SECTION 3 MD: MECHANICAL DIVISION

Latest Update 2-3-16, See underlined text

PART III: HEATING, VENTILATING AND AIR CONDITIONING SYSTEM DESIGN

1. SCOPE:

1.1. This part outlines the minimum requirements for the design procedures for heating, ventilation, and air-conditioning (HVAC) systems, and energy conservation, for new buildings, and repair and alteration projects for existing buildings on the UM campus.

2. DESIGN CRITERIA:

2.1. General:

a. **Comfort:** Comfort conditions to be maintained are dry-bulb temperature and relative humidify, as measured at five (5) feet above the floor. The indoor temperature varies with the activity and intended use of the building. Review the design of wall, floor, roof, and glazing assemblies to ensure they are optimized for energy efficiency, comfort, and condensation control.

b. **Wall and Roof Construction and Glazing:** Wall and roof construction and glazing should provide inside surface temperatures not lower than those in the following table when minimum outside design temperatures and maximum wind velocities prevail. Limits for office space should be used for laboratory and for other spaces where sedentary work is done near outside walls and windows. Limits for shops may be used in all other cases.

Minimum Inside Surface Temperature

Surface	**Office Space**	**Shop Space**
Glass.	45^0F	-------
Walls.	60^0F	45^0F
Ceiling/Exposed Roofs.	60^0F	60^0F

c. **Slabs on Grade:** Make recommendations to UM and the A/E team following the ASHRAE Handbook of Fundamentals for insulation of concrete slabs on grade.

2.2. Design Conditions and Calculations:

a. **Outdoor Design Conditions:** Base outdoor design conditions for heating and cooling as follows:

(1) **Winter:** 0^0Fdb

(2) **Summer:** 95^0Fdb/78^0Fwb

b. **Indoor Design Conditions:** Base indoor design conditions for heating and cooling as follows:

(1) Indoor design conditions to be used shall be 72^0F, winter, all areas; 75^0F, 50%RH summer, for laboratories, offices, classrooms and public spaces. Spaces housing elevator equipment shall be maintained at 80^0F or below. Spaces housing variable frequency drives shall be conditioned with tempered and filtered air where there is a concern that dirty conditions or an ambient temperature higher than 90^0F will exist. Relative humidify design shall be a maximum of 50% during the summer.

(2) Where individual user requirements exceed these limits, appropriate systems shall be provided for localized environmental control. These systems shall be separate and independent from the general building systems. However, it is the intent of the University to provide the majority of the HVAC needs with central building systems. Use of small, localized systems is discouraged, and should only be used for special circumstances, and will be subject to UM review and approval.

c. **Load Calculations and Energy Analysis:** Calculations and analysis shall be based upon established ASHRAE procedures and shall be presented using the published load calculation form as contained in the ASHRAE Load Calculation Manual, Publication GRP158 or electronic spreadsheets based on the ASHRAE procedure. For all renovation projects the engineer shall survey the existing areas to determine the impact on the cooling load from internal heat gain from neighboring spaces and all existing equipment.

2.3. Ventilation Requirements:

a. **Ventilation Rates:** Ventilation rates shall be established initially in accordance with ASHRAE Standard 62.1, 2007, Ventilation for Acceptable Indoor Air Quantity or latest edition and applicable NIH Guidelines for the anticipated occupancies.

b. Since operating experience shows that many UM Facilities undergo significant changes in occupancy during the life of the building, it is expected that the design ventilation rates will be reviewed and possibly modified by UM prior to incorporation into the system design.

c. **Indoor Air Quality Analysis:** The A/E shall perform an indoor air quality analysis to address the following:

(1) Identify interior and exterior contaminants.

(2) Provide containment or dilution control for all toxic, flammable and corrosive fumes.

(3) Review material safety data sheet (MSDS) information for all chemicals and materials to be used in the facility during construction when occupied.

(4) Eliminate all potential for standing water in the air handling and mechanical systems and equipment.

(5) Identify all volatile organic compound's (VAC) emitted by existing and proposed building finishes and furnishings.

(6) Establish area to area pressurization requirements where appropriate.

(7) Eliminate potential for microbial growth.

(8) Determine the level of particulate filtration required to minimize the potential for particulate contamination, such as dust, insects, pollen, dander and spores.

(9) Evaluate the need for monitoring the levels of carbon monoxide and other harmful gases.

3. BUILDING DISTRIBUTION SYSTEMS:

3.1. **General:** Campus building distribution systems include chilled water systems, process cooling water systems, condenser water systems, heating water systems, energy recovery systems, and steam systems. All building distribution systems shall be piped as reverse return unless otherwise directed by UM OFM.

a. Each piping system material and isolation valves shall be as specified in the UM master specifications.

b. For each distribution system include, at a minimum the design shall include isolation valves at each equipment connection, floor level branch piping and at the base of each riser.

3.2. **System Operation and Monitoring:** Campus building systems are operated and monitored by campus energy managers utilizing two (2) campus-wide automated energy monitoring and control systems. The HVAC system sizing and selection process shall be influenced by operating preferences and campus-wide standardization of systems where possible. In general, chilled water plants are not operated during the heating season. However, the typical system design includes connections to a campus wide chilled water loop, which requires the building chilled water circulation system to be operational at all times. It is generally preferred that system designs take full advantage of all available free cooling, economizer options.

3.3. **Unoccupied Hours:** During unoccupied hours, energy shall not be added to increase space temperature above 55^0F unless specific program requirements state otherwise. Since this will require heating the building mass on the next occupied cycle to at least above minimum inside surface temperature; make provisions to increase system capacity to provide this capability within two (2) to three (3) hours.

3.4. Building Supplemental Cooling Systems: In buildings connected to the campus chiller water loop system, design supplemental cooling systems to provide sensible cooling for cold boxes, laser systems, computer equipment rooms, laboratory equipment spaces, etc., to reject heat to the building's chilled water system through a process cooling water distribution system, or through the buildings AHU system cooling coils in accordance with UM requirements. In buildings not connected to the campus chilled water loop system, design a glycol cooling water system with dry coolers and pump packages located on the roof to reject the heat from the supplemental A/C systems. Meet with UM Facilities Management personnel to develop the desired system approach.

4. COOLING SYSTEMS:

4.1. General: Maintain required indoor design condition in spaces by supplying cooling adequate to offset the heat gain. In general, cooling energy shall be provided from cooling plants located in buildings on the UM campus. The cooling plants include chilled water, condenser water, and process cooling water distribution systems located in various campus buildings. The campus also has chilled water distribution loops between various buildings to optimize chiller plant operation. These plants supply chilled and/or cooling water to air distribution systems and sensible cooling systems located in the buildings.

4.2. Cooling System ATC Valves and Meters: All ATC valves and meters in the cooling systems shall be provided by ATC and monitored by the BAS. All meters monitored by the BAS shall be specified to be BAC Net IP compatible.

