assure that the mechanical rooms are adequately sized and equipment located to facilitate safe maintenance, operations and equipment replacement over a

100 year life of a typical building. Other sections contain specific standards for each system per CSI specification format.

## **DESIGN GUIDELINES**

### **A. Design General**

1. Access to mechanical equipment is critical to the operations and maintenance of the equipment. Safety of maintenance staff shall be considered in room and equipment layout. Maintenance will be performed for the expected equipment life of 30 to 50 years. It is likely that the equipment will be replaced before the building is replaced. Therefore adequate consideration must be given to getting replacement equipment in and out of the mechanical room.

### **B. Mechanical Room Planning**

1. During program planning, and study phase, an allowance of 10% of the gross square foot area shall be set aside for mechanical space. This may be adjusted during subsequent phases of a project but, in no case shall be less than that required for any piece of equipment, as shown on the sample plan.
2. The room size and equipment layout shall be reviewed by the architect to assure compliance with ICC. Egress paths around the equipment shall be reviewed and changed if necessary to comply with egress requirements.
3. Mechanical rooms shall be serviced by standard stairs or elevators large enough to accommodate routine maintenance parts such as motors and filters. Equipment rooms shall not be accessed by "ships ladders".
4. Doors to mechanical equipment rooms shall be 7'6" x 6'0" with corridors and access that do not limit the use of these doors. Access through another space is not acceptable. Exterior removable panels and louvers shall be provided for access for the replacement of large equipment that cannot be brought in pieces.
5. Mechanical rooms below grade shall be provided with an areaway large enough to replace the largest piece of equipment in the mechanical room.
6. Air intakes shall not be placed in areaways below grade and, unless approved by the PM, shall be at least 16 feet above grade to the bottom of the intake unless it is on the roof.

7. Roof top penthouses shall be provided with exterior doors, so located that they access a flat part of the roof. The float roof structure outside of the penthouse shall be capable of supporting the heaviest piece of equipment in the penthouse.
8. All penetrations for piping, duct of access shall be provided with the fire rating called or on the architectural plans.
9. Ductwork in mechanical rooms shall be designed to provide maximum headroom and provide straight runs for efficient operation of fans.
10. All equipment shall be drawn to scale using the design basis equipment. The drawings shall show all ducts, piping and accessories that would affect maintenance access.
11. Composite drawings of mechanical, electrical, plumbing, fire protection, controls, and other major components that will need maintenance clearances shall be prepared to show the general arrangement of equipment to assure the intent of these guidelines are met.
12. All equipment should be floor mounted within the mechanical room. If it is necessary to elevate equipment ABOVE 72", PERMANENT SERVICE PLATFORMS SHALL BE PROVIDED WITH STAIRS/LADDER ACCESS.
13. Mechanical rooms shall **not** be used as part of the return air path.
14. Floor drains shall be located next to each major piece of equipment which may need to be drained. Permanent drain lines from air compressors, air handing units, etc. shall not run across open floor space.
15. A condensate piping shall be routed from each piece of equipment that utilizes steam. Condensate shall drain by gravity from all equipment using steam. Piping shall terminate at the main condensate pump. In no case shall a F&T trap be used to lift condensate.
16. Piping shall be routed below any ductwork. Piping shall be routed a minimum of 7 ft above the floor.
17. Electrical service.

- 17.1 Provide GFCI receptacles at regular spacing throughout the mechanical room where additional task lighting or service equipment such as shop vacuums, welders may be required. Maximum spacing shall be 30 ft.
  - 17.2 Provide one welding outlet per mechanical room.
  - 17.3 Provide one receptacle and minimum of one light fixture on e-power by the main switchgear.
18. Water Service. Provide a hose bib in the mechanical rooms within 20' of each air handler to facilitate air handling unit cleaning. Provide a freeze-proof hose bib near condensing units at exterior locations.

#### C. Personnel and Equipment Traffic

- 1. There shall be adequate access paths in and around the mechanical room to allow for maintenance to bring in repair equipment, temporary equipment, electrical safety and also future equipment replacement.
- 2. There shall be adequate lighting throughout the mechanical room to facilitate maintenance work.

