Section 23 00 00
BASIC HVAC SYSTEM DESIGN
Design Standard

PURPOSE:

The purpose of this document is to standardize the basic elements of the HVAC system design process. This design standard has the purpose of creating a consistent application of HVAC system design throughout the San Mateo County Community College District therefore achieving a standard of quality for maintenance, energy efficiency, and reliability throughout all renovation and new building projects.

General:

A. Refer to 01 91 00 and 23 08 00 for Commissioning requirements. Provide all required support as required to allow the Commissioning to be performed.

B. Refer to 25 10 00 and 23 05 19 for metering and monitoring. All meters and the monitoring components required to be installed shall be furnished by the EMS contractor and installed by the mechanical contractor as directed by the EMS contractor.

Sustainable Design Practices:

- San Mateo County Community College District is strongly committed to promoting sustainability throughout their campus projects. Section 01 81 13 Sustainability of the Design Standard provides guidelines and recommendations for implementing sustainability strategies. Where relevant, specific sustainability criteria is noted in this section, however, each project should review and cross reference that front section while developing the specific project and its documentation. Each discipline shall confirm that specific performance and manufacturer information provided in the specification section is in alignment with code requirements, LEED Gold criteria and any other goals for sustainability.
- The minimum energy savings shall meet or exceed the EUI targets as established in Section 01 81 13
- Provide a life cycle cost analysis for all new building equipment under Division 23. The analysis shall include historic rate increases for energy and shall be based on the life expectancy for the structure of 50 years from the date of the analysis. Minimum life expectancy for equipment shall be 25 years, unless otherwise noted.
- Energy modeling shall be provided for all buildings 50,000 square feet and larger under Division 23.
- For all proposed natural gas-fired systems, a life cycle cost assessment of natural gas using systems and their equivalent electric alternatives shall be conducted.

Design Standard:

Codes – Systems will be designed in accordance with the latest edition of the following codes:

- California Building Code.
- California Mechanical Code.
- California Plumbing Code.
- California Fire Code.
- National Electrical Code; California Electrical Code.

- State of California Code of Regulations (CCR).
- Energy Efficiency Standards and Title 24 Regulations.
- Local City Amendments and Regulations.
- DSA – Department of the State Architect.

Standards – The following reference standards will be used for the design:

- AMCA – Air Movement and Control Association International, Inc.
- ANSI – American National Standards Institute.
- ARI – Air Conditioning and Refrigeration Institute.
- ASHRAE – American Society of Heating, Refrigeration, and Air Conditioning Engineers.
- SMACNA – Fire and Smoke Damper Installation Guide.
- SMACNA – Guidelines for Seismic Restraints of Mechanical Systems.
- SMACNA – Standards for Duct Construction.
- EPA – Environmental Protection Agency.
- NEMA – National Electrical Manufacturer's Association.
- UL – Underwriters' Laboratories.
- NFPA - National Fire Protection Association.
- NFPA 90A – Air Conditioning and Ventilating Systems.
- NFPA 101 – Life Safety Code.
- LEED – U.S. Green Building Council.

HVAC Calculation:

- Utilize the following outside air temperatures in calculating HVAC system capacities:
    - Skyline College (Climate Zone 3, CEC T-24 0.5%):
        - 80°FDB/64°FWB Cooling Calculations
        - 30°F Heating Calculations
        - Range: 23°F
    - Cañada College (Climate Zone 3, CEC T-24 0.5%):
        - 86°FDB/66°FWB Cooling Calculations
        - 28°F Heating Calculations
        - Range: 28°F
    - College of San Mateo (Climate Zone 3, CEC T-24 0.5%):
        - 84°FDB/65°FWB Cooling Calculations
        - 31°F Heating Calculations
        - Range: 24°F

