Facility Design Guidelines: Workplace, Architecture & Engineering

Heating, Ventilation and Air Conditioning Systems
MasterFormat Section 23-00-00

*The guidelines described herein shall be used on all projects, unless USAA’s Project Variance Request process has been used to secure an approved, project-specific variance.*

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Relevant Documents
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1. **Overview**
   a) The A/E is fully responsible for mechanical design. The following is a guide to the minimum design analysis required at the earliest possible stage in design. For new construction, and where economical on remodels; Dedicated Outside Air Systems (DOAS) with energy recovery shall be considered. The design teams shall evaluate methods to ensure occupant comfort at levels equal to or better than ASHRAE 55 (current version). The design team shall perform calculations to verify that the predicted percent dissatisfied (PPD) will be 10% or less, which is more stringent than the 20% or less called for by the Standard.
   b) Design Teams shall first develop the Basis of Design documents which call out the ventilation, heating and cooling requirements for the project and include Process Flow Diagrams that detail major pieces of equipment, air flow, temperature and humidity requirements. These shall be updated periodically through the design process as the design becomes more detailed.
   c) Design Teams shall develop a diagraphic Sequence of Operations (SoO) in flowchart (or similar) format. The Design Team may choose to deliver this in addition to a more typical text-based SoO. If so, one must be marked “for information” and the other marked as “For Construction.” The Design Team shall take great care in verifying that the controls submittals conform to the Design intent. The Commissioning Agent shall verify that the installed system performs per the Design intent and must produce a commissioning plan to owner.
   d) Applicable standards, but not limited to:
      iii. ASHRAE 62.1, Ventilation for Acceptable Indoor Air Quality, most current edition
      vi. ARI Standard 430, Central Station Air-Handling Units, most current edition
viii. NEMA Standards MG1, Motors and Generators, most current edition
x. ASME B31.9, Pressure Piping, most current edition
xi. OSHA 3074, Hearing Conservation, most current edition
e) Refer to Section 19, below, for required Life Cycle Cost Analysis Guidelines.
f) Work of this division related to HVAC shall be performed by a firm engaged in the business of heating/ventilation/air conditioning, and under the supervision of a Class A Licensed Air Conditioning Contractor, as defined by the State of Texas Department of Licensing and Regulation (TDLR).

2. Mechanical Drawings
a) Drawings must show equipment, ductwork, service access panels, and piping sufficiently to indicate all aspects of installation. Provide sections and elevations to supplement plan views.
b) Where practical, group all notes, legends, and schedules at the right of the drawings above the title block.
c) Provide legends to clarify all symbols and abbreviations used on the drawings.
d) To ensure serviceability, show the minimum access area around mechanical equipment, for both ground level and above ceiling equipment. Identify space necessary to access and replace items that require maintenance, such as filters, coils, heat exchangers, tube bundles, strainers, and chillers on the drawings in three-dimensions.
e) Show all pertinent seismic detailing for the mechanical systems on the contract drawings.
f) “Demolition” plans are to be separate and distinct from “new work” plans.
g) All volume dampers should be shown in the plans.
h) The equipment actually installed on a project may be different from that used in the basis of design. Therefore, mechanical equipment schedules must reflect actual required equipment capacities as calculated, not capacities provided by manufacturers’ catalog data. This helps ensure that the installed equipment is optimally sized for the application.
i) When drawing congestion is likely, ductwork and piping should not be shown on the same plan. Single line ductwork layouts are not allowed on final drawings; provide a two-line ductwork layout to scale. Provide large-scale details of congested areas on the drawings, with dimensions locating all work relative to structural features of the building.
j) Show thermostat locations on the plans, and other devices to measure dew point, CO₂, etc. when required.
k) Mechanical rooms must be drawn at no less than ¼” = 1’-0” (1:50). Congested mechanical rooms must be drawn at no less than ½” = 1’-0” (1:20). Mechanical room plans should be supplemented by at least one (1) section; at least two (2) sections for more complex, congested applications.
l) Provide a three (3)-dimensional isometric diagram representing the mechanical room piping or a two (2)-dimensional diagram indicating the entire system. Indicate shutoff valve locations to allow replacement of control valves and system components.
m) Provide an equipment schedule on the drawings indicating actual design conditions, not the manufacturer’s catalog data. Include as a minimum
   i. Air flow quantities (maximum and minimum if applicable) and static pressure requirements.
   ii. Coil water flow quantities and entering and leaving temperatures.
iii. Heating and cooling coil sensible and latent capacities including the sensible heat ratio.
iv. Coil entering and leaving air conditions. For cooling coils include wet bulb, dry bulb, and dew point temperatures at the design flow rate. Ensure these conditions adequately cover the design latent load. For heating coils provide entering and leaving air temperature. Include face velocity for coil selection.
v. Coil maximum allowable air side and water side pressure drops.
vi. Motor electrical characteristics including horsepower, voltage, RPM, and NEMA motor starter size.

