3.3 BUILDING SYSTEMS

3.3.1 HVAC SYSTEMS

3.3.1.1 Overview

The HVAC Design Standards described herein define the minimum design requirements and procedures that the consultant shall adhere to. The HVAC design standards are organized as follows:

- Design Guidelines and Standards
- System Selection Analysis
- Design Criteria
- Commissioning

3.3.1.2 Design Guidelines

Compliance with state and local codes is mandatory by law. It is the consultant's responsibility to provide a design that is in full compliance with the latest applicable codes and the local authority having jurisdiction (AHJ). The design guidelines included herein are intended to supplement all code and AHJ requirements. Where applicable code and the referenced design guidelines are in conflict, the consultant shall submit a written explanation describing the differences between the applicable codes and the referenced guidelines to Mason for review. The Design Guidelines Section is intended to provide guidelines which Mason recognizes and accepts to be applicable to all projects. The Standards and Guidelines listed herein apply to all projects.

Published Standards and Guidelines recognized by Mason to be applicable are listed below.

- American Institute of Architects
    - Guideline for the Design and Construction of Healthcare Facilities - Latest Edition
- ASHRAE Handbooks (All) - Latest Editions
- ASHRAE Standards - Latest Editions
    - Standard 15 - Safety Standard for Refrigeration Systems
    - Standard 55 - Thermal Environmental Conditions for Human Occupancy
    - Std. 62.1 - Ventilation for Acceptable Indoor Air Quality
    - Std. 62.2 - Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings
    - Std. 90.1 - Energy Standard for Buildings Except Low-Rise Residential Buildings
    - Std. 90.2 - Energy Efficient Design of Low-Rise Residential Buildings
    - Std. 154 - Ventilation for Commercial Cooling Operations
    - Std. 169 - Weather Data for Building Design Standards

- Std. 170 - Ventilation for Healthcare Facilities
- Std. 183 - Peak Cooling and Heating Load Calculations in Buildings Except Low-Rise Residential Buildings
- Std. 189.1 - Standard for the Design of High-Performance, Green Buildings Except Low-Rise Residential Buildings

- ASHRAE Guidelines - Latest Editions
  - Gdl. 0 - The Commissioning Process
  - Gdl. 13 - Specifying Direct Digital Control Systems
- American National Standards Institute - Latest Editions
  - ANSI/AIHA Z9.5 - Laboratory Ventilation Standard
- National Fire Protection Association (Latest Editions)
  - NFPA 45: Standard on Fire Protection for Laboratories Using Chemical
  - NFPA 90A: Standard for the Installation of Air Conditioning and Ventilating Systems
  - NFPA 90B: Standard for the Installation of Warm Air Heating and Air Conditioning Sytems
- SMACNA (Latest Editions)
  - HVAC Duct Construction Standards - Metal and Flexible
  - Rectangular Industrial Duct Construction Standards
  - Round Industrial Duct Construction Standards

3.3.1.3 System Selection Analysis

3.3.1.3.1 Overview

- The consultant will be responsible for an evaluation of applicable HVAC system options. The evaluation shall be based on both a qualitative and quantitative analysis. A minimum of three (3) systems shall be analyzed and the consultant shall provide a written summary of the analysis results including recommendations.

3.3.1.3.2 Qualitative Analysis

- The qualitative analysis shall be a comparison of each applicable HVAC system option based on qualitative evaluation criteria. The evaluation criteria shall include, but shall not be limited to the following:
  - Constructability: Impact on construction schedule, ongoing facilities operations, and overall project phasing requirements shall be considered.
  - Flexibility: The ability of systems to be modified to serve likely future changes in space usage without rework of central systems or main distribution.

- Maintainability: The ease at which system components can be accessed and serviced. As an example, utilization of above ceiling hydronic heat pumps would not rank high in this category because of the multiple compressors, fans, filters, and condensate drain pans located above the ceiling which access for regular maintenance.
- Comfort Control: The ability of the system to satisfy environmental requirements including temperature, humidity and space noise criteria.

3.3.1.3.3 Quantitative Analysis

- The life cycle costs for each HVAC system option shall be determined and used as the basis of quantitative comparison. Life cycle costs shall include the following system costs:
    - First Cost
    - Annual Energy Cost
    - Annual Maintenance Cost
    - Life Cycle Replacement Costs
- All life cycle costs shall be performed in accordance with NIST handbook 135 - "Life Cycle Costing Manual for Energy Management Program."
- First costs and replacement costs shall be determined using R.S. Means Cost Works (latest edition) or third party cost estimate.
- Annual energy costs shall be determined by one of the following energy modeling methods:
    - Modified Bin-Hair Method using preliminary HVAC loads
    - Software simulation using an approved load and energy simulation program
- Utility costs shall be based on the applicable utility rates and shall include all utility charges. Where records of historical energy costs and usage are maintained by the campus or facility; average and all inclusive rates may be used when justified by the historical data.
- Annual maintenance cost shall be estimated using the latest edition of ASHRAE Handbook, HVAC Applications, Chapter 36.

3.3.1.4 Design Criteria

3.3.1.4.1 Overview

- Design criteria described herein are mandatory. The design criteria address minimum system design and performance requirements.