- Lighting Loads: Lighting loads shall be calculated at CEC T-24 Watt per square foot values during preliminary design. Engineers shall execute final calculations upon selection of final lighting fixture selections.
- Equipment Loads: Equipment loads are variable and should be based on actual equipment to be installed in each location. Engineer shall apply diversity factors so as not to oversize central HVAC systems.
- Thermal Mass: Thermal mass shall be considered during calculations as a method to offset cooling loads.
- U-Values for Walls and Roofs: Loads shall be calculated at CEC T-24 allowances during preliminary design. Engineers shall execute final calculations upon selection of final building façade materials.
- U-Values for Solar Heat gain Factors for Windows: Loads shall be calculated at CEC T-24 allowances during preliminary design. Engineers shall execute final calculations upon selection of final building façade materials.
- Cooling system pick-up capacity: 10% of total load
- Heating system pick-up capacity: 25% of total load
- All calculations shall be completed utilizing DOE approved calculation software.
- Pipe sizing calculations: 4.0'/100'HD for main piping; 3.5'/100' HD for branch piping; 7 fps maximum velocity in occupied spaces.
- Duct sizing calculations: equal friction method - 0.1"/100' for main ductwork (never exceed 1,800 feet per minute); 0.08"/100' for low pressure branch ductwork (never exceed 500 to 800 feet per minute). Lower velocities may be needed for acoustical purposes.
- Return air systems – Return air ducts shall be sized on the equal friction method at 0.08"/100' (never exceed 1,500 feet per minute). Design plenum return air systems for low pressure drops. Design transfer air systems at 250 feet per minute to minimize pressure drop at grill faces, and at 500 fpm at open air spaces across the net free area. For multiple, cascading transfer openings the total pressure drop shall not exceed the allowable pressure drop for an individual opening.
- Interior temperature requirements:
  - General conditions:
    - Each zone to have three occupancy states:

      Occupied Mode:

      - Summer time cooling design 73°F +/- 3°F, no RH control (no cooling control except through ventilation for buildings deemed not to have cooling systems).
      - Winter time heating design: 70°F +/- 3°F, no RH control.

      Standby:

      - Summer time cooling design 73°F +/- 6°F, no RH control (no cooling control except through ventilation for buildings deemed not to have cooling systems).
      - Winter time heating design: 70°F +/- 6°F, no RH control.

      Unoccupied:

- Summer time cooling design 73°F +/- 10°F, no RH control (no cooling control except through ventilation for buildings deemed not to have cooling systems).
- Winter time heating design: 70°F +/- 10°F, no RH control.

- Acoustical and Vibration Calculations:
  - Acoustical calculations shall be completed by a professional specializing in the science of sound transmission, acoustics, and vibration.
  - Design shall conform to ASHRAE Chapter "Sound and Vibration Control", latest edition and the SMCCD Acoustical Design Standards.
  - Refer to the Acoustical Design Standard for general HVAC acoustical and vibration guidelines.

Buildings obtaining heating hot water or chilled water from the Site Central Utilities Plant:

- Any system obtaining heating hot water or chilled water from the Site Central Utility Plant shall be provided with two pumps per system in parallel (one redundant) to provide the pressures required to serve the new building.

Outside Air Make-up and Ventilation:

- Utilize CEC T-24 and/or ASHRAE Standard 62 (whichever is most stringent), latest edition, to determine outside air ventilation flow rates. Indicate quantities of minimum outside air on all equipment schedules.
- Outside air for ventilation and make-up shall be brought from a fresh source of air. Outside air openings and operable building systems shall be located at a minimum of 15-0" from any permanent or temporary points of:
  - Cogen plant exhaust
  - Boiler exhaust
  - Kilns
  - exhaust air
  - plumbing vents
  - areas of objectionable odor
  - locate away from loading docks, parking lots, adjacent roadways, etc.
  - 30'-0" separation from non-environmental exhaust systems (as defined by the CMC) such as kitchen exhaust, lab fume hood exhaust, garage exhaust, etc. Increase separation where openings are downwind from sources listed above.
- Design outside air intakes to eliminate the possibility of water carry over. Always utilize drainable weatherproof type louvers at intakes.
  - Provide CO_2 monitoring to accommodate demand controlled ventilation (DCV) to reduce energy use. Monitors shall be connected to the BMS. DCV shall be provided in all spaces that have an occupancy rating of 25 or more people per 1000 sq. ft. (40 sq. ft. per person). Minimum outside air shall be based on 15 CFM per person. When population I s reduced, as sensed by the CO2 monitor, the outside air can be reduced to 0.15 CFM per sq. ft. to satisfy the outside air requirements for reduced population. Typical rooms with DCV are:

    - Classrooms
    - Gymnasiums
    - Theatres
    - Lecture halls
    - Auditoriums
    - Lobbies
    - Cafeterias
    - Meeting rooms
    - Conference rooms

- Determine if natural ventilation can be utilized for comfort cooling either by itself or as part of a mixed-mode system. Prior to locating intakes, consider:
    - pollution sources
    - acoustical interferences
    - security
    - airflow patterns via CFD modeling
- For Skyline College utilize marine grade moisture eliminators at all intakes to outside air ventilation systems.
- Consider the use of ultraviolet lamps at AHU outside air coils to kill bacteria and mold that may grow in air handling units. Ultraviolet lamps will not only kill bacteria and mold but also have the advantage of reducing maintenance for coil cleaning.
- Consider the integration of systems that detect and measure the presence of particulate matter suspended in air including but not limited to dust, smoke, and other organic and inorganic particles 2.5 micrometers or smaller.
- Consider the orientation of the outside air intakes relative to the solar path, avoiding south and west facing intakes where solar heat gain may unnecessarily heat supply air into the building.

Equipment Selection:

- HVAC Systems: Specific system types are either addressed in the program or where a system is not indicated shall be addressed by the engineer of record for the project based on:
    - Lifecycle cost analysis to include first cost, operating cost, maintenance cost, energy cost
    - Reliability
    - Temperature control
    - Noise level
    - System complexity
    - Life expectancy – Minimum life expectancy for equipment shall be 25 years (this duration shall be utilized for the Life Cycle Coast Analysis unless otherwise noted).
    - Susceptibility to vandalism
- Equipment General:

- Provide an integrated design so that each element of the building is carefully considered. Produce a holistic solution. The actual design and installation shall address accessibility of equipment and its associated trim and provide all necessary clearances.
- Design documents shall indicate all minimum clearance requirements to ensure required space is provided around all equipment.
- Indicate the required clearances from exhaust systems to each outside air intake or building opening. Distances vary depending on the process being exhausted.
- Utilize shading, landscape, canopies, blinds, building thermal mass, etc. to reduce heating and cooling loads and minimize equipment sizes.
- Skyline Campus: All equipment to be located indoors unless absolutely unavoidable. All equipment having contact with the outdoors shall be corrosion resistant to the coastal fog climate. All interior section of equipment utilizing outside air shall be treated for corrosion protection. All support system and appurtenances located outdoors or exposed to the outdoor airstream shall be corrosion resistant.
- Cañada Campus and College of San Mateo: All equipment to be located indoors wherever possible. Where it is not possible due to cost constraints or aesthetics or other hardship, equipment may be located outdoors obstructed from view and architecturally shielded.
- Rooftop equipment: SMCCCD has found that rooftop equipment attracts birds, who roost in/around the units and eat away at anything they deem edible. Designers who specify the installation or repair of rooftop equipment shall also specify the installation of enclosures to protect existing piping, motors, etc from bird infiltration. Specify cages, solid metal, or any other material which will withstand the weather, moisture, etc.

- Fans:
  - Fans shall be selected on a stable point of operation of the fan curve. Fan selection shall be based on methods in the ASHRAE Handbook, most recent edition.
  - Select Motor sizes and speed should provide a 15% safety factor for deviation in fan static pressure and future airflow increases.
  - Static pressure of fans shall be determined from pressure drop calculations (based on the most hydraulically remote location) including:
    - ductwork
    - fittings
    - diffusers/grilles
    - ductwork accessories
    - system effects
    - specialties and appurtenances
    - discharge velocity pressure
  - Select fan noise sound and pressure levels to assure quite operation per acoustical requirements above.
  - Kitchen Grease Exhaust: Fans shall be UL listed for such service. Provide with drain. Consider location of kitchen smoke exhaust with regards to campus views, deterioration of building façade, and odors.
  - Fume Hood Exhaust Fans: Fans shall be UL listed for such service. Provide explosion proof systems with appropriate coatings to prevent chemical action on fan housing.