3. Energy Supply
   a) Disconnects for all fan and pump motors shall be installed adjacent to the units for clear identification of lock out.

4. Heat Generating Systems
   b) Hydronic heating water shall be the preferred heating system for large facilities

5. Cooling Generating Systems
   a) Chilled water systems employing the following technologies shall be the standard for new construction:
      i. Low pressure refrigerants such as R-123.
      ii. Variable speed motors or motors with variable speed drives.
      iii. Variable speed drives on chiller motors shall be standard unless economic analysis shows them to be too costly.
      iv. Optimized cooling tower fan, primary chilled water flow, and condenser water flow systems, Siemens “Demand Flow” or equivalent.

6. Distribution Systems
   a) Round duct shall be preferred over rectangular duct due to lower leak rates and lower pressure drop at a given flow rate. Design consultants and contractors must perform a cost/benefit analysis demonstrating the long-term benefit to USAA for installing rectangular duct over round or oval duct.
   b) Distribution pressure set-points shall be variable. The Building Automation System shall reset the pressure set-points to minimize pumping and fan energy while maintaining service to air handling devices.
   c) Isolation valves shall be included at logical and accessible locations, such as floor-plate service laterals, building-sector risers, etc.
      i. Ventilation Diffusers
   d) The following diffusers are preferred:
   e) Supply air diffusers – Titus TMS or approved equal
   f) Slot Diffusers - Titus TBDI-30 or approved equal
      i. slot diffusers:
         ii. All diffusers shall be set to blow air along the ceiling in the same direction so that air from adjacent diffusers does not make an unexpected down-draft.
         iii. Diffusers at the windows are an exception. At least half of the air shall be directed at the windows to perform window-wash.
         iv. The installer shall take care to install per manufacturer’s instructions. Specifically, no screws shall be allowed to penetrate the diffuser’s air plenum.

7. Return air Grilles
   a) Return Air Grills - Titus 50F Eggcrate or approved equal.
8. Terminal units, Package Units and air distribution
   a) For new installations in humid climates (dewpoint above 55 degrees F at least 2,500 hours per year) where cooling towers are to be used, condensate shall be collected at all air handlers with an estimated generation of 20,000 gallons per year or higher. The collected condensate shall be directed to the cooling towers. Collection and transportation systems shall be gravity drain, if practical. Full-pipe drains are acceptable in this application.
   b) If draw-through units are used, provision in controls must be made to keep fans from remaining wet for long periods. Preferred control loop is to close chilled water valve at the end of each day and allow the discharge air temperature to reach inlet air dewpoint plus 4-5 degrees. A second option is to run fans for 15 – 30 minutes after occupation time is complete and the chilled water valve is closed off.
   c) For new and replacement units the designer should consider the use of “fan wall” construction.
   d) All VAVs, FCUs and similar equipment shall be installed above aisle ways or in similarly accessible locations. No installation in offices, above desks or in conference rooms.
   e) Home Office maintenance personnel have seen poor performance from Titus VAV boxes due to bushing failures. Enviro-Tec and Price are preferred in general. Titus shall not be used in facilities with an expected occupancy of greater than five years unless the bushing design is improved.