3.3.1.4.1.1 Design Conditions

Outdoor Design Conditions

Location	Winter	Summer
Arlington	7°F DB	91°F DB/77°F WB
Fairfax	7°F DB	91°F DB/77°F WB
Prince William	10°F DB	93°F DB/77°F WB

For evaporative cooling, use 78°F WB.

Indoor Design Conditions

Space Type	Winter	Summer
Classrooms	70°F DB	76°F DB, 50% ORH
Offices	70°F DB	76°F DB, 50% ORH
Laboratories	70°F DB	76°F DB, 50% ORH
Assembly	70°F DB	76°F DB, 55% ORH
Commercial Type Kitchen	68°F DB	78°F DB
Residential	70°F DB	76°F DB, 50% ORH

For space types not listed above, indoor design conditions shall be as directed by Mason.

3.3.1.4.1.2 Sizing Criteria

Hydronic Piping Systems

Location	Maximum Velocity (FPS)	Maximum Friction Rate (FT WC/100FT)	Remarks
Below Grade	12	3.3	
Above Grade - Ultimate Spaces and Mechanical Rooms	12	3.3	
Above Grade - Above Ceilings and in Wall Chases	10	3.3	
Terminal and Coil Run-outs	10	3.3	

Ductwork

System		Building Location	Maximum Friction Rate (In.WC/100 FT)	Maximum Velocity (FPM)	Remarks
Type	Location				
VAV	Primary supply	Above Ceilings and In Wall Chases	0.25	1,500	
VAV	Primary supply	Shafts and Mechanical Rooms	0.25	1,800	
VAV	Secondary supply	All	0.08	1,200	Runouts to terminal boxes/valves less than 10' may e same size as terminal inlet.
`CVSZ	Supply	Above ceilings and In Wall Chases	0.08	1,200	
CVSZ	Supply	Shafts and Mechanical Rooms	0.10	1,400	
All	Return	Above ceilings and In Wall Chases	0.08	1,200	
All	Return	Shafts and Mechanical Rooms	0.10	1,400	
CVSZ	Exhaust	All	0.08	1,200	
VAV	Primary Exhaust	Above ceilings and In Wall Chases	0.25	1,500	
VAV	Primary Exhaust	Shafts and Mechanical Rooms	0.25	1,800	
VAV	Secondary Exhaust	All	0.10	1,200	

- The maximum friction rates and velocities listed above are maximum allowable and are based on the following general assumptions:
  - Typical classroom or office application with noise requirement no less than NC 35-40
  - Rectangular ductwork with aspect rations no greater than 4:1
  - Ductwork design provides adequate straight run between fittings and at fan connections to provide uniform velocity profiles and negligible system affect

    - Piping design provides adequate straight run between fittings and at pump connection to provide uniform velocity profiles

- The consultant is responsible for the acoustic performance of all systems and shall be responsible for determining appropriate distribution system velocities based on the specific acoustical requirements of each space.

3.3.1.4.2 Heating Systems

- Where central campus heating capacity and associated distribution is of adequate capacity to serve the heating load of the facility, the campus heating utility shall be utilized as the primary heating source. The consultant will not be responsible for evaluating the adequacy of the campus heating capacity or distribution for individual building projects. Mason will be responsible for determining adequacy of the central campus heating and distribution based on the building heating loads determined by the consultant.

- Where central campus heating capacity and associated distribution is not of adequate capacity to serve the heating load of the facility, the primary heating source for the facility shall be determined as part of the System Selection Analysis.

- Where central campus heating is utilized as the primary heating source, it shall be decoupled from the building heating water system as follows:

Primary Heating Medium	Decoupling Method	Remarks
Steam	Heat Exchanger	
High Temp. Hot Water	Heat Exchanger	
Medium Temp. Hot Water	Hydraulic Bridge	
Low Temp. Hot Water	Hydraulic Bridge	

- Where central campus heating is not utilized, the following heating methods shall be analyzed as part of the HVAC System Selection Analysis:
    - Hot water generation using condensing type boilers.
    - Hot water generation using fire tube boilers (Scotch Marine Types)
    - Geothermal heat pump system

- Electric boilers are not acceptable. Use of electric heat for supplemental heat in hydronic heat pump systems is not acceptable.

3.3.1.4.3 Heating, Ventilating, and Air Conditioning (HVAC)

- Refer to the CPSM.

- The Mason Fairfax Campus operates a Central Heating and Cooling Plant (CHCP) to supply High Temperature Hot Water (HTHW) and Chilled Water to campus buildings. New buildings are to be served by these systems, unless specifically directed otherwise by Mason.

- All equipment shall be designed and installed with sufficient clearances to insure proper maintenance access to the equipment and its components. Equipment shall be provided with adequate clearances to allow ease of regular maintenance activities such as filter replacement, removal and replacement of strainers, draining equipment, filter changes, lubrication, belt replacement adjustment, testing, inspection, etc. Adequate clearances and provisions within the facility shall be provided to all replacement of major components such as heat exchanger tubes, coils, fans, compressor and motors without removal of other equipment or system components. It is the Design Team's responsibility to identify access space and service clearance requirements in the contract documents.