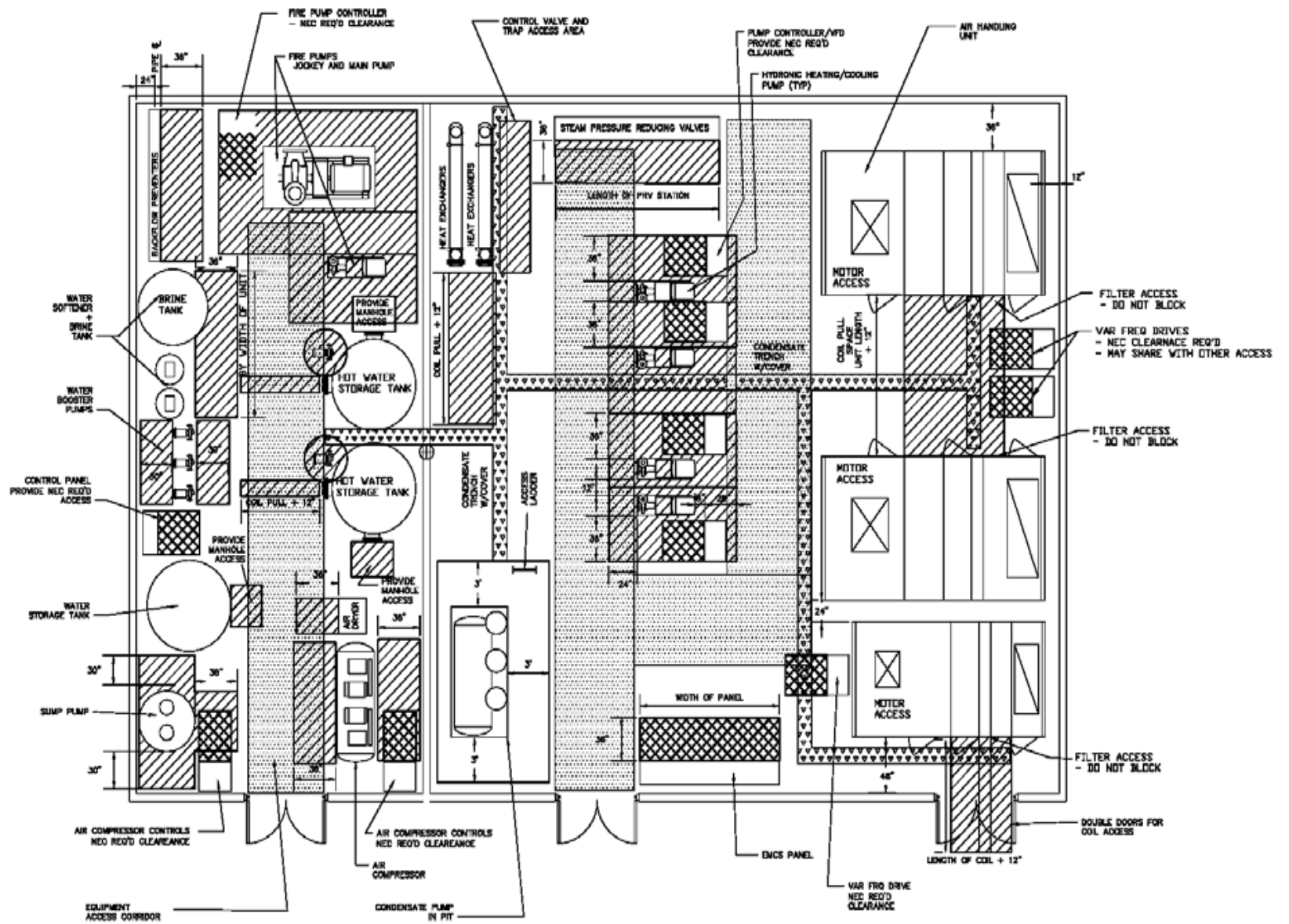


FIGURE 1 - SAMPLE MECHANICAL ROOM LAYOUT

**23 05 00 – COMMON WORK RESULTS FOR HVAC**

**23 05 09 – TESTING, ADJUSTING, AND BALANCING**

Contact UNI for instruction on whether UNI will issue separate purchase order or include in contract. If separate purchase order is issued, the Design Professional shall provide plans and specifications to use in obtaining quotes.

**23 09 00 – INSTRUMENTATION AND CONTROL FOR HVAC**

The Design Professional is solely responsible for the design of the HVAC control systems. During the design process, the Design Professional shall review control strategies with the Owner. Siemens will develop control drawings to be included in the bidding documents.

Siemens is the only approved BAS vendor.

For projects with a construction budget under \$250,000, the purchase and installation of the controls systems shall be included in the contractor’s bid.

For projects with a construction budget over \$250,000, Siemens will provide the Owner with the price of their bid. The Siemens bid, once approved by Owner, shall be included as an allowance in the bidding documents as part of the addenda. All installation work shall be as per the following matrix. This matrix shall be included in the bidding documents.

Electrical Contractor – EC  
 Mechanical Contractor – MC  
 Sheet Metal Contractor – SMC  
 Manufacturer – MF

<b>Item</b>	<b>Provided By</b>	<b>Installed By</b>	<b>Wired By</b>	<b>Controls Provided By</b>	<b>Notes</b>
Control dampers that are not within the AHUs	Siemens	SMC	N/A	N/A	
Control dampers within the AHUs	SMC	MF	N/A	N/A	
Damper actuators	Siemens	EC	EC	N/A	
Control Valves	Siemens	MC	EC	N/A	
Devices mounted in piping	Siemens	MC	EC	Siemens	
Air flow measuring stations	Siemens	EC	EC	Siemens	
Differential pressure transmitters	Siemens	EC	EC	N/A	

Duct detectors	Siemens	EC	EC	N/A	
VFDs w/bypass & BAS interface software	Siemens	EC	EC	N/A	Start up by Siemens
VAV box	SMC	SMC	EC	Siemens	
Meters w/direct input to BAS	MC	MC	EC	N/A	24VAC power
Any pneumatic demolition	MC	N/A	N/A	N/A	
Generator	EC	EC	EC	N/A	
Building automation system wire, size 1, 2 & 3	EC	EC	EC	N/A	See Anixter wire spec
Motion sensors with aux contact to BAS	EC	EC	EC	Siemens	
Lighting system contactors/relays	Siemens	EC	EC	N/A	
ERV Controls/VFDs	Siemens Preferred	EC or MF	EC or MF	Siemens Preferred	Prefer controls by Siemens, if not, Siemens to provide interface to unit
Wire terminations of controls wiring, both ends	N/A	EC	EC	N/A	See Siemens Drawings

### 23 09 13.13 – ACTUATORS AND OPERATORS

Electric actuation is preferred for all systems except as noted/specified otherwise.

#### Valve Actuators – Electronic

##### A. Reheat and/or Baseboard Radiation Service

1. 24 VAC, 3 – position (floating) control, fail-in-place. Basis of design is SSC81-U.

##### B. Major System Service

1. 24 VAC, proportional control, spring return.
  - a) Basis of design for ¾-inch stroke: SKD62UA or SKB62UA as required by close- off.
  - b) Basis of design for 1½-inch stroke: SKC62UA.

#### Damper Actuators - Electronic

- A. Actuators for terminal box control applications shall be 24 VAC, 3-position (floating) control, fail-in-place.
- B. Actuators for major system service shall be 24 VAC proportional control or two-position control as specified with fail-safe spring return.
- C. Basis of design: Siemens OpenAir™ Direct-coupled Electronic Damper Actuators with torque selected according to application.