4.3. Campus Chilled Water Systems: The campus chilled water system is comprised of three campus chilled water distribution loops as follows:

a. **North Loop:** Located in the vicinity of Baltimore and Pine Streets, the north loop interconnects the chilled water plants in the seven largest campus buildings: The Dental School, Pharmacy Hall, Medical School Teaching Facility, Health Sciences Facilities 1 and 2, Haden Harris Hall (currently unoccupied), Howard Hall, and Bressler Research Building. UM is considering extending the north loop to interconnect plants in buildings in the northeastern corner of the campus.

b. **South Loop:** Located in Lemmon Alley between S. Greene and Pine Streets, the south loop interconnects chilled water plants in the Health Sciences/Human Services Library, School of Nursing and the Campus Center.

c. **East Loop:** The east loop interconnects chilled water plants in the School of Social Work, Davidge Hall, George Gray Lab, and the Museum of Dentistry.

d. Because the chilled water systems in numerous buildings are interconnected, particular attention must be paid to fill pressures and the specification of pipe, fittings, coils, valves, and all other accessories in the chilled water system under design. The maximum fill pressure of the system will be determined by the height of the tallest building connected to the loop. In the case of the north loop that is Bressler Research Building. For all chilled water systems connected to the north loop, 250 lb. fittings are required.

4.4. **Building Chilled Water Distribution Systems:** Chilled water systems shall be designed as primary/secondary distribution systems configured to be similar to chilled water systems in the existing buildings.

a. **Building Primary Chilled Water Distribution Systems:** Primary chilled water systems shall include primary pumps sized for importing and exporting chilled water to or from the campus chiller water loop, as well as maintaining the required flow rate in the primary system to each chiller. Design primary pump head loss should be seventy five (75) ft. Provide one (1) primary pump for each chiller, sized for the design flow rate through the chiller. Provide a standby pump as well.

b. **Building Secondary Chilled Water Distribution Systems:** Secondary chilled water systems serving air handling units and other HVAC systems in the building shall be designed for a supply temperature of 45^0F, with a 12^0F temperature rise through the cooling coils. These systems shall include two (2) secondary pumps, two (2) VFD's, controls, etc.

c. **Building Secondary Process Cooling Water Distribution Systems:** Building secondary process cooling water systems shall be designed into the building to supply cooling water with a primary/secondary bridge connection to the campus chilled water loop system. The system shall supply cooling water to water cooled compressorized equipment serving environmental cold rooms, lasers, electron microscopes, etc. These systems shall include two (2) secondary pumps, two (2) VFD's, controls, etc. The pumps shall be served with emergency power.

d. **Existing Building Secondary Process Cooling Water Distribution Systems:** The following campus buildings have secondary process cooling water systems. This listing includes the differential operating pressure, in psi and ft (psi/ft.), for each system, and the design supply water temperature set point. Also use a 20^0F water temperature rise.

(1) **Bressler Research Building:** 12 psi/27.72 ft, and 70^0F.

(2) **Howard Hall:** 18 psi/34.65 ft and 62^0F.

(3) **Medical School Teaching Facility:** 8 psi/18.48 ft and 70^0F.

(4) **Dental School - North:** 16.7 psi/38.57 ft and 70^0F.

(5) **Dental School - South:** 13 psi/32.34 ft and 70^0F.

(6) **Health Sciences Facility I:** Limited capacity and 70^0F.

(7) **Health Sciences Facilities II - A:** 15 psi/34.65 ft and 70^0F.

(8) **Health Sciences Facilities II - B:** 16 psi/36.96 ft and 70^0F.

(9) **Pharmacy Hall:** 25 psi/46.20 ft and 70^0F.

(10) **Pharmacy Addition:** +/-14 psi/32.34.00 ft and 70^0F.

(11) **Allied Health:** Limited capacity and 70^0F.

(12) **MBI:** 30 psi/69.30 ft and 58^0F.

(13) **Connections to the Existing Systems:** For systems in locations one (1) through ten (10) above the system operation pressures could be as high as 150 psi between the lowest system connection point to and the middle elevation connection point in the building. All equipment and/or materials such as hoses that are connected to the systems between the low level and middle levels must be rated for the higher system operation pressure.

e. **Computer Room Secondary Process Cooling Water Distribution Systems:** Computer room secondary process cooling water systems shall be designed into the building to supply cooling water with a primary/secondary bridge connection to the campus chilled water loop system. This system shall be dedicated to computer rooms, server rooms; IT and BDF rooms to supply cooling water to the water cooled compressorized equipment serving these spaces. The system design shall include an infrastructure sized for present and future equipment loads. These systems shall include two (2) secondary pumps, two (2) VFD's, controls, etc. The pumps shall be served with emergency power. The A/E shall coordinate the system loads with UM.

4.5. Building Condenser Water Distribution Systems:

a. **System Design:** Condenser water systems serving cooling towers and chillers shall be designed for a supply temperature of 85^0F with a 10^0F temperature rise through the chillers and a 10^0F drop through the cooling towers. These systems shall include one pump per chiller, sized for the design flow rate through the chiller, a standby pump, VFD's, controls, condenser water filter/backwash system, and an automatic drain and fill system.

b. **Automatic Drain and Fill System:** The automatic drain and fill system shall be designed to drain the system to a level of two (2) feet below the roof when the ambient outdoor temperature is 35^0F or below. When the ambient air temperature rises to a pre-programmed temperature range of 55^0F to 65^0F the BAS shall fill the system automatically. The design and specifications for this system shall be coordinated with the UM A/E Staff.

c. **Tower Bypass:** The condenser water distribution system design shall include appropriately sized tower bypass piping. The bypass piping shall be located inside the conditioned building, and as close as possible to the cooling tower. The design and specifications for this system shall be coordinated with the UM A/E Staff.

d. **Makeup Water:** Cooling tower make-up water shall be an automatic fill system with reportable water meters on the tower make up water (tower fill), and chemical bleed lines. The meters for the tower fill and bleed systems shall be as approved by Baltimore City. The design and specifications for this system shall be coordinated with the UM A/E Staff.

e. **Cooling Tower Rebate System:** Provide a cooling tower rebate system including reportable meters, for makeup/fill water, chemical bleed, tower overflow, tower drain, tower water filter drain, condenser water supply and return drains to send recorded data to the BAS through a Bac Net IP or Modbus interface system. The design and specifications for this system shall be coordinated with the UM A/E Staff.

f. **Water Treatment System:** Provide a water treatment system for the condenser water system. The design and specifications for this system shall be coordinated with the UM A/E Staff.

g. **Cooling Tower Filter/Backwash System:** The condenser water system shall be provided with a cooling tower filter/backwash system located in a mechanical room near the cooling tower(s). This system shall include a filter system for the tower condenser water, a domestic water service connection for flushing the filter media and all necessary water and drain piping, valves, controls, equipment, electrical service etc. The design and specifications for this system shall be coordinated with the UM A/E Staff.

h. **System ATC Valves and Energy/Flow Meters:** All ATC valves and/or energy/flow meters in the condenser water systems indicated above shall be provided by ATC and monitored by the BAS.

i. **Exterior Condenser Water Pipe Material:** UM is currently utilizing FRP piping for exterior portions of the condenser water piping system to minimize corrosion and scale build up. All exterior pipe material for condenser water, drain, equalizing and overflow piping shall be FRP pipe and fittings to a point two feet below the roof level of the building. See UM Specifications for additional requirements.

j. **Cooling Tower Piping:** Cooling tower piping shall include separate headers for condenser water supply, condenser water return, equalizing line, tower drain, and tower overflow and appropriate branch piping for each service to each tower cell. UMB requires condenser water return piping to the tower cells to be installed exterior to each tower cell. Provide supports for the vertical piping and flexible connections on each service pipe to allow for movement of the tower on their isolation rails free of the piping. See UM Specifications and Details for additional requirements.