- Specifications prepared by the engineer shall include requirements for the Contractor to maintain a marked up set of Contract Drawings ("Red-Lines") which indicate all changes in construction and installation due to field conditions, coordination between trade, concealed conditions or other deviations from the Contract Documents. The engineer shall incorporate all changes indicated in the Contractor's "Red-Lines" and produce the As-Built Drawings for the project incorporating all marked-up information. The engineer shall submit As-Built Drawings in the format and media defined in Chapter 4, Section 01 78 39 of Division 01.

- All equipment, controls, and devices installed behind an inaccessible finished surface shall be provided with a suitable access door. It is the Design Team's responsibility to identify, in the contract documents, the minimum size of all access doors and ensure that access to those doors is not blocked by conduit, wire trays, ductwork, etc.

- The engineer shall field verify HVAC system performance in existing buildings prior to completion of the schematic design phase of all renovation projects. Performance verification shall include the following:

  - Air Handling Units:

    1. Air Flow: Supply, return, outside air, and relief.

    2. Fans: RPM, brake HP, Volts, Amps.

    3. Unit Pressure Map: Measure static pressure at unit discharge and across each unit component.

  - HVAC Risers: Measure total airflow and static pressure at all floor branch take-offs.

  - Floors and Spaces within the Area of Work: Measure airflow of all supply, return, and exhaust air devices.

  - Fans: Measure airflow, inlet static pressure, outlet static pressure, RPM, brake HP, Volts, Amps.

  - Measure airflow and pressure at all necessary locations in order to establish existing system performance.

- All HVAC performance measurements shall be recorded and submitted to Mason prior to completion of the schematic design. The report shall include a deficiency list, identifying all observed performance deficiencies. Performance measurements shall be performed by a qualified TAB Technician using instrumentation which has been calibrated within six months.

3.3.1.4.4 Cooling Systems

- Where central campus chilled water capacity and associated distribution is adequate to serving the cooling load of the facility, the campus chilled water system shall be utilized as the primary cooling source. The consultant will not be responsible for evaluating the adequacy of the campus chilled water generation capacity or distribution for individual building projects. Mason will be responsible for determining adequacy of the campus chilled water generation and distribution based on cooling loads determined by the consultant.

- Where central campus chilled water capacity and associated distribution is not of adequate capacity to serve the cooling load for the facility, the primary cooling source for the facility shall be determined as part of the System Selection Analysis.

- Where campus chilled water is utilized as the primary cooling source, the campus piping system shall be connected to the building chilled water system in accordance with Typical Building Central Cooling System Schematic.

3.3.1.4.5 Humidification Systems

- In general, Mason does not humidify its buildings for comfort. Humidification shall be provided to preserve materials such as wooden musical instruments, library collections, archives, artwork, etc. Humidification shall be provided for spaces and areas defined by Mason and its users as requiring winter humidity control.

- Where humidification is required, one of the following methods shall be employed:

    - Non-fired steam generator using high temperature hot water, medium temperature hot water or steam as primary heating medium.

    - Gas fired steam generator.

    - Gas fired packaged humidifier.

    - Electric steam generator.

    - Electric cartridge type humidifier.

- Electric type humidifiers (cartridge type) exceeding 75 pounds per hour (PPH) capacity or 30 amps shall not be allowed. Electric steam generators exceeding 500 PPH capacity or 200 amps shall not be allowed.

3.3.1.4.6 Dehumidification Systems

- Dehumidification equipment and controls shall be provided for spaces and areas defined by Mason and its users as requiring strict humidity control.

3.3.1.4.7 Airside Heat Recovery

- 100% exhaust air heat recovery shall be utilized with the following systems:

    - Laboratory general exhaust

    - Chilled Beam and DOAS system general exhaust

    - Air handling unit zones with 35% or greater exhaust/relief

- Heat recovery systems shall be in accordance with applicable codes and the AHJ.

3.3.1.4.8 Airside Economizer

- All air handling units shall be provided with economizer and/or enthalpy optimization controls. All air handling unit outdoor air intakes and outdoor air ductwork shall be sized for 100% outdoor air with a velocity no greater than 1200 fpm and a friction rate no greater than 0.08 inches wc/100 feet. Design of systems for minimum outdoor air (i.e. no economizers) is not allowed unless specifically approved or directed by Mason in writing. The consultant shall submit a written variance request to Mason with justification for the variance request.

3.3.1.4.9 Expansion Compensation

- Avoid using expansion compensators on Low Temperature Hot Water Systems. Use expansion loops and z-bends to maintain acceptable piping stress levels. Where there is inadequate space for loops and z-bends, bellows type can be used if approved by Mason.

- Do not use bellows type expansion joints on High Temperature Hot Water piping systems. Flanged, slip type expansion joints are preferred for High Temperature Hot Water piping systems.

3.3.1.4.10 General-Duty Valves for HVAC Piping

- Include sufficient zone isolation/shut off valves in heated water, chilled water, steam and other service piping to allow maintenance of equipment and replacement of terminal equipment without shutting down entire building or floor.