### **23 09 13.23 – SENSORS AND TRANSMITTERS**

#### Temperature Sensors

- A. Room sensors for terminal box applications
  - 1. Sensors shall monitor room temperatures between 55° F and 95° F.
  - 2. Sensing element shall be 10K-ohm NTC thermistor.
- B. Room sensors for monitoring only applications
  - 1. Range for field panel termination: -40° F - +240° F nominal.
  - 2. Range for terminal box/remote termination: -40° F - 257° F nominal.
  - 3. Element for field panel termination: 1000-ohm platinum, two-wire
  - 4. Element for terminal box/remote termination: 10K-ohm NTC thermistor, two-wire
- C. Liquid Immersion, Outdoor Air & Duct Temperature Sensors
  - 1. Range shall be -40° F - +240° F nominal.
  - 2. Sensing element: 1000-ohm platinum, two wire
  - 3. Liquid type shall be supplied with 2.5-inch minimum stainless steel well, threaded ½- inch NPT male.
  - 4. Duct single point type shall have a shaft length of 12 inches minimum, with insertion depth adjustable at mounting bracket.
  - 5. Duct averaging type shall have a length of 1.5 feet, 2 feet, or 4 feet if rigid, 25 feet if flexible, as required/where specified.
  - 6. Outdoor air sensor shall be installed away from any intake and/or



exhaust airstreams, under a sunshield.

## Pressure Sensors

A. All sensing elements shall be of ceramic strain gage with an output signal of 4-20mA DC. The calibration adjustments shall be zero and span.

B. Fluid pressure sensors

1. Range: 0-30 psig  
0-60 psig  
0-100 psig  
0-250 psig

C. Liquid Differential Pressure Sensors

1. Range: 0-25 psid  
0-50 psid  
0-60 psid  
0-100 psid
2. Basis of design: Setra 230

D. Duct and Building Static Pressure Sensors

1. Range: 0 -  $\pm 0.10$  inches WC  
0 -  $\pm 0.25$  inches WC  
0 -  $\pm 1.00$  inches WC  
0 -  $\pm 2.50$  inches WC  
0 - 1.0 inches WC  
0 - 2.0 inches WC  
0 - 5.0 inches WC  
0 - 10.0 inches WC
2. Basis of design: Setra 264

E. Differential Pressure Switches (Status Applications)

1. Liquid applications
  - A. Range: 8 - 70 psig
  - B. Differential: 3 psig
  - C. Maximum differential pressure: 200 psig

D. Maximum working pressure: 325 psig

E. Basis of design: Penn P74

## 2. Airflow applications

A. Range: 0.5 – 1.0 inches WC  
1.0 – 12.0 inches WC

B. Basis of design: Siemens SW141

## Humidity Sensors

A. Range: 0 – 100% RH

B. Sensing element: bulk polymer; element shall be field replaceable

C. Accuracy:  $\pm 2.0\%$  @ 77°F

D. Output signal: 4 – 20mA DC or 0 – 10VDC

## Current Sensing Relays

A. Relays shall be solid-state, adjustable, current operated type

B. Relays shall change switch contact state in response to an adjustable setpoint value of current in the monitored AC circuit.

C. Relay switch point shall be adjusted so that the relay responds to motor operation under load as an “on” state and so that the relay responds to an unloaded motor as an “off” state. A motor with a broken belt or coupling is considered an unloaded motor.

D. Basis of design for constant speed applications: Veris HawkEye H608 or H908

E. Basis of design for variable speed (VFD) applications: Veris HawkEye H904

## Air Flow Measurement Stations

### A. Duct Locations

1. Output shall be 4 – 20mA DC scaled in feet per minute (fpm) with range appropriate to the velocity in the duct, or alternatively in cubic feet per minute (cfm) if such output is available at the transmitter.

## 2. Basis of design: Ebtron Gold Series

### B. Fan Inlet Locations

1. Station shall contain parallel air straightener, total and static pressure sensing manifolds, internal piping and external pressure transmission ports with flexible tubing and quick-connect fittings.
2. Station shall be fabricated of galvanized steel and sized for the fan inlet in which it is mounted.
3. Maximum pressure loss through station shall be 0.08 inches WC at 1500 fpm.
4. Accuracy shall be 2%.
5. Identify by model number, size, area, and specified airflow capacity.

### Low Temperature Detection Thermostats (LTDT) (Freezestats)

- A. LTDT shall be four-wire, two-circuit type
- B. Setpoint shall be 15°F to 55°F, adjustable
- C. Provide manual reset
- D. LTDT shall be installed as indicated on the plans and shall provide protection for the coil such that one linear foot of element provides protection for one square foot of coil face area.
- E. LTDT shall stop associated fans and return automatic dampers to their normal position upon detection of low temperature.

## **23 09 13.33 - CONTROL VALVES**

### Proportional (Modulating) Valves

- A. Rangeability shall be 100:1 at a minimum
- B. ANSI Class 150, globe pattern body with screwed ends for 2-inch valves and smaller; globe pattern body with flanged ends for 2.5-inch valves and larger
- C. Body material shall be bronze for 2-inch valves and smaller; body material shall be cast iron for 2.5-inch valves and larger

- D. Body trim shall be stainless steel
- E. Stem shall be polished stainless steel
- F. Packing for steam service shall be high temperature type
- G. Controlled medium: steam, water, glycol solutions to 50%
- H. Flow characteristic – liquid: modified equal percentage
- I. Flow characteristic – steam: linear
- J. Control action: normally open, normally closed or three-way mixing as required/specified
- K. For liquid service, valves shall be provided with characterized throttling plugs and shall be sized for minimum 25% of system pressure drop or 5 psig, whichever is less.