9. Chilled water coil requirements:
   a) USAA requires accessibility to clean the coils adequately and coil manufacturing features that facilitate effective cleaning.
   b) Coils shall be built with copper tubes and aluminum fins, no more than 10 fins per inch. Fins shall be bonded to the tubes by mechanical expansion of the tubes.
   c) Coils arranged in series shall have a minimum of 18” between coils with an access door between.
   d) Coils shall not exceed 6 rows for single coils, 4 rows for two or more coils in series.
   e) Supply and return chilled water connections shall be on the same end of the coil. Air flow shall contact the return end of the coils first and exit through the coils on the supply end.
   f) USAA requires rugged, maintainable coils with the following features:
   g) Coil casings shall be stainless steel, no lighter than 16 gauge, with stiffeners no more than 48” apart.
   h) Coils shall be removable without affecting the integrity of the unit. Coil frames shall be independent of the unit.
   i) Coils shall have high point vent (isolatable) and low point drain.
      i. All appurtenances shall be compatible with the copper tubing – no black iron fittings without isolation.
      ii. Water velocity through the coil shall be no higher than 6 feet per second. Water velocity at low flow shall be no lower than 3.5 feet per second.
      iii. Copper tubes shall be at least ½” and have a minimum wall thickness of 0.035.”. Copper return bends shall have a minimum wall thickness of 0.049.”
      iv. All coils shall be tested under water with test air pressure of 1.5x design pressure. Test pressure shall be between 250 and 500 psig.
   j) Acceptable coil manufacturers are listed below, but others can be considered if quality can be demonstrated as equal to or better than the listed manufacturers.
      a. Aerofin
      b. McQuay
c. Temtrol
d. Trane

k) In order to minimize pressure drop across the chilled water coils and also minimize condensate carry-over, the maximum average air flow rate shall be 450 feet per minute. Maximum measurable air flow rate at any point in the coil shall be 600 feet per minute.
l) Stacked coils shall be installed with intermediate drain pans with downspouts extending to the next drain pan.
m) Supports shall not penetrate drain pans. Provide airtight seals between coil and casing.

10. HVAC units shall have the following features:
   a) Units shall be double wall.
   b) Drain pans shall be stainless steel, single-piece construction and insulated under the pan.
   c) Units shall be rated and certified under ARI Standard 430 and 410, current edition.
   d) Units shall be designed and tested to maintain air leakage rate of less than 0.5 cfm/square foot at 10” w.g. In addition, deflection of casing panels and frames shall not exceed 1/200 of the span at a static pressure of 10” w.g.

11. Standard filtration for Occupied Spaces
   a) Electrostatic MERV 14 filters, gasketed. Nalco 6042302 or approved equal.

   a) Air discharged from ceiling diffusers with ceiling return shall be heated to no more than 15 degrees above the room air temperature. This is to reduce the amount of ventilation air required for the space. Please reference ASHRAE 62.1 Equation 6.2.2.3 and Table 6.2.2.2.

13. Ventilation
   a) Stand alone supply fans and exhaust fans should use Electro-commutated motors (ECM) with direct drives. This reduces power and maintenance cost.
   b) Toilet exhaust fans should be controlled by occupancy sensors. Fan should be increased to 100% if air-side economizer is in operation since restrooms are some of the best places to remove air from buildings.

14. Special HVAC Systems and Equipment
   a) Areas connected to loading docks shall have carbon monoxide sensors installed with provisions to adequately ventilate the room should vehicle exhaust enter the room airstream. These areas should be balanced to maintain positive flow to the dock area to minimize vehicle exhaust intrusion.

15. Kitchen HVAC
   a) Kitchen HVAC design, construction and commissioning shall follow the Commercial Kitchen Ventilation (CKV) recommendations documented in chapter 33 of the 2015 ASHRAE Handbook—HVAC Applications. (Use revised versions when published every four years.) Specifically, each project must:
   b) Follow Enhanced Commissioning Guidelines
      i. OPR and Basis of Design must be approved by Food Service Operations, HVAC Maintenance and the Technical Services Director.
      ii. These documents must consider operations and maintenance tasks, training required for the tasks, mechanic-hours needed and frequency of maintenance.
      iii. These requirements do not relieve the project teams of providing safe and high-quality cooking systems.
   c) Hood selection shall have minimization of exhaust flow required for capture and containment as a design goal.
      i. Single island canopy hoods should not be used.
ii. Installation of side shields should be standard.

d) Air distribution must be designed so as to make hood operation effective.
   a. Room HVAC design must eliminate drafts and eddies.
      i. No 4-way diffusers within 20’ of hood.
      ii. Directional ceiling diffusers must be far enough away from hood to have less
          than 75 fpm velocity at hood when the diffuser is at max flow.
      iii. Displacement ventilation is preferred if the project will include architectural
           modifications.
   b. The team must rigorously ensure that no cross drafts can occur.