- Install valves on all piping that penetrate the floor from below.

- Install valves on all branch piping take-offs.

- Install valves on all lines at locations such that each floor can be isolated without affecting service to other floors. Example: Install valves at pipe riser horizontal branch take-offs at each floor.

- Chain-wheel operators for valves above 7'-0" shall be located in a place where they will not interfere with normal access and shall be restrained at wall or column if necessary.

- OS&Y gate valves shall be used on all piping 2-1/2" and above, unless Mason provides written direction/acceptance of another valve for a specific application.

- Drain valves shall be installed in accessible locations at all low points in the piping system to permit drainage and servicing.

3.3.1.4.11 Fuel Burning Equipment

- The Design Team shall be responsible for preparation and follow-up correspondence for all permitting required for fuel burning equipment.

3.3.1.4.12 Hangars and Supports for HVAC, Piping, and Equipment

- All High Temperature Hot Water, Medium Temperature Hot Water, High Pressure Steam (>15psig) and High Pressure Condensate piping systems shall be designed based on a piping system stress analysis and shall be designed to meet the requirements of the latest edition of ASME B31. The piping system stress analysis shall include piping system geometry, routing, equipment nozzle loads, hanger locations, support locations, and specific support types (anchors, guides, slides, springs, etc.). Conform to ASME Code for allowable piping stresses. Submit stress analysis to Mason for review.

- Seismic requirements must be considered as required.

3.3.1.4.13 Facility Fuel Piping

- Fuel oil systems shall be designed for No. 2 fuel oil and diesel fuel.
- Gas fuel systems shall be natural gas, connected to the local or campus natural gas utility, unless otherwise approved by Mason in writing. Refer to Section 3.3.3 " Plumbing Systems" for additional requirements.

3.3.1.4.14 HVAC Piping and Pumps

- Definitions:
  - High Temperature Hot Water - Hot Water Systems operating with a maximum water temperature between 350°F and 400°F, with a maximum system pressure of approximately 300 psi.
  - Medium Temperature Hot Water - Hot Water Systems operating with a maximum water temperature between 250°F and 350°F, with a maximum system pressure of approximately 160 psi.
  - Low Temperature Hot water - Hot Water Systems operating with a maximum temperature below 250°F and a maximum system pressure of 160 psi.
  - Dual Temperature Water - A system which utilizes one piping system to distribute heating and cooling water. These systems operate within the pressure and temperature limits of Low Temperature Hot Water systems. The typical winter design supply temperatures are 100°F to 180°F and the typical summer supply water temperatures are 40°F to 450°F.
  - Chilled Water - A system which distributes cold water. Typical design supply temperatures are 40°F to 58°F depending on the application. Antifreeze solution may be used in lieu of water to prevent freezing.
- All new hydronic pipings systems shall be specified to be cleaned and flushed by Mason's term water treatment contractor. The current term water treatment contractor is:

  Water Chemistry, Inc.
  3404 Aerial Way Dr.
  Roanoke, VA 24016
  540-343-3618

3.3.1.4.15 Hydronic Piping and Pumps

- Encase all key crocks for chilled water building isolation in a 1′ x 1′ x 6″ concrete pad.
- Do not run piping above telecommunication racks.

3.3.1.4.16 Hydronic Piping

- Below Grade Piping:

- Mason Chilled Water systems are designed at 42°F with a 14°F delta.
- Provide a 2-way flow control valve on the building main, located in the main mechanical room.
- CHW distribution system (campus loop, on the Fairfax, VA Campus):
  - General: The CHW Piping to be pre-insulated Schedule 40 steel pipe (do not use plastic piping). All components, including piping, valves, flanges and fittings must be manufactured in either Canada or the United States. The system must be designed to minimize system low points to the maximum extent possible. Any deviations from the George Mason University Utility Master Plan Update (current edition) in piping system sizes or design must be approved in writing by George Mason Facilities.
  - Clearances & Pipe Bedding: Wherever the chilled water lines are run alongside the HTHW Distribution System tunnel, maintain a minimum clearance between the insulated CHW pipe and HTHW tunnel or manhole wall of two feet. Maintain a minimum depth of 30 inches. All CHW piping to be set in minimum 6 inch bed of washed natural sand or mason sand. Sand to extend to mid-point of pipe section. Refer to Chapter 5, details 4.1-1 – HTHW Tunnel Detail, Fairfax Campus, 4.1-2 – HTHW Tunnel Top Details, and 4.1-3 – HTHW Manhole Detail for information on HTHW tunnel and piping clearances.
  - Under Building Slab: Whenever the CHW distribution system piping is run under a building slab, the piping must be run in a tunnel system which has a minimum clear height of seven feet and minimum three foot clear walkway. Such a tunnel system must be lighted, ventilated and accessible for maintenance. The same tunnel system can be used for HTHW lines.
  - Valves: At each branch line or building takeoff provide a three valve combination on both supply and return lines which allow back feed capability. Valves shall be OS&Y type gate valves with flanged connections. Triple duty valves are not acceptable. Provide two way flow control valves on the building main, located in the main mechanical room of the building(s) being served.
  - Drains and Vents: At CHW system low points, provide drains (on both supply and return lines) to discharge to the sanitary sewer. Drains to be 1" pipe size for 6" CHW lines; 2" pipe size for lines above 6". At CHW system high points, provide 3/4" vents. All drains and vents to be valved with gate or ball valve with valve box. Valve boxes located in other than paved areas shall be encased in a 20"x 20" x 6" thick concrete pad.
  - Insulation. Use manufacturer supplied pre-insulated pipe kit for piping joints and fittings. All raw ends shall be sealed.
- Dual temperature systems shall be designed for 100-190°F., winter and 42°F to 55°F summer.
- 4-pipe systems are preferable.
- Mason prefers diaphragm-type compression tanks.
- Triple duty valves are not acceptable.
- Flexible connection shall be installed at pumps only when directed by Mason or when acoustic consultant recommendations are accepted by Mason.