#### Two-Position Valves

- A. ANSI Class 150, globe or ball pattern body with screwed ends for 2-inch valves and smaller; globe pattern body with flanged ends for 2.5-inch valves and larger
- B. Shall be line size unless otherwise specified
- C. Butterfly pattern shall be used only on valve sizes larger than 6-inch
- D. Body trim shall be stainless steel
- E. Stem (or ball) shall be polished stainless steel
- F. Packing for steam service shall be high temperature type
- G. Control action: normally open or closed as required/specified
- H. Controlled medium: steam, water, glycol solutions to 50%

#### **23 09 13.43 – CONTROL DAMPERS**

All dampers shall be low leakage with airfoil type blades

ACCEPTABLE MANUFACTURERS: T. A. Morrison (TAMCO) (1500 series), Arrow AFD, Ruskin CD-50

## Construction

- A. Frames shall be extruded aluminum hat channels with minimum 0.125-inch thickness.
- B. Blades shall be extruded aluminum with maximum 6-inch blade width
- C. Hardware shall consist of molded synthetic or sealed ball bearings (as required/specified), zinc plated steel axles, linkage brackets, connecting rods and mounting bolts.
- D. Seals shall consist of silicone or flexible metal compression type at frame ends, and silicone or extruded vinyl inflatable type at blade edges.

## Leakage

- A. Leakage shall not be more than 6 cfm per square foot of damper area, measured at a minimum differential pressure of 4 inches WC with an applied torque of 50 inch-pounds.

## Operating Limits

- A. Temperature range: -25°F to 200°F
- B. Differential pressure: 6 inches WC
- C. Velocity: up to 4000 fpm

## Selection

- A. Opposed blade type shall be used in proportional service
- B. Parallel blade type may be used for two-position service, and may be used in mixed air applications to promote improved air mixing.
- C. Sizing
  - 1. Sizes shall be as indicated on the drawings.
  - 2. Sizes differing from those indicated on the drawings may be provided if improved performance can be demonstrated by calculations.
  - 3. Multiple sections may be provided to achieve required size.

4. When multiple sections are provided, individual sections shall in no case be larger than 6 by 6 feet.

## **23 09 23 – DIRECT DIGITAL CONTROL SYSTEM FOR HVAC**

### Scope of Work

- A. The Building Automation System (BAS) manufacturer shall furnish and install a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and subsystems with open communications capabilities as herein specified. The BAS System will be Siemens Apogee.

The system shall provide for seamless read and write access by the main Siemens Building Technologies (SBT) Apogee Building Automation System campus network. This shall include.

but not be limited to, monitoring and reporting point data (particularly fire and /or security alarms), commanding points, modifying system set points and scheduling equipment through the existing Apogee network workstations.

The intent is to allow information about the system provided in this contract to be sent to existing workstations accessing the SBT system. The user shall have a single seat interface *on the existing SBT system* from which to perform daily operation of the system provided in this contract *without* bridges, routers, gateways or protocol converters.

- B. The installation of the building automation system shall be performed by the Electrical Contractor under the general supervision of the BAS manufacturer with the shop drawings, flow diagrams, bill of materials, component designation or identification number and sequence of operation all bearing the name of the manufacturer. The installing contractor shall certify, in writing, that the equipment manufacturer's personnel have prepared the shop drawings and that the equipment manufacturer's personnel have supervised the installation. In addition, the manufacturer shall certify, in writing, that their company prepared the shop drawings and that all temperature control equipment was installed under their general supervision.
- C. All materials and equipment used shall be standard components, regularly manufactured for this and/or other systems and not custom designed specially for this project. All systems and components shall have been thoroughly tested and proven in actual use for at least two years.

### Quality Assurance

- A. This system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability to upgrade existing peer-to-peer Automation Level Network controllers / field panels to the current level of technology and to execute said upgrade in increments of one panel at a time without the need to upgrade all controllers on the network. Compatibility shall also be defined as the ability to extend a previously installed network with new peer-to-peer Automation Level Network controllers / field panels. Compatibility shall be further defined as the ability for any existing peer-to-peer Automation Level Network controller/field panel to be connected to, and directly communicate with, new peer-to-peer Automation Level Network controllers / field panels without bridges, routers or protocol converters.

### Submittals

- A. Submit complete sets of documentation in the following phased delivery schedule:
1. Valve and damper schedules
  2. Equipment data cut sheets
  3. System schematics, including:
    - sequence of operations
    - point names (furnished by Owner)
    - point addresses
    - interface wiring diagrams
    - panel layouts
    - system riser diagrams
  4. Auto-CAD or Revit compatible as-built drawings
- B. Upon project completion, submit operation and maintenance manuals, consisting of the following:
1. Index sheet, listing contents in alphabetical order.
  2. Manufacturer's equipment parts list of all functional components of the system.
  3. Auto-CAD or Revit disk of system schematics, including wiring diagrams.
  4. System schematics, including sequence of operations.
  5. As-Built interconnection wiring diagrams.
  6. Operator's Manual.
  7. Trunk cable schematic showing remote electronic panel locations and all trunk data.
  8. List of connected data points, including panels to which they are connected and input device (e.g., temperature sensors, ionization detectors, etc.)
  9. Conduit routing diagrams

### Warranty

- A. Provide all services, materials and equipment necessary for the successful operation of the BAS system for a period of **two (2) years** after substantial completion.

## Networking Communications

- A. The design of the BAS shall network operator workstations and stand-alone DDC Controllers. The network architecture shall consist of multiple levels for communication efficiency. An existing campus-wide Ethernet network based on TCP/IP protocol (Management Level Network), high performance dedicated peer-to-peer Automation Level Network(s) and DDC Controller floor level local area networks with access being totally transparent to the user when accessing data or when developing, editing, and implementing control programs.

