

**GENERAL:**

This section provides general standards for overall sizing and design of Heating, Ventilating, and Air Conditioning (HVAC) systems. Other sections contain specific standards for each system per CSI specification format.

1. The consultant is strongly encouraged to confirm with the PM the choice of systems or components where there are options. These choices should be clearly noted and the reasoning behind using alternatives should be described in the Basis of Design.
2. Systems designed under this standard are to provide comfort related heating, cooling, and ventilating systems that meet applicable ASHRAE standards. The designer is to consider such things as:

|                        |                     |
|------------------------|---------------------|
| Occupant comfort       | Reliability         |
| Temperature            | Accessibility       |
| Humidity               | Maintainability     |
| Air motion             | Redundancy          |
| Air quality            | Space requirements  |
| Local climate          | Life cycle cost     |
| Interior cooling loads | Safety              |
| Equipment sizing       | Innovation          |
| First cost             | Acoustics and Noise |
| Operating cost         | Space pressure      |
| Complexity             |                     |

3. The guidelines in this section are to cover most facilities of the University of Missouri. There are also special sections in the Consultant Procedures and Design Guidelines (CPDG) that cover facilities that will have different requirements because of the specialized use or requirements of the facility. The designer must use provisions in those sections where they are more specific than this general section.
4. The consultant is advised: Do not leave the design up to a vendor or contractor. Specify, size, and show the design requirements on the contract documents.
5. Ensure construction drawings include details for all the proposed firestopping systems that could be encountered on the project based on the construction type and rating of the assemblies being penetrated. A specific Division 23 firestopping spec can be inserted, or reference related section 078400 for details.

**DESIGN GUIDELINES:**

## 6. Temperatures

### 6.1. Interior Conditions

- 6.1.1. Interior design temps shall be 75°F/ 50% RH in the summer and 72°F in the winter.
- 6.1.2. For specialized spaces such as operating rooms, microprocessor processing, laboratories, animal rooms, please refer to ASHRAE recommendations and/or user requirements. Where other temperatures are used, the reasons shall be documented in the Basis of Design.
- 6.2. For systems using outside air for ventilation, the design temperatures shall be 95°F db and 78°F wb.
- 6.3. For cooling towers, the design temperatures shall be 95°F db and 81°F wb; Condenser water temperatures to match equipment that is selected.
- 6.4. Chilled water coils shall be selected based on a 15° F “ $\Delta$ -T” across the coil with an inlet chilled water temperature of 45°F and an outlet temperature of 60° F. (This is based on the status of campus chilled water loops.) Higher or lower  $\Delta$ T may be desired or required by specific equipment in some circumstances. Lower inlet chilled water temperature may also be necessary to meet space requirements. The campus PM may approve changes and these changes are to be documented in the Basis of Design. Exceptions in ASHRAE 90.1 may also apply and should be referenced when applicable.
- 6.5. Air handler cooling supply air temperatures should be delivered to the space at 55° F db and 54° F wb (max). If the air handler is a Ducted Outside Air Supply (DOAS) providing ventilation air only, the delivery temperature must be 72° F db and 60° maximum wet bulb. If the space requires temperatures lower than 75° F db and 50% RH, the supply air temperature (wb and db) must be revised accordingly. Care must be taken to prevent condensation inside air handlers and duct work where low supply air temperatures are used. Extremely low supply temperature requirements may need the application of wrap-around coils, heat wheels, or DX cooling.
- 6.6. Building heating systems using campus steam will use 180 °F maximum with OA temperature reset. For existing buildings, make sure that reset temperature is not too low where existing coils cannot provide heating. Check re-heat coils on VAV boxes to make sure they can provide enough heat at reset temperature to maintain spaces at minimum VAV box airflow.
- 6.7. Building heating systems at **Missouri S&T** shall include the following design criteria, specifications, piping flow diagram, and sequence of operations for their lot temperature heating coils served by the geothermal campus system. This will ensure consistency across the buildings as well as appropriate flow capacity from the plants:
  - 6.7.1. AHU and VAV reheat coils shall have a coil  $\Delta$ T of 40 °F at 120 °F heating water supply temperature. Please note that this may be difficult using traditional VAV selection programs. It may be necessary to specify duct

mounted coils separate from the VAV boxes for adequate face area and reduced gpm, or contact the VAV box manufacturer for custom selections.