4.6. **Building Supplemental Cooling Systems:** In buildings connected to the campus chiller water loop system, design supplemental cooling systems to provide sensible cooling for cold boxes, laser systems, computer equipment rooms, laboratory equipment spaces, etc., to reject heat to the building's chilled water system through a process cooling water distribution system, or through the buildings AHU system cooling coils in accordance with UM requirements. In buildings not connected to the campus chilled water loop system, design a glycol cooling water system with dry coolers and pump packages located on the roof to reject the heat from the supplemental A/C systems. Meet with UM Facilities Management personnel to develop the desired system approach.

4.7. **Building Sensible Cooling Systems:** In laboratory areas where the calculated room sensible heat gain requires a supply/exhaust air volume that exceeds six (6) air changes per hour (ACPH) of 100% outdoor air, provide the air volume equal to the six (6) ACPH from the building air system. The balance of the room sensible heat gain shall be offset utilizing one and/or a combination of the following systems for both new and renovation projects:

a. **Fan Coil Units:** Fan coil units including a fan, cooling coil, and filter enclosed in a metal housing and supplied with chilled water from a secondary chilled water system that provides chilled water at 45^0F, with a 12^0F temperature rise year-round. Depending on available space in the laboratory these units can either be floor or wall mounted or located above the ceiling of the laboratory. Units located above the ceiling shall be specified with duct collars and must be located so the units can be accessed for service. Floor or wall mounted units shall be specified with supply and return grilles in the casing.

b. **Chilled Beams:** When space is available include in the design the required number of chilled beams arranged along the ceiling and supplied with chilled water from a secondary chilled water system that provides chilled water of not less than 60^0F, with a 12^0F temperature rise year-round. Include the required controls to maintain a supply water temperature without condensation and an automatic shut off of water flow if the space dew point temperature could produce condensation.

c. **Compressorized Cooling Units:** In buildings where 45^0F chilled water is not available year around provide water cooled compressorized cooling units supplied with cooling water from the building process cooling water system at 70^0F, with a 20^0F temperature rise. Depending on available space in the laboratory these units can either be floor mounted or located above the ceiling. Single or multiple units located above the ceiling can either fit within a ceiling grid or be configured for supply and return ductwork. Units located above the ceiling shall be specified with duct collars and must be located so the units can be accessed for service. Floor mounted units shall be specified with supply and return grilles in the casing.

5. MECHANICAL COOLING:

5.1. **Compressorized Equipment:** Selection of the type of refrigeration systems shall be coordinated with UM. Selection criteria shall address:

a. Peak load performance.

b. Part load performance.

c. Unloading capability to 20% of capacity.

d. Multiple units for redundancy.

e. Compliance of refrigerants with current environmental requirements.

f. Compatibility with campus-wide energy management and control system.

g. Acceptable noise level (indoor and outdoor).

h. Special systems such as hot gas bypass, low ambient controls, etc.

i. Reliability.

5.2. **Packaged Roof Top Equipment:** Where packaged roof top equipment is used, such as air cooled chillers or self contained roof top air handling units, specify high efficiency performance.

5.3. **Heat Rejection Equipment <u>Selection</u>:**

a. **Cooling Towers:**

(1) Cooling tower selection shall be based on performance rating at 80^0F wet bulb. Multiple units shall be provided for redundancy where appropriate. Noise criteria shall be determined and shall influence selection. Potential for winter operation shall be coordinated with UM. Special consideration shall be given to the plume characteristics of the unit discharge with respect to helicopter approach and exit paths from the MIEMMS helipad. Coordinate with the A/E team for any screening requirements, and provide adequate clearance for air flow and service. When VFD's are considered for cooling towers specify a direct drive fan assembly or a gear drive fan assembly. Coordinate with UM.

(2) All other heat rejection equipment shall be selected for an outside air temperature of 100^0F dry bulb when located on grade and an outside air temperature of 110^0F dry bulb when located on a roof level.

5.4. **<u>Cooling Tower Service Platforms, Hand Rails and Stairs:</u>**

a. **<u>General:</u>** <u>Where cooling towers are elevated above the finished grade or finished roof level by three (3) feet or more the project design shall include service platforms, safety rails, toe kicks, access stairs with hand rails. The service platforms shall be located around the entire perimeter of the tower(s) to access the fill basin from the exterior of the tower for maintenance and to access the doors at the ends of each tower. All</u>

components shall be constructed of galvanized steel with bolted and/or welded joints. All walking surfaces shall be open grate non slip type surfaces. The Engineer shall coordinate the requirements for the service platforms and all accessories with the Architect and Structural Engineer for inclusion with the support system for the cooling towers.

b. **Service Platforms:** Service platforms shall be level with the bottom of the cold water basin and shall extend outward thirty six (36) inches from each side of the cooling tower with forty two (42) inch high hand rails and two (2) inch high toe kicks around the perimeter of the platform. The load bearing capacity of the assembly shall be not less than 300 lbs. /sq. ft. These service platforms shall be connected to the steel support dunnage for the cooling towers. Do not support these platforms off of the base rails for the cooling tower. Leave clearance to allow for the free movement of the cooling tower on their isolation rails.

c. **Access Stairs:** Access from the finished grade or roof level to the service platforms shall be provided by a thirty six (36) inch wide stair with thirty six (36) inch high hand rails.

6. HEATING SYSTEMS:

6.1. **General:** Maintain required indoor design condition in spaces by supplying heat adequate to offset heat loss. In general, heating energy shall be provided from the district steam system serving the UM campus. The engineer shall contact UM to determine the process for design of the steam service and first stage of pressure reduction for the building. In general, the steam service and metering shall be as directed by the district steam provider. Where not economically feasible, other sources shall be investigated. Where gas is used, gas-fired heating systems shall have output-to-input energy efficiency ratings of not less than that recommended in ASHRAE 90.1. Systems may be combined with ventilating and air-conditioning if functionally and economically feasible. Selection of heating source shall be subject to review and approval by UM.

6.2. **System ATC Valves:** All automatic ATC valves in the heating water systems shall be provided by ATC and monitored by the BAS.

6.3. **Heating Water Distribution Systems:**

a. **Primary Heating System:** The heating water distribution system shall include a set of primary water pumps arranged for lead/lag operation and temperature reset controls and with separate pumps for each heating zone.

b. **Heating Zones:** The heating water distribution system for each heating zone shall include a set of secondary pumps arranged for lead/lag operation, and temperature reset controls. The following separate zones shall be designed. Where appropriate, a combination of zones may be permitted, subject to UM review and approval.

(1) Perimeter heating, zoned by exposure.

(2) Terminal reheat and duct heating.

(3) Air handling unit, unit heaters and convectors.

(4) Air handling unit preheat and energy recovery run around loop.

c. **Heating System Relief Valves:** Relief valves in heating systems shall be piped to the system make up water treatment tank, floor drains or other storage vessel unless directed otherwise by UM. Relief valves in pre-heat glycol systems shall only be piped to the systems glycol feeder or other storage vessel unless directed otherwise by UM.