- Hanger spacing for copper pipe shall be as follows:

Pipe Size	Hanger Spacing
1"	6’-0”
1-1/2"	8’-0”
2"	9’-0”
3"	10’-0”
4"	12’-0”

- Do not use butterfly valves for throttling hydronic systems.

3.3.1.4.17 High Temperature and Medium Temperature Hot Water Piping

- All welding of High Temperature Hot Water and Medium Temperature Hot Water systems shall be performed by welders certified in accordance with ASME B31.1 Power Piping, latest edition.

3.3.1.4.17.1 Fairfax, VA Campus:

- The HTHW tunnel shall be separated from the mechanical space in the building by a removable solid steel or aluminum plate to keep heat, water vapor, etc. from entering the mechanical space and damaging equipment. Ensure the plate can be easily removed from the mechanical room for servicing, and the tunnel side as a means of escape in case of emergency.

- Design tunnel and piping with as little abrupt elevational and lateral direction change as possible to avoid anchorage and expansion joints. Tunnel height can vary with site contour, but height shall not exceed 8’-0”.

- The HTHW Piping system to be designed for an operating temperature of 400° F and operating pressure of 350 psig; with a 100°F delta. Use ANSI Class 300 Rating for valves, flanges and flanged fittings. All HTHW piping must be Schedule 80 or Extra Strong seamless steel. All HTHW distribution system components, including piping, valves, flanges and fittings must be manufactured in either Canada or the United States. Any change in piping direction must be made using standard welded fittings. Mitered fittings are not allowed in the piping system. The piping system should be designed with as little abrupt elevation and lateral direction change as possible to minimize requirements for additional anchorage points and expansion joints. The piping system must be designed to minimize system low points to the maximum extent possible. The pathway for the campus wide HTHW distribution system piping shall be a system of tunnels and manholes which are designed to facilitate operations and maintenance. Any deviations from the George Mason University Utility Master Plan Update (current edition) in piping system sizes or design must be approved in writing by George Mason Facilities.

- Clearances: The minimum clearance between pipe and tunnel or manhole floor is 12 inches. The minimum clearance between pipe and tunnel wall is 16 inches. Refer to Chapter 5, details 4.1-1 – HTHW Tunnel Detail, Fairfax Campus, 4.1-2 – HTHW Tunnel Top Details, and 4.1-3 – HTHW Manhole Detail for information on HTHW tunnel and piping clearances.

- Under Building Slab: Whenever the HTHW distribution system piping is run under a building slab, the piping must be run in a tunnel system which has a minimum clear height of seven feet and minimum three foot clear walkway. Such a tunnel system must be lighted, ventilated and accessible for maintenance. The same tunnel system can be used for chilled water lines.

- Valves: At each branch line or building takeoff provide a three valve combination on both supply and return lines which allow back feed capability. Valves shall be OS&Y type gate valves with flanged connections. Triple duty valves are not acceptable.

- Expansion Joints: Expansion joints shall be the packed slip tube type which allows for additional packing to be injected while the expansion joint is under full line pressure. The ends of slip and body shall be furnished with raised face forged steel flanges. The stuffing box shall have integral internal and external guide surfaces. The guide surfaces shall have low friction, non-metallic inserts. The sliding surface of the slip is to be dual chrome plated with 0.001" of hard chrome applied over 0.001" of crack free hard chrome, permascope inspected in accordance with ASTM STD B-499. Each expansion joint to be provided with a two piece removable, reusable insulation blanket which cover the expansion joint body and slip, and incorporates access to the packing cylinders without removal of the body portion of the blanket. The basis for design is Advanced Thermal Systems, Inc. “TP2 Thermal Pak Expansion Joint”.

- Slides, Guides and Anchors: All slides, guides and anchors to be hot dipped galvanized steel. Field modification of manufactured components cannot be made without prior approval of the Engineer of Record.

- Bolts: All bolts and nuts at flanges to be ANSI Class 300 Rating. All bolts, studs or expansion anchors used to affix expansion joints, slides, guides or anchorage points to the concrete tunnel structure to be properly engineered and specified by the Engineer of Record. All bolts, studs, expansion anchors and nuts used to fix components to the concrete tunnel structure to be hot dipped galvanized.