## Controllers

- A. Basis of design shall be Siemens Apogee Modular Controller (PXM) or Compact Controller (PXC).
- B. Programming language shall be text-based, similar to BASIC. DDC Controllers that require different programming languages or tools for each type of controller are not acceptable.
- C. Each Controller shall support firmware upgrades without the need to replace hardware.
- D. Provide all processors, power supplies and communication controllers so that the implementation of a point only requires the addition of the appropriate point input/output termination module and wiring.
- E. The operator shall have the ability to manually override automatic or centrally executed commands at the DDC Controller via local, point discrete, on-board operator override switches. These shall be hand/off/auto switches for digital control type points and gradual switches for analog control type points.
  - 1. Switches shall be mounted within the DDC Controller's key-accessed enclosure to prevent unauthorized overrides.
  - 2. DDC Controllers shall monitor the status of all overrides and inform the operator that automatic control has been inhibited. DDC Controllers shall also collect override activity information for reports.
- F. Existing DDC controller(s) may be reused if applicable. If they are NOT REUSED, they shall be salvaged and retained by the Owner. Carefully remove and transmit intact to Owner's designated personnel for storage. If panels are reused, reuse point modules wherever possible, install replacements as required.



- G. When controllers are needed for laboratory rooms or fume hoods, controllers shall be BAS supplier's OEM products. Third-party controllers are not acceptable.
1. Laboratory rooms, and the fume hood(s) and general exhaust terminal(s) in those rooms shall be controlled to allow for a variable flow of conditioned air into the room and exhaust through the hood while maintaining a safe velocity at the hood sash opening.
  2. Face velocity control input shall be sash position. Other types of sensing are not acceptable.
  3. The airflow through the open face of the hood, regardless of sash position, shall be controlled at a face velocity of between 100 FPM and 120 FPM.
  4. The controller shall control, based on this input, a damper in the hood discharge terminal to maintain specified face velocity.

#### Graphical Interface

- A. Provide color graphic floor plan displays and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems and hot water boiler systems, and room level terminal units, shall be provided by the BAS contractor as indicated in the point I/O schedule of this specification to optimize system performance, analysis and speed alarm recognition.
- B. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection, point alarm association, or text-based commands. Graphics software shall permit the importing of Autocad or scanned pictures for use in the system.
- C. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations within the system schematics and graphic floor plan displays, and shall automatically update to represent current conditions without operator intervention and without pre-defined screen refresh rates.
- D. Provide the user the ability to display real-time point values by animated motion or custom picture control visual representation. Animation shall depict movement of mechanical equipment, or air or fluid flow. Picture Control shall depict various positions in relation to assigned point values or ranges. A library (set) of animation and picture control symbols shall be included within the workstation software's graphics application. Animation shall reflect, ON or OFF conditions, and shall also be optionally configurable for up to five rates of animation speed. Animation shall also indicate the priority and alarm status of the point.

- E. Sizable analog bars shall be available for monitor and control of analog values; high and low alarm limit settings shall be displayed on the analog scale. The user shall be able to "click and drag" the pointer to change the setpoint.
- F. Provide the user the ability to display blocks of point data by defined point groups; alarm conditions shall be displayed by flashing point blocks.
- G. Equipment state or values shall be able to be changed by clicking on the associated point block or graphic symbol and selecting the new state (on/off) or setpoint.
- H. State text for digital points shall be user-definable up to eight characters.
- I. Colors shall be used to indicate status and change as the status of the equipment changes. The state colors shall be user definable.
- J. Advanced linking within the Graphics application shall provide the ability to navigate to outside documents (e.g., .doc, .pdf, .xls, etc.), internet web addresses, e-mail, external programs, and other workstation applications, directly from the Graphics application window with a mouse-click on a customizable link symbol.

#### Field Devices

- A. Provide four digital inputs for emergency generators. Generator circuiting to BAS shall provide Form C dry contacts with no shorts and no voltage.
  - 1. Generator Run (with or without transfer)
  - 2. Generator Transfer (normal or emergency power indication)
  - 3. Generator Fault
  - 4. Generator Fuel Tank bladder rupture (if required / specified)

#### Start-Up and Commissioning

- A. When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. The BAS supplier shall complete all testing, calibrating, adjusting and final field tests. Verify that all systems are operable from local controls (if required / specified) in the specified failure mode upon panel failure or loss of power.
- B. Provide any recommendations for system modification in writing to the Owner. Do not make any system modification, including operating parameters and control settings,

without prior approval of the Owner.

- C. After BAS supplier has completed system start-up and commissioning, joint commissioning of any integrated system segments shall be completed. As well as any commissioning work with the Cx Authority.

## Electrical Wiring and Materials

- A. Power and Control Wiring: Control voltage for the Building Automation System shall be 24V nominal. Power and control wiring and conduit shall be run in a neat and workmanlike manner, parallel and perpendicular to the building structure, concealed wherever possible, without splices between terminal points, and properly supported from structure.
  - 1. All wiring over 30 volts shall be color coded wire, No. 14 minimum, run within electrical metallic tubing.
  - 2. All wiring under 30 volts shall be color-coded, Class 2, plenum rated, shielded if and where required / specified.
  - 3. Cable shall be by The Cable Company as follows (or approved equal):
    - a. Automation Level Network (ALN) (RS-485): 5200BLN
    - b. Floor Level Network (FLN)(RS-485): 5200FLN
    - c. I/O for DDC Controllers and HVAC & Mechanical Equipment controllers: 5031LAN or 5041LAN
    - d. Outputs for Application Specific Controllers: 5033LAN
  - 4. Low voltage wiring (under 30 volts) shall be run within electric metallic tubing where exposed to view or where subject to physical damage, such as in mechanical equipment rooms; and where inaccessible, such as in concrete walls or floors, in furred walls, or above ceilings with no access.
  - 5. Low voltage wiring (under 30 volts) where accessible and concealed, such as within instrument panels or above suspended ceilings with easy access, may be run without conduit. Such wiring shall be neatly run, bundled with a maximum unsupported length of 4' 0", or installed in cable tray.
  - 6. Number code, color code, or otherwise clearly label cables, except local individual room control cables, for future identification and servicing of the system.
- B. Provide 120 volt, single phase, 60 hertz emergency power to every B.A.S. DDC Controller panel. The power supplies are to be extended in conduit and wire from

dedicated emergency circuit breakers in emergency power panelboards. Provide a battery powered uninterruptable power supply (UPS) at each controller.