6.4. Perimeter Heating System:

a. Since control between interior and exterior spaces may cause a lack of comfort as seasons change, provide a perimeter heating system for the building glazing load only. Provide individual zones of control based upon building exposures and building component thermal characteristics. The design shall provide perimeter heat below every window or glazing element, ten (10) sq. ft. and larger, used in the perimeter building envelope, and shall consist of finned tube radiation. Hot water radiant heating panels shall not be used.

b. No space temperature controllers shall be used with the perimeter heating system. The perimeter heating media temperature shall be controlled with a temperature reset schedule, based on outside air temperature, controlled separately for each exposure.

6.5. Terminal Reheat and Duct Heating: For systems of appreciable size, as coordinated with UM, a separate heating distribution system shall be provided for reheat and duct coils.

6.6. Air Handling Unit Heating, Unit Heaters and Convectors: Where there is no air handling unit heating coil, unit heaters and convectors may be combined with another zone as coordinated with UM.

6.7. Preheat/Energy Recovery Systems: Each system shall be provided with a 40% ethylene glycol/water solution, using Dowtherm SR-1. Glycol is considered a hazardous material. System(s) shall be designed with a main recovery point for each system. Drain down points for glycol systems shall not be piped to any storm or sanitary drains in the building or on the roof. A central drain down point shall be designed so that glycol can be recovered in appropriate containers.

6.8. Redundant Heating Source and Distribution: Redundancy of the heating source shall be provided in the form of multiple, primary heating equipment. Primary heating equipment shall be sized for at least 2/3 of the peak load unless otherwise indicated or directed by UM. The following primary heating sources shall be considered, subject to UM review and approval:

a. **Boilers:** Where hot water boilers are selected as the primary heating source, provide two boilers, each sized for 2/3 of the peak load. Boilers shall utilize either gas, electric, or fuel oil as the source of thermal energy.

b. **Converters:** Where steam-to-hot water converters are used, provide 1/3 - 2/3 control valve arrangements. Each heating water system shall be provided with two converters, each sized for approximately 2/3 of the total anticipated load to provide for redundancy and future expansion.

c. **District Steam Distribution System:** When using steam from the district steam distribution system, steam is provided at high pressure, with the first stage of pressure reduction provided by the utility. Coordinate space and location requirements with the local utility. Provide an estimated steam demand load to the local utility and coordinate service sizes, capacities and design requirements. The steam distribution system serving converters, coils and equipment shall be a medium pressure supply and condensate return system with an operating pressure of approximately 60 psi. Steam condensate from the high pressure and medium pressure piping, reducing stations and distribution systems shall be routed through a flash tank vented to atmosphere. Steam condensate is not returned to the district steam system. When steam condensate is not considered for heat recovery the condensate shall be cooled to the maximum temperature permitted by Plumbing Codes prior to discharge into the storm water system.

d. **Heat Recovery Methods:** Heat recovery methods, such as for as recovering waste heat from steam condensate, shall be considered for domestic water preheat and for reheat systems preheat.

e. **Pumps and Zones:** Multiple heating water pumps shall be designed for each zone to provide standby potential. Provide four (4), one (1) inch valved and capped connections per floor in the reheat distribution system for future expansion.

6.9. **Floors Exposed to the Outside:** Where occupied areas have floors exposed to the outside temperatures, provide unit heaters or other methods of maintaining a reasonable temperature in the space below the floor. Coordinate with the A/E team to appropriately insulate this space.

6.10. **Entrance Heating:** Heat entrance vestibules by cabinet unit heaters, located at floor level. Provide areas adjacent to frequently-opened doors with adequate heating equipment to overcome excessive heat loss when doors are opened in cold weather. Areas near exterior doors intended for occasional use shall be designed with heating equipment sized only to offset normal heat transmission, infiltration, etc.

7. HUMIDIFICATION SYSTEMS:

7.1. During late fall, winter and early spring, when buildings typically require heat to maintain comfortable interior environmental conditions, the outdoor environment experiences a significant drop in humidity levels. This is due to the inherent inability of cold air to hold much moisture. Because of the lack of sufficient vapor barriers in modern building construction, this low humidity outside will translate into low humidity levels inside buildings as well. With very few exceptions, low humidity will not cause health or other problems for building occupants. The only real requirement for humidity levels to be artificially controlled is in animal areas where fluctuations in humidity levels may negatively impact ongoing experimentation and research. Providing a humidification system in the mechanical equipment is a very costly process. The required humidification equipment and additional piping adds to the first cost of the system. The added expense of constructing a building or specific rooms in the building with the continuous vapor barrier necessary to overcome the resulting differential vapor pressure caused by the humidification process is significant. The continuous addition of moisture to the supply air system required to maintain an elevated humidity level increases annual energy costs. Continuous addition of moisture to air distribution system can cause mold growth in the ductwork, creating a problematic, unhealthy environment. The maintenance burden imposed by the humidification equipment is significant. Generation of steam, by its very nature; leaves behind deposits of minerals and other impurities which coat the humidification apparatus, rendering it useless and unserviceable within a relatively short period of time. For these reasons, it is the policy of the Office of Facilities Management at UM to forego the provision of humidification systems in the buildings' main air handling systems, and instead provide local humidification systems in areas where humidity control is critical to the occupants' function, such as in animal rooms, historical archive, display and storage rooms, and other special use areas. Where localized humidification systems are used all metallic components shall be specified to be constructed of stainless steel.

7.2. The University has determined that in buildings where the heating source is supplied from a connection to the local district steam utility, the central steam is of sufficient quality that it can be utilized directly for those special circumstances where local humidification is required. For buildings that will not be served from the district steam utility, the source of steam, if needed for special circumstances, will be determined in conjunction with the heating source assessment for the building.

8. PIPING SYSTEMS:

8.1. **Arrangement:** Design of the heating, chilled and condenser water piping systems shall incorporate the pressure rating requirements of coils, piping, valves and fittings where the combination of system fill pressure, determined by vertical height, and pump discharge pressure exceed the standard ratings.

8.2. **Water Systems:** Heating, chilled water, and all other hydronic systems shall be designed with a reverse return distribution system. Dual-temperature piping systems shall not be considered.

8.3. **Sizes:** Size piping for a maximum friction loss of three (3.0) feet per one hundred (100) feet of straight pipe, or a velocity of six (6) feet per second, whichever results in the larger pipe size.

8.4. **Layout:** The chilled water and heating water piping layouts shall be logically designed to provide organized distribution systems which permit the isolation of distinct sections without disruption to the entire building. This includes provision of a major branch to each section and installation of isolation valves at every major branch. Isolation valves shall also be provided at all unit connections. Manual air vents shall be provided and shown on drawings at all high points of piping systems. Hose-end drain valves shall be provided and shown at all low points of piping systems, including all trapped sections of piping. For all chilled water connections to self contained, compressorized water-cooled equipment for heat rejection, provide hose-end drain valves on supply and return piping for emergency hook-up of domestic water. Obtain from UM the latest schematic diagram for cooling water hookup for cold box units and other water cooled compressorized equipment.

8.5. **Piping Expansion:** Show locations of expansion compensators, loops, and anchors on drawings. Incorporate flexible connections and acoustical treatment to prevent transmission of vibration and fluid noise. Due to maintenance problems with compensators, expansion loops shall be used wherever possible.