- Drains and Vents: At HTHW system low points, provide drains (on both supply and return lines) piped to a tempering tank to discharge to the sanitary sewer. Drains to be 1" pipe size for 6" HTHW lines and smaller; 2" pipe size for lines above 6". At HTHW system high points, provide 3/4" vent. All drains and vents to be welded Schedule 80 pipe with socket weld fittings. All drains and vents to be double valved, with ANSI Class 300 gate valves only.

- Tempering Tanks: The water supply line to the tempering tank must be 2" copper and valved at both the source and at the tempering tank. Hanger spacing for copper water supply line to be to code.

- Insulation: Insulation to be calcium silicate or cellular glass with aluminum jacket nonflammable moisture barrier. Staples are not to be used. All raw ends shall be sealed. Aluminum jacket to be secured using straps, not screws.

3.3.1.4.18 HVAC Pumps

- Secondary pumping of the HTHW and Chilled water at the building is not required at the Fairfax campus. The Fairfax campus Central Plant is designed to provide these services without additional pumping.

- Consult with Mason about pump selection philosophy. Limit speed to 1750 RPM. Any pumps handling High Temperature Hot Water shall be selected with Mason’s input. Industrial pumps may be required.

    - For small flows and low heads, in-line circulators may be used, this application is limited to coil freeze protection pumps, heating zone pumps. Typical limits are 80 GPM at 30 feet TDH.

- Utilize vertical in-line pumps or close coupled end suction pumps for smaller capacity primary, secondary, tertiary pumping systems. Typical limits are 80 GPM at 70 feet TDH.
- Utilize base mounted separately-coupled end suction pumps for medium capacity primary, secondary, and tertiary pumping systems. Typical limits are 900 GPM at 120 feet.
- Utilize double suction horizontal spit case pumps for larger capacity primary, secondary, and tertiary pumping systems.
- Vertical pumps may be used in lieu of base mounted separately-coupled end suction pumps where space is limited. Mason must approve use of vertical pumps.
- Vertical split case pumps (Bell & Gassett VSC or equal) may be used in lieu of horizontal split case pumps where space is limited. Mason must approve use of vertical split case pumps.
- Base-mounted, separately coupled double-suction, horizontal split-case type pumps shall be used for connections 4" and larger. B&G VSC or equal may be used. Consider vertical pumps where space is at a premium.
- Selection should be made for high efficiency. Consideration of life cycle cost study of variable speed pumping should be made.
- Use mechanical seals when choice is available. Use cyclone separator type seal waste cleaning device on all pumps that can be equipped with it (generally on all double suction pumps).
- Piping design provides adequate straight run between fittings and at pump connections to provide uniform velocity profiles.

- Do not use vibration isolators or flexible connectors on pumps located on slabs on grade. Provide vibration isolation, flexible pipe connectors, and inertia base for all pumps located above occupied spaces.
- Pump suction diffuser shall be installed at the inlet side of the pump and shall have flanged outlet with grooved inlet connections. Ductile iron body with removable stainless steel frame and perforated sheet diffuser with 5/32″ or 3/16″ diameter holes, 20 mesh stainless steel start-up pre-filter and base support boss. Victaulic Series 731 and W731.

3.3.1.4.19 Steam and Condensate Piping

- Steam system shall be designed for low pressure (15 psig or less) unless otherwise approved by the university. When steam is obtained from a High Temperature Hot Water steam generator, it is especially important to realize that pressures of 30 psig or greater are difficult to justify because they use an enormous flow of primary High Temperature Hot Water. All kitchen equipment (dishwasher, steam tables, etc.) should be operated at less than this pressure. Autoclaves, sterilizers and cage washers should be capable of operating at less than 30 psig steam. If this is not possible, the use of an electric steam generator that can be separately metered (electrically) shall be considered.
- Steam for user-required humidification shall be generated by unitary humidifiers.
- Use bimetallic element traps only with Mason approval.

- Low Temperature Heating Water for coil and terminal is preferred heating medium. Do not utilize steam heating coils or terminals unless directed in writing by Mason
- Adjust class of safety valves for pressure and temperature used in each system.
- Sizing of reducing valves shall be clearly shown on the Drawings for all equipment.
- Pipe discharge from safety valves shall be terminated at a safe height and location to prevent personnel harm.

3.3.1.4.20 HVAC Fans

3.3.1.4.20.1 Air Handling Unit Fans

- Air foil type or backward inclined fan blades shall be used for all centrifugal fans. Use of forward curved or squirrel cage type fans is not allowed without written approval from Mason.
- Fan bearing shall be grease lubricated with extended lube lines.
- Fans shall be selected based on greatest efficiency.
- Housed centrifugal fans shall be belt drive. Unhoused centrifugal fans (plenum fans, plug fans) shall be direct drive. Where unhoused fans are utilized use of multiple fans in parallel duty is encouraged.

3.3.1.4.20.2 In-Line Fans

- In-line fans for return air duty shall be vaneaxial type. Tubeaxial fans for air handling systems which require fan tracking is not allowed because current fan inlet airflow measurement technology cannot be applied to tubeaxial fans.
- Provide thrust restraints on all axial inline fans to prevent fan movement and excessive compression/tension in fan flex connector.