## Training

- A. The manufacturer shall provide a factory-trained instructor to give full instruction to designated personnel in the operation of the system installed. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. The manufacturer shall provide all students with a student binder containing product specific training modules for the system installed.
- B. Discuss with Owner the amount of hours of training for Owner's designated operating personnel. Training shall include:
  - 1. Explanation of drawings, operations and maintenance manuals
  - 2. Walk-through of the job to locate control components
  - 3. DDC Controller and ASC operation / function
  - 4. Operator control functions including graphic generation and field panel programming
  - 5. Explanation of adjustment, calibration and replacement procedures
  - 6. Student binder with training module

## **23 20 00 – HVAC PIPING AND PUMPS**

### **23 21 00 – HYDRONIC PIPING AND PUMPS**

- A. Hydronic heating and cooling coils shall be piped for counterflow.
- B. When new roof openings are required for existing buildings, verify with the Owner's Representative whether roof is under warranty. If roof is under warranty, all openings must be made according to roof manufacturer's details so that warranty will not be made void.
- C. All piping shall be sized on drawings. Do not use pipe-sizing schedules.
- D. All interconnections between domestic water and any other services shall include a backflow preventer in the domestic water line. If line is used for filling system, include a water meter that reads in gallons.
- E. Oversize incoming domestic water service by 25% to allow for some future expansion. Contractor shall be required to furnish and install the water meter(s) and coordinate installation with the utility. Specify Badger meter with remote read in cubic feet (gallons will not be accepted).

- F. Piping mains, with the exception of sanitary and storm piping, shall not be buried under floor slabs. Accessible piping tunnels shall be installed as required.
- G. All equipment in mechanical spaces shall be readily accessible. This includes but is not limited to, dampers, valves, actuators, etc.
- H. Basis for high pressure steam design shall be 150 psig, 550°F.
- I. For well water used in cooling systems, maximum discharge temperature leaving building is 97°F.
- J. All steam vaults shall have a sump pump.
- K. Backflow preventers shall be used where city water could be contaminated through siphoning or back pressure.
- L. Chemical pot feeders shall be included on all hot water systems and on chilled water systems.
- M. Provide meter for well water system. Badger industrial turbo/MSERI Register. Connect and transmit data via the building automation system to UNI Energy Management.

### **23 22 00 – STEAM AND STEAM CONDENSATE PIPING AND PUMPS**

- A. Steam trap capacity shall be at least twice the maximum rating of the anticipated load requirements.
- B. Traps shall be piped for easy servicing. Install inspection valve for testing trap.
- C. Traps shall be piped a minimum of 12” below the outlet of the devices they serve.
- D. Do not use inverted bucket traps on any application over 50 psig. Use Armstrong, Hoffman, or TLV steam traps. – See appendix for details. Owner will supply all high pressure steam traps.
- E. Safety valves shall have the appropriate ASME stamp.
- F. Desuperheaters will feed from condensate receiver tank.
- G. Steam pressure reducing valves shall provide tight shut-off for “dead end” service to prevent safety valve pop off. This shall include reducing valves on autoclaves and other equipment supplied with steam.
- H. Pressure reducing valve (PRV) shall be Masoneilan Camflex 3500 Series. Normally closed valve. Reverse acting control head. **Rotork, SM-1700 actuator. Honeywell DC 3200 controller. Endress hauser PMC51 pressure sensor. Provide emergency power circuit and UPS.**

- I. Condensate pumps need a union, a check valve, and a stop valve on discharge connections. Grundfos preferred. Packaged receiver/pump unit – Sterling preferred (steel tank, 40 psi discharge). DO NOT place condensate receiver underground. Install condensate bypass and receiver drain per Condensate Pump detail in Appendix.

### **23 23 00 – REFRIGERATION PIPING**

- A. Vibration isolators shall be provided in the suction and discharge lines of all refrigeration compressors. Both suction and discharge lines shall be insulated.

### **23 25 00 – HVAC WATER TREATMENT**

- A. Initial glycol concentration shall be 35% for heating.

### **23 25 14 – WATER TREATMENT (CLOSED SYSTEM)**

#### **A. Materials**

1. Proprietary blend containing the following items:
  - a) Corrosion Inhibitors: Sodium, nitrite-borax with added inhibitors such as mercaptobenzothiazole, sodium tolytriazole, or phenyltriazole to protect copper and brass and minimize dielectric pitting of steel. Maintain 2,000 ppm nitrate in heating systems and 900 ppm in cooling systems. Adjust borax content to maintain correct pH for type of system (mainly steel or mainly copper).
  - b) Scale Inhibitor: Organic phosphonates such as aminomethylene-phosphonate; phosphonates such as hydroxyethylidenediphosphonate or polyamino-substituted phosphonates; or synthetic polymers such as low-molecular-weight polyacrylates, poly-methacrylates and polyacrylandies. Inorganic polyphosphates are not acceptable. Maintain residual concentration as recommended by the manufacturer.

#### **B. Equipment**

1. Bypass (Pot) Feeder with funnel, fill valve, drain valve, air cock, working pressure of 300 psig. Install eyewash station near the chemical pot feeder.

### **23 30 00 – HVAC AIR DISTRIBUTION**

- A. Maximum length of flexible duct at any one point shall be 3'-0" for terminal boxes and 6'-0" for diffuser.
- B. Provide air blenders in air handling units to mix outside air and return air to prevent stratification.
- C. Fume hood exhaust fans shall be installed on roof or near air discharge point from building in order that most of exhaust duct is under negative pressure.
- D. Provide exhaust fans for each fume hood.