- Cooling Coils:
    - Design direct expansion and chilled water coils on basis of a nominal 400-500 foot per minute face velocity.
    - All cooling coils shall be pipe counterflow of refrigerant against airflow.
    - Select the Cv of each coil control valve at design conditions.
    - Design with upward flow through coil and air vents at all high points of coils to eliminate trapped air.
    - At a minimum design with isolation valves on supply and return, two or three way control valve based on pumping system design, drain, flexible connections, and temperature gage.
- Heating Coils:
    - Design heating water coils on basis of a nominal 600 foot per minute face velocity.
    - All heating coils shall be pipe counterflow of refrigerant against airflow.
    - Select the Cv of each coil control valve at design conditions.
    - Design with upward flow through coil and air vents at all high points of coils to eliminate trapped air.
    - At a minimum design with isolation valves on supply and return, two or three way control valve based on pumping system design, drain, flexible connections, and temperature gage.
- Air Distribution Devices:
    - Supply Diffusers:
        - Preferred method of air distribution due to aspiration and entrainment of room air (reduction of drafts and more even room temperature profiles) as well as the ability to distribute air in many different directions.
        - Supply air grilles shall be sized based on manufacture's airflow, noise criteria, mounting height, and pressure drop data.
    - Supply Grilles:
        - Avoid wall grilles where possible. Wall grilles have a lack of aspirating qualities and when discharging in cooling can create a perceived feeling of drafts. Where designed, use care. Utilizes a larger width to height aspect ratio for maximum induction of room air. Utilize double deflection type grilles to maximize adjustability. Do not throw air longer than 15-20 feet in rooms with low ceilings (below 9 feet).
        - Supply air grilles shall be sized based on manufacture's airflow, noise criteria, mounting height, and pressure drop data. Do not exceed 500 feet per minute.
    - Return Air Grilles:
        - Locate to aid in contaminant displacement.
        - Design for low pressure loss in return plenum systems to assure that rooms do not get over-pressurized.
        - Return air grilles shall be sized based on manufacture's airflow, noise criteria, mounting height, and pressure drop data. Do not exceed 400 feet per minute for ducted systems and 250 feet per minute for plenum return systems.
- Sound Attenuation and Vibration Control:

  - Where required utilize sound traps or acoustical duct lining to mitigate noise attributable to HVAC equipment.
  - Refer to the Acoustical Design Standards for general HVAC acoustical guidelines. Size of sound traps and length to be provided by an acoustical engineer after completion of calculations.
  - Length of acoustical lining to be provided by an acoustical engineer after completion of calculations.
  - Provide vibration isolation devices as required to meet ASHRAE recommendations for vibration transmission.
- Pumps:
  - Select systems with two pumps. Deliver 100% capacity with both pumps operating in parallel. When one pump shuts down, a single pump shall be capable of providing 75-80% of the total capacity. Due to cost considerations standby pumps are not required unless there is a specific concern for redundancy.
  - For economical design and energy efficiency, end suction, base mounted pumps and in-line pumps should be used for most systems except when the systems become very large.
  - Dynamic head of pumps shall be determined from pressure drop calculations (based on the most hydraulically remote location) including:
    - piping
    - fittings
    - valves
    - coils
    - system effects
    - specialties and appurtenances
  - Pumps shall be capable of being removed for maintenance without having to drain the entire system.
- Temperature Control and Zoning:
  - All buildings shall be connected to the campus wide DDC control network (a Schneider Electric based system). See DDC Controls Design Standards and Standard Specifications for additional criteria.
  - Individual temperature controls will be based on function, exposure, and Owner request Unless otherwise dictated by applicable code(s).
  - Each corner exposure (NE, NW, SE, and SW) shall be on a separate temperature control zone.
  - Each conference room, lobby, classroom, lecture hall, break area shall be on a separate temperature control zone.
  - Closed offices will be provided with individual thermostatic control and associated variable air volume or demand control ventilation system terminals. This requirement may be relaxed with approval from SMCCCD.
  - Large group spaces shall allow user-adjustable controls restricted to +/- 2°F with a time-out after 2 hours.