- 6.7.2. Pumped hot water pre-heat coils shall have a coil  $\Delta T$  of 20 °F at 100 °F coil supply water temperature and system  $\Delta T$  of 40 °F at 120 °F system heating water supply temperature.
- 6.7.3. Up to 8 fins/inch is preferable but no more than 10 fins/inch. For AHU coils, fin types A (flat) or b (thermally enhanced with lower air pressure drop) are acceptable, but not type C (high performance with higher air pressure drop).
- 6.7.4. 3-row coils with same end connections are acceptable.
- 6.7.5. AHU coils shall have a maximum air pressure drop of 0.3" wc, and VAV or other terminal heating coils shall have a maximum air pressure drop of 0.5" wc.
- 6.7.6. All coils shall have a water pressure drop less than or equal to 5'.

## 7. Humidity

- 7.1. Space humidity is not usually controlled directly. Summer dehumidification is a function of the cooling coil selection and the proper balance of supply and exhaust air.
- 7.2. Design to keep the building at neutral to slightly positive air pressure.
- 7.3. During cooling, coils are to be designed for a space condition of 75° F and 50% RH. During heating, there is no active humidity control except for specialized spaces such as hospitals, some library spaces, museums, and laboratories.
- 7.4. Spaces that require 100% outside air shall be humidified.
- 7.5. See the special sections in this manual for space conditions for those applications or obtain the information from the Project Manager if the type of space is not covered in the CPDG.
- 7.6. Where humidification is used, direct steam humidification is generally used. The consultant should verify with the PM that campus steam is acceptable. If direct humidification cannot be used, a steam-to-steam generator is the preferred method of generating humidification steam.

## 8. Ventilation

- 8.1. Follow provisions in the IMC and ASHRAE Standard 62. IMC is the code and the minimum ventilation in IMC must be met even if ASHRAE allows for lower rates.

Note: See the MUHC Planning Design and Construction Guidelines. Healthcare Facilities required to meet FGI must follow the most recent ASHRAE Standard 170.

- 8.2. Make sure critical space calculations have been done and include them in the Basis of Design.

- 8.3. Provide a DOAS air handler if the existing space does not have ventilation (existing fan coils that are not to be replaced or are replaced in kind).
  - 8.4. Ventilation (outdoor air) is to be compared to space and building exhaust to assure that building pressurization has been obtained.
  - 8.5. Infiltration shall be calculated and pressurization shall not be assumed to offset infiltration.
  - 8.6. See the special sections in this manual for space conditions for those applications or obtain the information from the Project Manager if the type of space is not covered in the CPDG.
9. Load Calculations
- 9.1. Up to DD phase lighting loads can be done on a W/sq. ft. basis. CD loads are to be calculated on the actual lighting design and documented in the Basis of Design.
  - 9.2. Internal gains and equipment may be estimated on a BTU/sq. ft. or W/Sq Ft. basis up to DD phase. At CD, loads shall be done based on the project design, installed components, and actual occupancy.
  - 9.3. For special facilities, provide basis of specialized internal gains and methodology if not covered in a special section of the CPDG.
10. Energy Analysis Data (ASHRAE)
- 10.1. Columbia: St. Louis data
  - 10.2. St. Louis: St. Louis data
  - 10.3. Kansas City: Kansas City data
  - 10.4. Rolla: St. Louis data
11. Air Handling Systems
- 11.1. Variable volume forced air systems that comply with ASHRAE Standard 90.1 are required unless an exception is approved based on the technical requirements of the facility or as designated elsewhere in this manual for special facilities.
  - 11.2. Larger single air handlers are preferred over multiple small units.
  - 11.3. Air handlers are to be located in dedicated spaces that can be secured.
  - 11.4. Rooftop units are not to be used unless approved by UM's University Engineer.
  - 11.5. Heat recovery shall be investigated and a life cycle cost done where there are high ventilation loads.
  - 11.6. Window air conditioners are to be used as a last resort and should generally only be used for temporary facilities.
  - 11.7. **Fan coil systems** should not be used except in renovations where low ceiling heights restrict the use of duct work. Where fan coil systems are used, outside air shall be introduced by a DOAS. Windows are not a source of required ventilation for buildings.
  - 11.8. Renovations of systems that are dual duct or multizone should convert these systems to VAV. Major renovations including these systems shall convert them to VAV. For the purposes of the definition of major or minor, a major

renovation is one where over 75% of the space served by the unit is being renovated.