8.6. **Flow Measurement:** Provide suitable devices so flow (GPM) can be measured in major branches and major equipment such as chillers, cooling towers, boilers, coils, convertors and primary and secondary loops. Where required by UM the measured data shall be transmitted to the building automation system and to the energy managers. Provide balancing devices to allow adjustment. The piping layouts shall incorporate manufacturer's installation requirements of flow measuring devices to ensure accurate readings. This includes the provision of the necessary straight runs of piping required upstream and downstream in the piping system for proper operation. Separate taps shall be provided on the suction and discharge of each pump for installation of energy management monitoring devices. Specify that flow charts and meters be supplied with all flow measuring devices. Flow meters that are reportable to BAS shall be BAC Net IP based meters.

8.7. **Energy and Flow Measurement:** Provide suitable devices so energy (BTU) and flow (GPM) can be measured in major branches and major equipment such as chillers, cooling towers, and primary and secondary loops. The measured data shall be transmitted to the building automation system and to the O&M energy management team. The piping layouts shall incorporate the manufacturer's installation requirements of flow measuring devices to ensure accurate readings. This includes the provision of the necessary straight runs of piping required upstream and downstream in the piping system for proper operation. Energy meters that are reportable to BAS shall be BAC Net IP based meters.

8.8. **Expansion and Air Elimination:** Provide an expansion tank and air separator for each closed system. The design of the connection to the expansion tank shall include a lockable isolation valve and a drain valve between the isolation valve and the tank to permit reducing system pressure on tank during draining and recharging operations. Specify tanks with field charging and drain connections.

8.9. **Makeup Water Connections:** Provide each piping system with a makeup water connection for filling purposes that complies with local codes, with a reduced pressure backflow preventer. Design shall include determination of fill and relief valve pressures. Provide pressure and temperature relief valves for both heating and cooling systems. The pressure rating of all make-up piping, valves and fittings shall be specified to exceed the system operating pressure by at least 20%. On all glycol systems, design a manual make-up water feed to a mix tank with a pump fill system. Do not provide an automatic make up water system directly piped to the distribution piping on glycol systems. The relief valve on glycol systems shall be piped to discharge into the mix tank.

8.10. Water Treatment: Provide, in each closed-loop water piping system, three quarter (3/4) inch valved connections for the chemical treatment systems. Coordinate system requirements with UM. Obtain water treatment chemical requirements from UM.

8.11. Variable Speed Pumping: Design variable speed distribution on systems with twenty (20) HP pumps and larger, or where economically justified, for all heating and cooling systems. Specify two (2) way ATC valves where variable speed distribution is used. Specify a dedicated VFD for each pump.

8.12. Materials: The UM master specifications permit the use of grooved pipe and fittings, such as victaulic. The use of grooved pipe fittings is preferred in areas such as mechanical rooms, where the potential for future modifications exists. However, grooved pipe fittings are not an acceptable substitute for flexible connections or for expansion compensation.

9. AIR HANDLING SYSTEMS:

9.1. General:

a. Air handling systems shall maintain the interior space conditions required for the building by simultaneously controlling the supply air temperature, humidity, and air volume to the space. The following systems shall be considered for use:

(1) Modular air handling units.

(2) Built-up air handling systems.

(3) Constant air volume. (CV)

(4) Constant volume (CV) with reheat.

(5) Variable air volume (VAV)

(6) Variable air volume (VAV) with reheat.

(7) Four (4) pipe fan coil.

(8) Self-contained, direct expansion (limited to special applications).

b. The mechanical engineer shall identify the proposed air distribution system design to UM at the Design Development Phase for review.

c. **Constant Volume Reheat Systems:** Where constant volume reheat systems are used, provide one terminal reheat unit for no more than four hundred (400) square feet of space, but more terminal reheat units may be necessary to meet control requirements contained elsewhere in these standards.

d. **Capacity Control:**

(1) Provide inlet vane control and/or variable pitch blade control or VFD's for fan capacity control.

(2) Where variable air volume (VAV) systems are designed, no credit for system or load diversity shall be assumed. Air quantities shall be calculated on total connected peak loads similar to constant volume system design.

9.2. **Laboratory Spaces:** Where the HVAC system will serve laboratory spaces, a 100% outside air, constant volume terminal reheat system shall be designed with a dedicated terminal reheat unit and exhaust terminal unit for each space.

9.3. **Animal Room Ventilation:** The A/E team shall consider the use of cage ventilation systems for animal room ventilation where appropriate. If required by the UM OFM Project Manager, the A/E team shall conduct a life cycle cost analysis of the cage ventilation system and compare it to a more traditional ventilation design approach.

9.4. **Location of Outside Air Intakes:**

a. It is generally desirable to locate outside air intakes at the roof level. Where this is not economically feasible, outside air intakes shall be located not less than ten (10) feet above the surrounding grade, and never in an areaway or below grade well.

b. The design shall maintain a minimum separation of fifty (50) feet between outside air intakes and relief or exhaust air discharge, and the outside air intake shall always be located on the windward side, as determined by local prevailing wind direction.

c. Outside air intakes shall not be located where exhaust from vehicles at loading docks, parking spaces, dumpsters, emergency generator exhaust or other idling motors can enter.

9.5. **Energy Efficient Systems:** All air handling systems with recirculating air shall be designed with 100% outside air economizer, unless otherwise directed by UM. The design shall include a powered exhaust for 100% relief air.

9.6. **Louvers:**

- **a.** Coordinate the location, selection and specification of all intake and exhaust louvers with the A/E team. If specified by the architect, provide appropriate performance and construction data for inclusion in the specification.

- **b.** Size intake louvers for a free area face velocity not to exceed five hundred (500) FPM with zero moisture penetration.

- **c.** Size exhaust louvers for a free area face velocity not to exceed eight hundred (800) FPM.

- **d.** All louvers shall be specified to be storm proof.

- **e.** Specify that one half (1/2) inch wire mesh shall be provided on all louvers.

10. AIR DISTRIBUTION SYSTEMS:

10.1. General: The air distribution system shall be designed to maintain a slight positive pressurization of the building with respect to the outside. All areas shall be provided with conditioned air as required to satisfy heating, cooling and ventilation requirements. The requirements for laboratories shall be six (6) air changes per hour (ACPH) for makeup air for fume hood and general exhaust, whichever represents the highest air flow rate and shall generally be negative with respect to the surrounding areas. When the room sensible heat gain exceeds the six (6) ACPH, provide a sensible cooling system as indicated elsewhere in these standards. Minimum requirements for all other occupied spaces shall be one (1.0) CFM per square foot of floor area.

10.2. Mechanical Equipment Spaces: For mechanical equipment spaces where positive ventilation is required, such as rooms housing atmospheric burners, the minimum air change rate shall be twelve (12) air changes per hour. Intermittent, thermostatically controlled supply air is acceptable, provided that sufficient combustion air is provided during burner operation.

10.3. Future Expansion: Future expansion capability shall be incorporated into the air distribution system design. The degree of expansion shall be coordinated with UM.

10.4. Ventilation: Ventilation for mechanical rooms housing refrigerating equipment shall be designed in accordance with the latest ASHRAE Standards.

10.5. Supply Air Temperature: Conventional supply air systems shall be designed with a supply air temperature of not less than 55^0F.