- E. Do not locate exhaust fan discharge near building outside air intakes.
- F. Provide exhausting of one custodial room to allow battery operated floor scrubber storage and recharging.
- G. Drains from rooftop exhaust fans shall be run to the nearest roof drain (not drained onto the roofing material).
- H. Utility set type fume hood exhaust fans are preferred. Provide special construction and linings as required.

### **23 31 00 – HVAC DUCTS AND CASINGS**

- A. All ductwork drawings shall be double line type.
- B. Fume hoods require stainless steel or other non-corrosive metal ductwork. Verify requirements for each project.
- C. Low-pressure ductwork shall have all joints sealed.
- D. Medium and high-pressure ductwork shall be sealed and leak tested per SMACNA standards. Seal class shall be specified.
- E. Outside air ducts subject to snow or water infiltration shall have drain pans piped to floor drain.
- F. Duct thickness and construction shall be specified for all materials used.
- G. Do not line fume hood exhaust ducts or HVAC ducts unless requested by Owner.

### **23 33 00 – AIR DUCT ACCESSORIES**

- A. Automatic dampers shall be a low leakage type with replaceable seals.
- B. Fire dampers shall have an access panel for inspection and replacement of fusible links. Locations of all fire dampers shall be shown on drawings.
- C. Access panels shall be insulated and quick opening.
- D. Flexible connections shall not exceed 6" in width.
- E. Manual dampers shall be provided at all trunk duct branches.
- F. Manual dampers shall be provided with a locking type quadrant at exterior of duct.
- G. Splitter dampers will not be allowed. Use 45° takeoffs.

### **23 33 19 – DUCT SILENCERS**

- A. Duct systems shall not transmit excessive airborne or radiated noise to occupied spaces. Fan selection, duct construction, air velocity and sound attenuators shall be evaluated to produce acceptable noise levels.
- B. Use sound attenuation to reduce room to room noise transmission as needed.

### **23 34 00 – HVAC FANS**

#### **23 34 16 – CENTRIFUGAL FANS**

##### **A. General**

1. Fans shall meet Class III standard when this class is available for the fan size involved.
2. Housings shall be constructed of continuously welded steel to assure no air leakage.
3. Housing and bearing support shall be constructed of welded structural steel members to prevent vibration and rigidly support the shaft and bearings.
4. Fan wheel shall be of the non-overloading backward inclined centrifugal or air foil type.
  - a) Wheels shall be statically and dynamically balanced.
  - b) The wheel cone and fan inlet cone shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.
5. Turned, precision-ground and polished steel shafts shall be sized so the first critical speed is at least 25% over the maximum operating speed for each pressure class.
6. Bearings shall be heavy duty grease lubricated, self aligning ball bearing or roller pillow block type.
  - a) Bearings shall be selected for a minimum B-10 life of 200,000 hours at the specified operating condition.
7. Fan performance shall be based on tests conducted in accordance with AMCA Standard 210 test code for air moving devices.
  - a) Fans shall be licensed to bear the AMCA Certified Ratings Seal.
8. After assembly, each fan shall be given a final balance test at the specified operating RPM to ensure smooth, vibrating-free operation and meet section 15240 requirements.

- B. Variable frequency drives are the preferred equipment for volume control.

#### **23 34 23 – HVAC POWER VENTILATORS**

- A. Provide fan coatings and/or explosion-proof motors as required for service.
- B. Install drip pans below power roof ventilators which do not have ductwork connected.



### **23 36 00 – AIR TERMINAL UNITS**

- A. The selection of air terminal units has great impact on the acceptability of the design.
  - 1) The units should be pressure independent in operation.
  - 2) The units must be acceptably quiet in operation.
  - 3) Flow sensor air test hose shall be provided with factory installed brass plugs. Plastic and caps shall not be acceptable.

### **23 37 00 – AIR INLETS AND OUTLETS**

- A. Perforated air supply diffusers shall not be allowed.

### **23 40 00 – HVAC AIR CLEANING DEVICES**

- A. The filtration system should provide a good habitable environment for the average person in a reasonably cost-effective manner when projected for the life of the system.
- B. Low ventilation rates of VAV systems tend to concentrate contaminants and should be addressed.

### **23 50 00 – CENTRAL HEATING EQUIPMENT**

#### **23 54 00 – FURNACES**

- A. Furnaces will not be installed except in special cases approved by the Owner's Representative.
- B. Duct furnaces will only be installed in special cases approved by the Owner's Representative.

#### **23 57 00 – HEAT EXCHANGERS FOR HVAC**

- A. Unit Heater
  - 1) The preferred unit heater will be steam. Gas or electric units will only be approved in cases where steam or hot water is unavailable.
- B. Provide check valve vacuum breakers on the shell of steam-to-water heat exchangers to assure free condensate drainage when control valve closes.
- C. Plate type steam-to-water heat exchangers shall not be used.
- D. Plate Frame Heat Exchangers: Contact Owner to determine if a spare set of gaskets are to be provided. Acceptable Manufacturers: Alfa Laval, Tranter, WCR. Plate shall be 304 stainless 0.5 mm thick with clip on gaskets.

### **23 60 00 – CENTRAL COOLING EQUIPMENT**

### **23 61 00 – REFRIGERATION COMPRESSORS**

- A. Compressors shall be equipped with some type of capacity control, (unloaders, variable speed, step control, etc.) when their normal capacity is 5 tons or more.
- B. All compressors which are placed outdoors should be equipped with crankcase heaters.
- C. All compressors are to have the normal safety controls:
  - 1) A combination high and low pressure cutout.
  - 2) An oil failure switch.
- D. See ASHRAE-IESNA 90.1, codified version, for minimum efficiencies.