11.9. All new and renovated building HVAC systems shall be provided with air filters meeting the following requirements:

11.9.1. Office and classroom: 30% pre-filter and 60% final filter (MERV 11)

11.9.2. Research labs\* 30% pre-filter and 85% final filter (MERV 13)

11.9.3. MUHC projects: ASHRAE 170

11.9.4. All other areas shall be filtered in accordance with ASHRAE Handbook or as dictated by special conditions of the facility design. Generally, filtration shall not be less than above unless approved by the PM.

\*Does not include Bio-containment labs and clean rooms. See special section "Biocontainment Laboratory Design Criteria" for these requirements.

11.10. Return fans shall be provided when return/exhaust/relief duct system pressure drop exceeds 0.30" wg.

11.11. Relief fans are required whenever the economizer air relief path  $\Delta P$  exceeds 0.07" Wg. (0.07" wg exerts 8 lbs of force on a 36" x 72" exterior door and will prevent the door from closing and locking)

12. Zones must be set up to contain spaces with similar usage, internal gains and skin exposures. In general, a VAV zone (box) should not serve more than three offices or similar sized rooms. Conference rooms, classrooms and larger spaces must be on their own zone apart from other spaces. Executive offices and other special spaces may be on a single zone.

13. Perimeter heating systems shall be provided when the BTU loss per ft of surface exceeds 450 BTUH/sf at the design temperature difference. Perimeter heat is essential for occupant comfort where there are high building skin losses.

#### 14. Hydronic Systems

14.1. Chilled water is the "base" method to be used for all space cooling applications. Where chilled water is not available, the facility's cooling needs shall be assessed and an economic life cycle of the building and systems shall be performed to select a viable system. Any system other than chilled water will require the Project Manager approval.

14.2. Hot water is the "base" method to be used for all space heating applications including 100% outside air coils (pumped coil arrangement). Other sources should only be used if there is no feasible way to provide a source of hot water. If electricity is the only heating source available, hot water heating will not be required, but may be used. Systems other than hot water require approval of the PM.

14.3. Variable flow pumping should be used for chilled water, hot water, and condenser water systems.

- 14.4. A means shall be included in long branches such as bypass lines with an autoflow limiting valve to keep the distribution lines at temperature during low loads.
- 14.5. Pressure Independent Valves shall be used for control at chilled water coils at all AHUs. If stacked coils are used at the AHU, add calibrating balance valves at each coil.
- 14.6. Automatic flow limiting balance valve and a modulating control valve shall be used at all hot water coils at AHUs. If stacked coils are used at the AHU, add calibrating balance valves at each coil.
- 14.7. Automatic flow limiting balance valve and a modulating control valve shall be used at VAV boxes, fan coil units and terminal units. PICV's are also an option. See Valves for Hydronic Systems in 232100.
15. Steam Systems
- 15.1. Steam pressure available will vary from campus to campus. The pressure available at a given site will be provided to the consultant by the PM. The pressure available at MU will generally be above 40 psig and is sufficient for space and domestic water heating applications.
- 15.2. Steam powered pumps are the preferred method of returning condensate and shall be used unless directed otherwise by the PM.
- 15.3. Steam is the preferred source of heat on heat exchangers and can be used on heating coils, primarily on renovations, where approved by the PM.
16. Equipment Redundancy
- 16.1. Heating systems – unless approved by the PM, the heat generating equipment (boiler or heat exchanger) including control valves, steam traps, and pumps shall be 100% redundant (n+1). Where sources of heating other than hydronic or steam have been approved by the PM a cost/risk decision shall be made by the PM as to whether a redundant heating source is to be provided.
- 16.2. Cooling systems - do not need redundant capabilities, however, larger systems may require multiple pumps etc., giving some redundancy. For buildings not served from a chilled water loop, options for chiller and pump arrangements shall be discussed with MU campus engineers, or the University Engineer (for the other 3 campuses).
17. Noise and Vibration
- 17.1. Provide flex duct on the end of runs from the metal duct to the elbow above a diffuser for noise reduction. This flex duct should be no longer than five feet except on lab systems where it should be five feet long and only on supply duct.
- 17.2. Sound levels shall be designed for background sound in rooms at the following levels or lower:
- |               |       |
|---------------|-------|
| Libraries     | 30 NC |
| Hospital OR   | 30 NC |
| Hospital Room | 30 NC |