10.6. Re-Circulating Air Systems: Where re-circulating air handling systems are used and the minimum outside air requirements are 40% or less, do not provide a preheat coil in the design. The chilled water coil shall be designed to function as a dual temperature coil for heating, as required to permit heat recovery. For ventilation air control provide a Co_2 sensor.

10.7. Heat Recovery: Where 100% outside air systems are used, include in the design a heat recovery run-around loop using 40% glycol or a heat wheel system. The maximum operating temperature in the heat recovery loop is typically 80^0F.

10.8. Reheat Systems: Where reheat systems are used, the maximum reheat water temperature supplied to the reheat coils shall be 180^0F, with a reset control based on outdoor air temperature included in the design. Where heat recovery from steam condensate is incorporated, the reheat system, including reheat coil selection, shall be designed for a lower entering water temperature of 140^0F.

11. LABORATORY HVAC DESIGN FOR NEW AND/OR RENOVATION PROJECTS:

11.1. Design Intent: The intent of the laboratory HVAC design is to standardize the use of materials, equipment, and systems for all new laboratory installations and all laboratory renovation projects. The A/E shall discuss with UM the selection of all material and equipment prior to proceeding with the design.

11.2. General Laboratory Requirements: Standard laboratory requirements shall include but not be limited to the following:

a. Designs: All designs shall include the use of constant volume terminal units with reheat for supply air from the 100% outside air units, constant volume general exhaust terminal units, and constant volume exhaust terminal units for general purpose low flow fume hoods connected to the building general exhaust systems. When special purpose fume hoods are required provide dedicated exhaust systems for each hood. All terminal controls shall be DDC.

b. General Purpose Low Flow Fume Hoods: The use of general purpose low flow fume hoods is preferred for all projects at UM. All general purpose low flow fume hoods shall come with a lockable ventilated chemical storage cabinet. When flammable storage cabinets are required the cabinet shall be located next to the general purpose fume hood and the cabinet shall be provided with a ventilation duct connected to the fume hood exhaust duct above the fume hood. The exhaust terminal unit and exhaust ductwork serving the low flow general purpose fume hoods shall be sized for a face velocity of 100 fpm through an eighteen (18) inch high sash opening and have the ability to maintain 80 FPM face velocity.

c. Special Purpose Fume Hoods: The use of special purpose fume hoods shall be limited to laboratory areas where perchloric acid and/or radioisotopes are used. All special purpose fume hoods shall come with a lockable storage cabinet. The exhaust terminal unit and exhaust ductwork serving special purpose fume hoods shall be sized for a face velocity of 100 fpm through an eighteen (18) inch high sash opening.

d. Room Control: Laboratories and equipment support spaces shall have individual room control with supply and exhaust terminals, unless otherwise directed by UM. Administrative spaces with the same exposure shall be grouped together with three (3) spaces on a single room sensor unless otherwise directed by UM.

11.3. Special Laboratory Requirements: Special laboratory requirements shall include but not be limited to the following:

a. **Laboratories with General Purpose Low Flow Fume Hoods:** In laboratory areas with general purpose low flow fume hoods include a terminal reheat unit (TRU) for supply air and an exhaust terminal unit (ETU) for the room’s general exhaust with VAV controls. For the general purpose low flow fume hoods, connected to the building’s general exhaust, include an ETU with constant volume (CV) controls. The TRU will track the ETU to maintain the proper room environment and room pressurization while the fume hood general exhaust will maintain the proper exhaust air volume for the hood. Where general purpose low flow fume hoods are connected to a dedicated exhaust fan, the ETU for the hood is not required.

b. **Laboratories with Existing General Purpose Fume Hoods:** In laboratory areas where the existing general purpose fume hoods are to remain, and/or be reused from another location include a terminal reheat unit (TRU) for supply air and an exhaust terminal unit (ETU) for the room’s general exhaust. The TRU will track the ETU to maintain the proper room environment and room pressurization.

c. **Laboratories without General Purpose Fume Hoods:** In laboratories without general purpose fume hoods include a TRU for supply air and an ETU for the room’s general exhaust. The TRU will track the ETU to maintain the proper room environment and room pressurization.

d. **Biological Safety Level 2 Laboratories (BSL-2):** In BSL-2 laboratories include a TRU for supply air and an exhaust terminal unit (ETU) for the room’s general exhaust. The TRU will track the ETU to maintain the proper room environment and room pressurization. The biological safety cabinet (BSC) must be installed so that the fluctuations of the room air supply and exhaust do not interfere with the proper operation of the BSC.

e. **Biological Safety Level 3 Laboratories (BSL-3):** A/E design team must coordinate the designs for biological safety level 3 areas with UM Facilities Management.

f. **Animal Biological Safety Level 3 Laboratories (ABSL-3):** A/E design team must coordinate the designs for animal biological safety level 3 areas with UM Facilities Management.

g. **Surgery Laboratories, Survival:** In surgery laboratories, survival, include a TRU for supply air and an exhaust terminal unit (ETU) for the room’s general exhaust. The TRU will track the ETU to maintain the proper room environment and room pressurization.

h. **Surgery Laboratories, Non - Survival:** In surgery laboratories, non – survival, include a TRU for supply air and an exhaust terminal unit (ETU) for the room's general exhaust. The TRU will track the ETU to maintain the proper room environment and room pressurization.

i. **Animal Holding Rooms:** In animal holding rooms include a TRU for supply air and an exhaust terminal unit (ETU) for the room's general exhaust. The TRU will track the ETU to maintain the proper room environment and room pressurization.

j. **Tissue Culture Rooms:** In tissue culture laboratories include a TRU for supply air and an exhaust terminal unit (ETU) for the room's general exhaust. The TRU will track the ETU to maintain the proper room environment and room pressurization.

k. **Administrative Support Areas:** In administrative support areas include a TRU for supply air and an exhaust terminal unit (ETU) for the room's general exhaust with VAV controls. The TRU will track the ETU to maintain the proper room environment and room pressurization.

l. **Equipment Rooms:** In equipment rooms provide water cooled supplemental A/C Units connected to the buildings process cooling water loop system sized for the sensible cooling load of the room. Coordinate the system requirements with UM. These units shall be controlled and monitored by the building automation system. Provide ventilation air to these rooms from TRU's and ETU's serving adjacent areas.

11.4. **Room Pressurization Requirements:** Room's shall be negative or positive to corridors with individual room control with supply and exhaust terminals, and related controls. Room pressurization is typically negative to the corridor and shall include but not be limited to the following unless otherwise directed by UM:

a. **Laboratory Room Pressurization:** Provide exhaust terminal units to control the general exhaust and/or fume hood exhaust air volume to a minimum of 100 CFM above the supply ventilation air volume to ensure the laboratory is negative to the surrounding rooms. Supply terminal unit(s) shall track the exhaust terminal units to provide the required air volume differential between supply and exhaust to maintain a negative pressure in the laboratory.

b. **General Room Pressurization:** Non-laboratory areas such as offices, conference rooms, and other administrative areas shall be positive to the corridors and adjacent areas.

12. AIR FILTERS:

12.1. Filter Efficiency Requirements:

Space Served	**Filter Efficiency***
Office areas, general occupied spaces.	60%

Laboratory areas.	Final Filter - 95%
FUME hoods, toxic, tissue culture and biological containment (coordinate requirements with EHS).	99.5% (HEPA)

*Per NBS dust spot test method or ASHRAE test method.
Provide a two (2) inch pleated pre-filter (throw-away type) as well.