e) Teams should use demand control kitchen ventilation operations as the baseline design.
   a. Before selection of a system that will independently modulate exhaust rates through
      hoods served by a common fan, these conditions must be met:
      i. Vendor must demonstrate that detection of cooking condition is robust (i.e.
         Does not require frequent checking or adjustment).
      ii. Cooking condition detection must be able to switch to cooking mode when
         cooking starts – temperature rise is not adequate because the temperature of
         the cooking appliance often drops at the beginning of cooking and the release of
         grease, steam, etc.
   b. Also prior to selection, exhaust system vendor must disclose:
      i. the sequence of operation,
      ii. sensor types and locations,
      iii. maintenance requirements for these sensors,
      iv. alarm detection, communication method and
      v. system condition on alarm.

f) Replacement air may not be delivered at the hood.
   a. Transfer air is the preferred method to deliver replacement air.
      i. Control Sequence of operations must verify that HVAC equipment bringing in
         the replacement air is functioning when hood operation begins.
   b. If makeup air is delivered in the kitchen, it should be delivered as far from the hoods as
      practical so that it provides space conditioning prior to being removed by the hoods.
   c. Replacement air delivery be designed and operated to ensure that the kitchen operates
      at slightly lower pressure than surrounding areas, containing cooking odors.

16. MDF/IDF Room cooling
   a) Cooling system design must factor in the need to do maintenance near sensitive IT
      equipment and the cost of MDF/IDF room architectural systems.
   b) Cooling systems must be able to maintain cooling 24 x 7, 365 days per year, not relying on
      air handlers that are only on during occupied times.
   c) Temperature must remain constant within the range of 75F – 80F degrees at front of IT
      equipment.
   d) The preferred design is to have the cooling unit installed in nearby mechanical space with
      supply air ducted to the floor of the MDF/IDF room consistent with displacement ventilation
      principles.
   e) Return air (taken from the ceiling of the room) can be ducted to the cooling unit or returned
      to the general overhead plenum.

18. Data Centers
   a) Provide CRAC cooling with positive pressure, 24 x 7 – hour space conditioning, 365 days per
      year. Coordinate with USAA Facilities for stand-by power requirements on HVAC equipment.
   b) A Data Center designer must be contracted to provide a dense design for this space.
c) No outside air is allowed to mix with recirculated CRAC air flow.
d) Chilled water or DX condensing units are allowed.
e) Relative humidity must be maintained between 35% – 50%.
f) Dust: <100 micrograms / cubic meter / 24 hour period.
g) Temperature must remain constant within the range of 75 degrees (± 3 degrees)

19. Life Cycle Cost Analysis Guideline
a) Cost effectiveness of a design is a key component and Life Cycle Cost Analysis (LCCA) is a design process for evaluating and controlling the initial and future cost of building ownership. Life Cycle Cost Analysis (LCCA) is defined by the National Institute of Standards and Technology (NIST) Handbook 135 as the total discounted dollar cost of owning, operating, maintaining, and disposing of a building or building system over a period of time. NIST Handbook 135 is available at http://www.fire.nist.gov/bfrlpubs/build96/PDF/b96121.pdf.
b) LCCA is based on the premise that multiple building design options can meet programmatic needs and achieve acceptable performance, and that these options have differing initial costs, operating costs, maintenance costs, as well as different life cycle costs. By comparing the life cycle costs, LCCA can show the trade-offs between low initial first cost and long-term cost savings. Thus, the most cost-effective system for a given use can be identified, and the length of time it will take to “pay back” the incremental cost for this system can also be determined. In keeping with USAA’s sustainability practices, LCCA can identify environmentally desirable solutions. Careful design choices that result in efficient use of energy, water and other resources often yield long-term cost savings. In addition, should environmentally friendly choices not save money over time, LCCA may reveal that their additional cost over time is minimal. These guidelines define the LCCA process, and establish the standards and metrics to ensure accurate and consistent life cycle data collection and evaluation across projects.
c) During the Schematic Design (SD) and Design Development (DD) phases of a project, the A/E is required to perform an LCCA comparative analyses from several building system categories. Each LCCA comparative analysis can have up to four (4), or more, alternatives (one base case plus three alternate cases). Building system categories are as follows, but are not limited to Energy Systems, Mechanical Systems, Electrical Systems, Building Envelope Systems, Building Interior Construction, Building Siting/Massing, Structural Systems.
d) System designs shall be evaluated by the design team on the basis of total ownership and operations cost over a period of twenty (20) years for, not energy or capital cost alone.

END OF SECTION