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|                  |       |              |       |
|------------------|-------|--------------|-------|
| Private Offices  | 30 NC | Laboratories | 40 NC |
| Open Offices     | 35 NC |              |       |
| Conference Rooms | 25 NC |              |       |
| Classrooms       | 35 NC |              |       |

## 18. Controls

- 18.1. Controls for all systems shall be DDC based on the system(s) used by the campus. The PM will advise the consultant as to which vendor(s) to use.
- 18.2. Mixed Air Dampers, VAV boxes, reheat coils, and smaller devices shall use electric actuators.
- 18.3. All actuators shall fail safe and shall be specified as such.
- 18.4. Drawings shall show full point lists with point type.

## 19. Equipment Rooms

- 19.1. Mechanical Rooms will usually be ventilated using outside air intake louvers and a thermostatically controlled exhaust fan. Use a supply fan in lieu of an exhaust fan in rooms where atmospheric burners are located. Ventilation rate shall limit the temperature in the mechanical room to 10°F above ambient. If exhaust fan ventilation is not feasible, all passive forms of heat gain using insulation should be specified and a cooling unit provided to keep space temperature below 85 °F.
- 19.2. Electrical Rooms – Maintain temperature between 50°F and 90°F.
- 19.3. Telecom Rooms – Maintain temperature at nominal 75°F. Cooling methods similar to Elevator Equipment Rooms may be necessary. Consult with campus IT.

## 20. Elevator Equipment Rooms

- 20.1. A dedicated VAV box, FCU or split system should be used depending upon the existing or new systems in the facility to provide the most reliable source of cooling. Consult the campus PM should there be any concerns.

21. HVAC Testing Adjusting and Balancing (TAB) will be done by an owner provided TAB Agent. A word template [230593 Contractor Scope for Owner Supplied TAB](#) is provided on the UM FPD website for the consultant to edit to fit the project. It defines the contractor's role in assisting the Owner provided TAB firm to perform their scope of work. Some projects may allow the contractor to provide the TAB. See the word template [230594 Contractor Provided TAB \(MU\)](#) and edit to fit the project.

## 22. Drawing Requirements

- 22.1. Enlarged drawings at a minimum scale of ¼" = 1'-0" will be done for mechanical spaces and congested areas.
- 22.2. Elevations shall be done of congested areas to show clearances. These drawings shall show pipe, duct, conduit and other services **at full scale including insulation. Drawing shall note that representation includes insulation.**

- 22.3. Floor plans to show piping, duct work and equipment on the floor where it occurs. That would mean that hydronic piping serving the first floor is shown on that drawing and A/C condensate below the second floor is shown on the same floor drawing. The consultant is encouraged to use separate sheets where systems become too congested to read the drawings at reduced scale (1/2 size).
- 22.4. Air flow balance dampers shall be shown on floor plans. General notes and/or typical details should be avoided unless it can clearly specify all locations applicable to the project. Regulators for these balance dampers shall not use wingnuts or notches. A hand twist locking damper handle that provides infinite range of control shall be specified.
- 22.5. Piping may be represented as one line up to 4" size. At 4" and larger, pipe is to be drawing to scale. When drawing 1D and 2D piping, make sure spacing of pipes allows for insulation and space between the insulation so that piping can be installed as drawn.
- 22.6. Schedules shall be provided for any equipment that must be specially sized. This includes items from balance valves and dampers to air handlers. All safety equipment shall be included in schedules and sized by the consultant.
- 22.7. Except for small renovations, provide riser diagrams of all major systems including supply air, exhaust air, chilled water, hot water, and steam.