### **23 63 00 – CONDENSING UNITS**

- A. Condensing units shall not be installed except in special cases, approved by the Owner's Representative.
- B. All condensing units which are located outdoors shall be provided with the following equipment:
  - 1) Head pressure stabilization control, either through condenser fan control or a head pressure control valve.
  - 2) Heat tape on the condenser receiver.
  - 3) A compressor crankcase heater.
- C. Compressors in condensing units shall comply with the guidelines in Section 15655 Refrigeration Compressors.
- D. Unit must be capable of using a condenser air fan motor speed control device for head pressure control. Unit must also have provisions for low ambient starting, when the low pressure switch is connected at the liquid line service valve port.
- E. See ASHRAE/IESNA 90.1, codified version, for minimum efficiencies.
- F. Air-cooled condensers shall have some type of head pressure stabilization control either through condenser fan control or a head pressure control valve.
- G. All condenser coils shall be easily accessible for cleaning.
- H. All outside condenser coils must have a hail guard.
- I. Water flow shall be controlled by discharge temperature with an automatic valve.
- J. When there are multiple water cooled condensers that would normally use city water, the preference is to recirculate condenser water through a chilled water-to-condenser water heat exchanger to avoid wasting water.

K. Domestic water cooled condensers are not allowed.

### **23 64 00 – WATER CHILLERS**

- A. All water chillers shall be equipped with freeze protection on the evaporator heat exchanger.
- B. Refer to Section 15655 Refrigeration Compressors and Section 15740 Condensers for other applicable guidelines.
- C. See ASHRAE/IESNA 90.1, codified version, for minimum efficiencies.
- D. Specify a minimum of 2-year warranty for chillers. Consultant shall contact major vendors to discuss extended warranty options and review with UNI for inclusion into the specifications.
- E. Specify lifting eyes on headers to accommodate removal.
- F. Specify lifting beam above chiller at both ends for head removal **or provide a Gantry and chain hoist for chiller maintenance.**
- G. Specify spool pieces on piping to accommodate head removal at both ends of chiller.
- H. Specify appropriate clear space to accommodate re-tubing of unit.
- I. **Confirm the amount of superheat in the low pressure steam system in order to correctly specify the steam absorption chiller.**

### **23 65 00 – COOLING TOWERS**

- A. Do not use indoor cooling towers.
- B. Ceramic towers preferred.
- C. Towers shall not be installed on roofs.
- D. Provide condenser water treatment.

### **23 72 00 – AIR TO AIR ENERGY RECOVERY EQUIPMENT**

- A. The use of energy recovery units is encouraged, providing the economics are based on acceptable payback.
  - 1) The designer must exercise special care if these items are adapted to laboratory air exhaust streams. The maintenance of such a system may not be possible.

### **23 73 00 – INDOOR CENTRAL -STATION AIR-HANDLING UNITS**

- A. Provide space at air handling units to allow coil and fan shaft replacement without major building revision.

- B. Provide space at air handling units for filter replacement.
- C. HVAC units requiring large amounts of outside air shall include preheat coil per OA prior to mixing with return air. Use steam distribution, “non-freeze”, heating coils with 1” tubes, wing or control air vertical tube coils for preheat.
- D. Install ½” ball valves with ¾” hose connection on supply and return piping at coils to allow venting and drainage.
- E. Provide a light (interior) at all AHU with interior mounted motors. Light should be a weatherproof type.
- F. Variable frequency drives are the preferred equipment for volume control.
- G. Coil drying connections are required. See appendix.

### **23 80 00 – DECENTRALIZED HVAC EQUIPMENT**

#### **23 81 00 – DECENTRALIZED UNITARY HVAC EQUIPMENT**

- A. Consult Owner regarding use.

### **23 82 00 – CONVECTION HEATING AND COOLING UNITS**

#### **23 82 16 – AIR COILS**

- A. Chilled water coils for air handlers shall have minimum 0.035” copper tube with minimum 0.049” bends and shall have aluminum fins. Must be certified to ARI Standard 410.
- B. Cooling coils using raw well water shall have minimum 0.049” copper tube with removable heads and shall have aluminum fins.
- C. Integral drain pans and center supports shall be provided according to good construction techniques and application of coil.
  - 1) Standard design shall be 45°F EWT, 55°F LWT, chilled water.
- D. Water fan coil units shall have 0.016 copper tube and aluminum fins.
- E. Steam and hot water coils for air handlers shall have 0.035” tube thickness.
  - 1) Non-freeze type coils shall have 1” tube diameter and wall thickness of 0.035”.
- F. All water coils should be provided with integral ½” minimum vent and drain connections, and they shall be extended to the outside of the housing and valved.
- G. Cooling coils shall not exhibit condensate carry over. Preferred cooling coil face velocity is 500 FPM or less.

- H. The maximum number of rows for any single coil shall be 6. Install coils in series if more rows are required. Provide space between coils to allow for coil repair and cleaning.
- I. Provide space to remove coils.
- J. Provide access panels to inspect coils.

### **23 83 00 – RADIANT HEATING UNITS**

- A. Steam and hot water unit heaters, convectors, and finned tube radiation shall meet the following guidelines.
  - 1) Coils in all units are to be easily accessible for cleaning and removal.
  - 2) All units should have individual automatic control.
  - 3) Provide shut off valves on both sides so that all parts can be repaired or replaced.
- B. Use electric heating only where no other means is available.

### **23 84 00 – HUMIDITY CONTROL EQUIPMENT**

- A. In general, use steam grid dry bar type humidifiers with jacketed manifolds.
- B. Building steam supply shall not be directly injected into airstream. Provide steam-to-steam exchanger type packaged humidifiers, or a steam fired steam boiler serving grid type humidifiers. Omit manufacturer control package. Control humidifier with BAS.
- C. Install humidifier at proper location in air system. Verify that design conditions of air at humidifier mounting point will allow humidifier to work properly.