12.2. Selection of Filters: Select filters for maximum operating velocity of four hundred (400) FPM to give an economic combination of static pressure loss and dust-holding capacity.

12.3. Access Door: Provide a hinged access door with a minimum width of eighteen (18) inches, and sized as necessary for filter removal/replacement. Coordinate with the A/E team to provide access to filter assemblies. Where 95% efficiency filters are required, the design shall include walk-in access doors, and the filter frames shall provide for front load clip type filter holders. Side load track type filter frames are not acceptable.

12.4. Pre-Filters: Pre-filters shall be used on the inlet of all energy recovery coils, in both the outside air and exhaust air streams. Prefilter efficiency shall not be less than 35%.

12.5. Filter Housings: Filter housings shall not be installed above ceilings in labs, or above plaster or inaccessible ceilings. Bag–in/bag–out filter housing assemblies shall be located in an accessible area on the roof level of the building.

13. AIR TERMINAL UNITS:

13.1. Terminal Reheat Units:

a. Terminal reheat units (TRU) shall be specified to be provided with a factory mounted control panel, velocity sensor, reheat coil with access door, antimicrobial insulation and all necessary DDC controls mounted in a control enclosure on the side of each TRU. Reheat coils shall be a minimum of two (2) rows. Each coil shall be sized for the air pressure drop at the maximum air flow with 55^0F entering air temperature and 90^0F leaving air temperature and 150^0F average water temperature (160^0F - 140^0F). Where it is deemed appropriate by UM, reheat coils shall be selected for performance with an entering water temperature of 140^0F to maximize heat recovery from steam condensate systems. TRU's serving laboratory areas with fume hoods shall have constant volume controls. TRU's serving laboratories without fume hoods, and laboratory equipment areas, shall have variable volume controls. TRU's serving administrative areas shall also have variable volume controls.

b. When terminal reheat units include VAV control size the reheat coil and box for the maximum air quantity in the heating mode.

13.2. General Exhaust Terminal Units:

a. General exhaust terminal units (GETU) shall be specified to be provided with a factory mounted control panel, velocity sensor, antimicrobial insulation and all necessary DDC controls mounted in a control enclosure on the side of each GETU. GETU's serving laboratory areas with fume hoods shall have constant volume controls. GETU's serving laboratories without fume hoods and laboratory equipment areas shall have variable volume controls. GETU's serving administrative areas shall also have variable volume controls.

13.3. Return Air Terminal Units:

a. Return air exhaust terminal units (RATU) shall be specified to be provided with a factory mounted control panel, velocity sensor, antimicrobial insulation and all necessary DDC controls mounted in a control enclosure on the side of each RATU. RATU's shall have variable volume controls.

13.4. Fume Hood Exhaust Terminal Units:

a. Fume hood exhaust terminal units (FHETU) shall be specified to be provided with a factory mounted control panel, velocity sensor, antimicrobial insulation and all necessary DDC controls mounted in a control enclosure on the side of each FHETU. FHETU's shall have constant volume controls.

13.5. Air Terminal Unit Access: To minimize disruption to occupants during periodic maintenance, locate air terminal units above corridors or other transient spaces wherever possible. Location must provide points of access to the control panel, reheat coil, velocity sensor, and reheat control valve.

14. AIR DUCT SYSTEMS:

14.1. Design Requirements:

a. Either the equal friction method or the static pressure regain method in the ASHRAE Fundamentals Handbook may be used to determine duct sizes. Use, the static regain method for high velocity systems.

b. Where ducts are connected to equipment housings, transition should be smooth, with a transition no greater than fifteen (15) degrees on the upstream side and no less than thirty (30) degrees on the downstream side. Avoid transitions in elbows. All duct distribution systems shall be efficiently designed with a minimum of fittings, and with economical duct routing. System design shall be modified or re-routed where directed by UM without additional cost or time delay where OFM has determined that the duct layout as designed is not in the best interest of UM.

c. Provide hinged access doors or panels no smaller than 18 inch x 18 inch in ductwork for maintenance, inspection, and service for:

(1) Filters.

(2) Cooling coils and heating coils.

(3) Sound absorbers.

(4) Fire and smoke dampers.

(5) Controls (dampers, switches, relays, sensing devices, etc.).

(6) Coordinate with the A/E team to provide access openings through finished construction. Show locations of all access doors on drawings and in details.

d. Generally, use galvanized sheet metal ductwork. Construction is to be per SMACNA Standards. Flexible ductwork to air terminal devices, i.e. VAV and constant volume boxes, diffusers, etc., shall not be permitted. Experience at UM has shown that flexible ducts are very susceptible to leakage, damage and kinking. Where budget constraints exist, flexible ductwork may be permitted if restricted to a maximum length of five (5) feet for final connections to diffusers. No designs shall include the use of flexible ductwork unless permission is specifically granted by UM for a specific project or location.

e. Ductwork and related equipment shall be supported from the building structure and shall be isolated from vibration.

f. Design shall include the anticipated operating pressure of every duct system and the calculated pressure drop for system components, such as dirty filters, wet coils, plenums, dampers, sound attenuators, AHU accessories, terminal devices, dampers.

g. All ductwork shall be specified to be sealed using mineral impregnated woven fiber tape equal to Hardcast, Inc., and all seams and joints shall be sealed, including longitudinal seams.

h. All ductwork, including low pressure duct over fifteen (15) feet in length, shall be leak tested using the method prescribed by UM.

i. Acoustic and thermal duct liner may be used for noise control in ductwork and terminal reheat units provided the material specified is non-porous engineered polymer foam closed cell insulation. Provide sound attenuators at the discharge and return of all AHU's, fans and terminal reheat units where needed for noise control.

14.2. **Dampers:** Provide manual volume dampers in every air distribution device branch duct and where it is necessary to obtain proper control, balancing, and distribution. For ducts sized twelve (12) inches and larger, specify opposed blade volume dampers. Use self-closing, gravity-operated or motor-operated dampers to stop back flows of air. Locate fire and/or smoke dampers in accordance with

NFPA; refer to local fire codes for use, location, and construction. Show all dampers on drawings, with access doors.

15. AIR DISTRIBUTION DEVICES:

15.1. Locate supply air outlets to provide proper throw, drop, and spread. Air should not blow against obstructions such as beams, columns, and lights, and should not blow on occupants.

15.2. Locate supply outlets uniformly and within the range of throw to distributed loads, and coordinate with architectural layout and ceiling grid. If loads are concentrated, locate supply outlets near the load source.

15.3. Select air distribution devices for variable air-volume systems (VAV) to be compatible with characteristics of the VAV system. The devices must be capable of performing at full and partial load. Standard air devices do not perform satisfactorily with VAV systems.

16. EXHAUST SYSTEMS:

16.1. **General Exhaust Systems:** General exhaust systems shall be designed for toilet rooms, janitor closets, storage rooms, mechanical and electrical rooms, utility areas, and areas with kitchenettes or pantry sinks, with rates as established by ventilation requirements. General laboratory exhaust may be combined with fume hood exhaust where a manifolded or combined system is used, but the laboratory exhaust systems shall be kept separate from all other building exhaust systems. Sufficient make-up air for all exhaust systems shall be provided, conditioned as appropriate.