3.3.1.4.20.3 Exhaust/Relief Fans

- Exhaust/relief fans shall be located at terminus of system such that there is no positively pressurized exhaust ductwork within the building envelope.
- Direct drive fans shall be provided with manually operated factory speed dial to be used for balancing in the field.
- Provide low leakage type two-position control dampers where exhaust duct penetrates the building envelope and interlock with the fan operation to close when the fan is de-energized.
- Exhaust fans shall be located on the roof, or in an adequately ventilated fan loft. Exhaust motors shall be located to allow access for maintenance.

3.3.1.4.20.4 Smoke Evacuation Fans: Shall be listed for smoke evacuation duty.

3.3.1.4.20.5 Fume Hood Exhaust Fans:

- Utilize either single width/single inlet housed centrifugal or strobic type.

- The exhaust stack termination height shall be based on the required effective stack height determined by an air dispersion model.

- Fans and duct systems for hoods are to be sized and designed to provide an average hood face velocity of 80-100 LFM, as measured at the face, with the sash wide open. Deviations in this value shall not be greater than 20% at any point across the hood face. To assure this standard, the designer must work closely with the duct installer to determine the effects of duct routing on motor sizing.

- Do not use dampers on laboratory fume hood fans unless specifically approved by Mason.

- Utilize direct drive fans for applications requiring variable fan speed control. Variable frequency drives shall not be the primary means for initial fan balancing.

- Drains shall be provided in fan scrolls, especially when the fan may receive storm water in its ordinary course of duty. This applies to most of the fume hood exhaust fans that use Mason's preferred vertical discharge stackhead.

3.3.1.4.21 Air Terminal Units

3.3.1.4.21.1 Location

- All terminal units shall be located and oriented in accessible locations for routine and emergency maintenance and meet minimum manufacturer service clearances.

- Terminal units shall be placed in typical unoccupied areas (i.e. corridors) in lieu of directly overhead occupied areas where possible.

- Terminal units shall be located so that they can be accessed from an 8 foot ladder for maintenance.

3.3.1.4.21.2 Application

- Fan powered parallel supply air terminal units shall be used to serve perimeter zones and areas with exterior walls.

- Single duct supply air terminal units shall be used for all other spaces.

- Provide reheat coils on all units serving perimeter zones and areas with exterior walls and/or roofs. All reheat coils must be sized to provide reheat with 100 degree water.

- Provide reheat coils on all units serving conference rooms and other high occupancy spaces.

3.3.1.4.22 Air Cleaning Devices

3.3.1.4.22.1 General

- Every supply air system shall be provided with a filter bank. Every air terminal unit shall have filters if it is fan powered.

- Filters shall be pleated type and shall be designed for a maximum 400 feet per minute face velocity unless directed otherwise by Mason.

- Filters shall meet the requirements of International Mechanical Code, latest edition to provide suitable indoor air quality.

3.3.1.4.22.2 Filter Efficiency Requirements

- Supply air system filters shall be provided in accordance with ASHRAE 52.76 to meet these minimum efficiencies:

    1. Classrooms, lecture halls, and auditoriums: 60% (MERV 11)
    2. General Office Space: 60% (MERV11)
    3. Laboratories: 85% (MERV 13)
    4. Clean rooms: Based on room classification
    5. Healthcare: Based on the latest edition of the AIA Guidelines for the Design and Construction of Healthcare Facilities

- Provide higher efficiencies when directed by Mason.
- All other supply air systems that require specialized air filtration shall meet criteria given by the university.
- All supply air systems shall have 35% efficient (MERV 7) pre -filters.

3.3.1.4.23 Breechings, Chimneys, and Stacks

- Terminations of chimneys and stacks shall be "open" (without weathercap) so that an upward velocity is possible, without sideward flue gas movement. Design so that velocity of gases will clear any surrounding roofs, building and especially outside air openings. A velocity control device may be necessary at the outlet of the stack.
- Mason may require an analysis of effluent flume shape and dispersion by a specialist in air wake analysis. Specialist shall be approved by Mason. Such analysis is typical for all discharge stacks such as laboratory fume hood or other laboratory discharges.

3.3.1.4.24 Heating Boilers

- Boilers shall be operating at pressures 15 psig or less.
- Do not use electric boilers.
- Develop water treatment system specification and design in collaboration with Mason.

3.3.1.4.25 Heating Boiler Feedwater Equipment

- Consult Mason’s engineers concerning feedwater equipment.

3.3.1.4.26 Heat Exchangers for HVAC

- HW for heating shall be 190°F (or 200°F if approved by Mason).

3.3.1.4.27 Packaged Cooling Towers

- Induced draft cooling towers shall be utilized for process and building cooling loads. Type of cooling tower (counter-flow verses cross-flow) shall be evaluated by the engineer based on the following:
    - Noise
    - Building Esthetics (Height)
    - Maintainability
    - Efficiency
- Use of forced draft cooling towers is not permitted without review approval by Mason.
- Winterizing requirements shall be discussed with Mason. The appropriate design shall be reviewed prior to such application.
- Fan motors shall be variable speed, controlled and sequenced to obtain the condenser water temperatures needed.
- Provide automatic control valves on cooling tower inlet and outlet where multiple cooling towers are manifolded to common supply and return piping.
- Provide equalizer pipe connecting all cooling tower basins to maintain equal basin water levels under all potential operating conditions. Equalizer pipe shall be appropriately sized to maintain equal basin levels under all operating conditions.