16.2. **Special Exhaust Systems:** Exhaust air containing toxic material, viruses, radioactivity or undesirable odors shall require special treatment before being released into the atmosphere and should be discharged as far away from air intakes as possible. The proximity of air intake and exhaust to nearby buildings shall be considered in the design to ensure a suitable air quality in the buildings. Adequate discharge height, location, wind direction, etc. for exhausted air contaminants shall be determined. Design all necessary controls and separate systems for special exhaust, such as perchloric acid exhaust with duct and hood wash down. For systems requiring filtration design a bag-in/bag-out filter assembly complete with standby fans, controls, including isolation dampers support details, and air monitoring devices necessary or as directed by OFM and/or EHS.

16.3. **Fume Hood Exhaust Systems:** Fume hood systems, such as manifolded systems and variable air volume systems, shall be presented for UM review during the Schematic Design Phase. Where such systems are approved by UM, a dedicated exhaust terminal unit shall be designed for each fume hood to maintain proper exhaust air flow. Minimum exhaust duct size shall be ten (10) inches in diameter.

a. **Information from the User:** User shall supply a list of hazardous substances which will be used in the hood or cabinet

b. **Manifold Systems:** Where combined or manifolded exhaust systems are permitted by UM, the common manifold exhaust duct may be constructed of galvanized steel where sufficient dilution of the corrosive air stream is anticipated. The duct run outs to each fume hood shall be stainless steel

c. **Filter Systems:** Fume hood exhaust systems requiring filtration must be provided with a bag in/bag out filter housing assembly, appropriate filter media, positive shut off isolation dampers at the inlet and outlet of each filter housing assembly, two (2) exhaust fans connected to emergency power (one (1) stand by) and all necessary supports, flashing details etc. These systems shall be completely independent of the central fume hood and general exhaust systems.

16.4. Energy Recovery Systems: The use of energy recovery systems between exhaust and supply air systems shall be designed where economically feasible or where requested by UM. A hydronic, run-around loop, heat pipe, or heat wheel system shall be used. Heating and cooling load calculations shall be performed using ASHRAE methods. If fume hood exhaust is part of the general exhaust system and sufficient dilution is attained, all of the exhaust air may be used in a heat recovery system. Separated fume hood exhaust shall not be used in heat recovery systems unless specifically approved by UM. When a heat wheel energy recovery system is designed the engineer shall size the cooling coil and heating coil for the full delta 'T' needed if the wheel fails.

17. AUTOMATIC TEMPERATURE CONTROL (ATC):

17.1. General: Provide automatic temperature controls for HVAC systems. Provide controls to maintain dead-band temperature ranges, to control air-conditioning, and to reset temperatures during periods of non-occupancy. If smoke control is provided, coordinate controls and systems. Controls may be pneumatic, electronic, electrical, or a combination of these depending on the application, availability of service, and cost. Coordinate automatic controls with the existing campus central control and monitoring systems, manufactured and installed by Siemens Building Technologies and Johnson Controls. During the design review process, the University will determine which of the control systems shall be specified. If required, the cabling necessary to connect this building with the central processor shall be incorporated in the design. Delineate the pneumatic, electronic, or electric type, with standard symbols, schedules, descriptions of operation, sequences, throttling ranges, set points, etc., as part of the design. Show room thermostats or sensors on floor plans, and coordinate all locations with the A/E team for conflicts with furnishings, finishes, equipment, etc.

17.2. Control Sequences: Coordinate all automatic temperature control sequences with UM. UM will provide point schedules for all HVAC equipment to be connected with the campus central control and monitoring system. These point schedules shall be included in the contract documents.

17.3. Individual Room Control: Provide individual room control for all private offices, classrooms, laboratories, conference rooms and all other special use areas as required by UM. Where offices have similar loads and exposures, these may be grouped together on a single temperature control point at the option of UM.

17.4. Room Pressurization Control: Provide individual room pressurization for research laboratories as required by the project program or as directed by the UM. All research laboratory spaces shall be designed to be negative to the surrounding spaces.

17.5. Room Terminal Unit Tracking: When room supply terminals, room exhaust/return terminals, and/or fume hood exhaust terminals are required by the project program, or as directed by UM, these terminal units shall be interlocked together through the BAS to track the room air volumes to maintain the rooms set point and pressurization in the occupied and unoccupied modes of control. Supply terminals shall track the exhaust terminals to maintain the required room pressurization.

17.6. Room Humidity Control: When required by the project program or as directed by UM include in the design individual room humidification. Control shall be through the BAS. Coordinate with UM for the type of humidification system proposed by the engineer. Humidification systems shall be designed for individual space control only.

17.7. Energy Flow Measurement: Provide energy and flow measurement devices in primary, and building secondary chilled water systems, and in secondary process cooling water systems, and import/export chilled water systems and condenser water systems. All energy and flow measurement devices shall be IP based and capable of sending the recorded data to the campus automation system and/or the campus energy management system. Coordinate all requirements with UM.

17.8. Enthalpy Control: Include enthalpy control as part of the BAS design as directed by the University or as required by the project program. Coordinate the requirements of this control sequence with UM.

17.9. Fire Alarm and Security Systems: Provide the required integration of ATC with the fire alarm and security systems as required by the project program or as directed by UM. For additional information see Section 3 ED of these Design Standards. Coordinate all requirements with UM.

17.10. UM Renovation Projects: For renovation projects where equipment with DDC controls are either added, relocated or removed and replaced with new equipment with DDC controls, include in the design the requirements for system program and graphic modifications to the BAS. Coordinate all requirements with UM.

17.11. Occupancy Based Control: Specify occupancy sensors and programming for all rooms and spaces where intermittent occupancy is anticipated, such as conference rooms, meeting rooms, corridors, and toilet rooms. The occupancy sensor shall control the lighting and terminal reheat units serving the space.

17.12. Unoccupied Periods: Provide automatic controls and programming to permit re-setting of room temperature controls and room supply and/or exhaust rates during the unoccupied periods, as directed by UM.

17.13. Floor ATC Closets: In buildings without an accessible central utility core, or mechanical rooms on each floor the design team shall include ATC closets on each floor for DDC controls. Each ATC closet shall have sufficient space for at least four (4) panels. Each closet shall be accessible from a corridor through a pair of double doors and shall be a minimum of sixteen (16) square feet (eight (8) feet long x two (2) feet deep). The A/E team shall include these closets in the space planning phase of the project.

17.14. Alarm Monitoring: In addition to the requirement for monitoring the operation of all mechanical and electrical equipment and systems, there are additional specific locations and systems that shall be monitored as well. These include:

a. Elevator sump pumps, including pump status and high level alarm.

b. Elevator travel signals.

c. Temperature and humidity levels in elevator machine rooms, server rooms and environmental cold rooms.

18. SPECIAL HVAC WASTES:

18.1. All air conditioning condensate shall drain to the storm water system.

18.2. All steam condensate shall be cooled by mixing with domestic cold water, using an economizer tank for preheating domestic hot water where feasible, and drain to the storm water system. Steam condensate shall be cooled to a temperature below 140^0F before discharging into the storm water system.

18.3. All cooling tower drain piping shall be piped to the storm water system.

END OF SECTION 3 MD - PART III