3.3.1.4.28 Air Handling Units

- Utilize indoor modular air handling units wherever possible. All units hall be double wall construction.
- Modular air handling units shall not exceed 35,000 CFM capacity.
- Air tunnels and fans in custom air handling units shall not exceed 35,000 CFM capacity.
- All fans shall be non-overloading type (backward inclined or airfoil blades).
- Air handling units located on the roof shall be provided with heated pipe enclosures/vestibules which include adequate space for control valves. Locating control valves above the ceiling in occupied spaces shall be avoided.
- Fan wall systems shall be considered. Where applied on variable volume systems, a minimum of two variable frequency drives shall be provided for the fan wall.
- All air handlers feeding common ductwork need isolation dampers on supply and return ducts at the unit.
- Provide return air fans whenever return static pressure at peak design air flow will exceed 0.50 inches water column. Return fans are required for all units utilizing air side economizer/enthalpy optimization controls. Return fans may be integral or external to air handling units.

- Relief Fan configurations are not acceptable. Return Fans shall be utilized in all applications except where approved in writing by Mason.

- Provide fan inlet airflow measuring stations on centrifugal and vaneaxial fans. Where tubeaxial return fans, other in-line return fans are utilized; provide return air flow measuring stations in the ductwork. The engineer shall design the ductwork to allow for the manufacturers recommended inlet and outlet straight run at all airflow measuring stations.

- Provide outdoor air flow measuring stations, specifically design for outdoor air flow measurement.

- Do not use electric heat without specific permission of Mason.

- Properly locate face and bypass dampers on 100% outside air systems so that no coil will receive a low temperature blast of cold air when bypassed, or provide a properly sized pumped water protective system.

- All hot water pre-heat coils shall be provided with freeze protection pumps unless Mason allows the pumps to be deleted.

- Humidifiers should be used only with Mason approval. Use canister type steam generator with proper distributing grid if approval is obtained.

- Condensation drain pans shall be stainless steel. Secondary drain pans are required in suspended applications and will require either overflow safety switch or be piped to floor drain with appropriate signage. Drain piping to include cleanout plug.

- All drains shall be properly trapped. Units shall be elevated to allow for proper trap height.

- Unit utilizing steam coils shall be elevated to allow proper steam trap elevation.

- Access doors on negative pressure casings shall open outward. Access doors on positive pressure casings shall open inward. Where there is inadequate clearance within the unit to allow an inward door swing, the access door shall be removable. Supply side doors to open inward and be removable if space is limited inside the unit.

- Provide differential pressure indicator (manometer) for all serviceable filters and locate the indicator where it can be readily observed. Mark on the indicator the “clean” and “replace filter” points.

- Constant volume AHU's should utilize a VFD for energy cost savings. Since most of the AHU's for this application are over sized, instead of using a pulley size reduction to achieve the required CFM a VFD should be used. A 20% turn down results in a 50% reduction in rated H.P. size of the motor.

- Cooling coils used in constant volume systems shall be sized for no more than 450 feet per minute face velocity. Coiling coils used in variable volume systems shall be sized for no more than 500 feet per minute face velocity.

- Heating coils shall be sized for no more than 650 feet per minute face velocity.

- The maximum airflow for an individual coil shall be 17,500 CFM.

- All coils shall be completely drainable at each row. Drainage of coil shall be accomplished by opening vent valves and opening the drain valve with hose connection; no other means shall be required.

Copper tubes with aluminum fins are satisfactory. CHW temperature delta should be 14°F with an entering temperature of 42°F. For 100% outside air applications, a higher delta T may be used with Mason permission.

3.3.1.4.29 Outdoor Intake Locations

- The lowest elevation of an outdoor air intake shall be no less 2 floor levels above grade. Outdoor air intakes shall not be provided via areaways unless approved by Mason. As a general rule, outdoor air intakes shall be located no less than 25’-0” from building exhaust outlets and plumbing vents. Air dispersion studies shall be performed where there is a potential for entrainment of hazardous exhaust/fumes/emissions into the building outside air intake(s). The results of the air dispersion study will determine acceptable outdoor air intake locations, exhaust locations, vent locations and/or additional filtration requirements to eliminate both gaseous and particulate contaminants from entering the building outside air intake(s).

3.3.1.4.30 Mailrooms

- Refer to Section 3.2.8 – Support Facilities for mailroom ventilation system requirements.

3.3.1.4.31 Laboratory Ventilation Systems

- Refer to Section 3.2.3 – Laboratory Facilities for laboratory ventilation system requirements.
- For fume hood duct design and construction, see Chapter 4, Section 11 53 00.

3.3.1.4.32 Type 1 Kitchen Hoods

- Refer to Section 3.2.7 – General Use Facilities for kitchen ventilation system requirements.