    - Thermostats shall be positioned to minimize external influences so the thermostat senses as close to the true room ambient temperature. The thermostats shall not be installed in direct or reflected sunlight, on an exterior wall unless an insulated subbase is provided, within 5' of exterior doors, the direct path of air discharged from diffusers or near heat producing equipment (photo copiers, coffee makers, computer drives, etc.).
    - CO2, motion and other sensors shall be integrated as appropriate and must be controlled and monitored points on the Building Automation System

- Specialty Considerations:
    - Central Plants:
        - The purpose of a central plant is to reduce overall energy costs, limit noise and vibration to occupied spaces, reduce maintenance to a single location for boilers, chiller, and pumps, increase the aesthetic nature for the remainder of the campus.
        - All campuses that have existing central plants for heating and/or cooling shall have new and/or modernized buildings connected to the central plant. Exceptions will be made based on project budget and other factors.
        - Equipment selection for new central plants should be industrial commercial grade.
        - Systems should be easy to maintain and operate.
        - Consideration should be given for expansion.
        - Provide manual shut-off valves on all services entering each building to allow for total isolation of each building from site services. Provide a valved by-pass between the supply side and the return side of the system to maintain constant flow of the central plant.
        - Isolation valves shall be installed, at a minimum, on each floor to allow the isolation from the remainder of the building.
        - Provide all required valves to facilitate the replacement or maintenance of system components. For critical equipment that must be active for the building to function, provide a valved by-pass around the component requiring maintenance.
        - Sequences shall be determined to minimize energy use and take advantage of low part-load conditions that occur frequently at the campuses.
        - Heat recovery systems and electric heat pumps should be considered where appropriate.
    - Specialty Pressure Requirements and Exhaust Systems:
        - Specific rooms shall be designed to be at a negative pressure to adjoining spaces and to be exhausted 100%. These rooms include but are not limited to: restrooms, certain labs (confirm with activity and use), certain science classrooms (confirm with activity and use), kitchens, janitor closets, copy rooms, food service rooms, loading docks, locker rooms, shower facilities, photograph rooms and dark rooms, art classrooms (confirm with activity and use), refrigeration machinery rooms, boiler rooms, etc.
        - Areas with products of combustion need removal of the products and a source of combustion air.

    – General: Coordinate and provide the access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Coordinate with construction manager for Access panels, doors and requirements from other trades. Access panels and doors shall be sized to allow full access to the item requiring access, up to, and including, full body access if required. Minimum Access Door Sizes:

- One-Hand or Inspection Access: 8 by 5 inches.
- Two-Hand Access: 12 by 6 inches.
- Head and Hand Access: 18 by 10 inches.
- Head and Shoulders Access: 21 by 14 inches.
- Body Access: 25 by 14 inches.
- Body plus Ladder Access: 25 by 17 inches.

– Food Service Facilities:

- The kitchen shall be designed with separate exhaust systems for each hood allowing each hood to be separately controlled. Fans shall be at the end of the exhaust system and located in the exhaust duct. Exhaust airflow shall be at a rate of 1500 feet per minute minimum to create a capture velocity. No duct accessories are allowed in the kitchen exhaust system.
- Provide separate exhaust systems for dishwashing. Ductwork shall be non-corrosive stainless steel or aluminum and pitched for drainage. A duct drain shall be provided at the low point of the ductwork. Do not trap water in the duct.
- Exhaust ductwork shall be specifically designed of materials compatible for kitchen grease exhaust
- Make up air can either be provided from make-up air handlers or by transfer of air from adjoining spaces, Code permitting.
- The make-up air and exhaust air systems shall be interlocked.

- Equipment Rooms:

Provide mechanical cooling in Equipment Rooms where heat is generated by the process within the equipment room. Heat loads shall be calculated and a split cooling system (rooftop condensing unit and an internal fan coil unit) shall be provided to compensate for the heat gain. Provide condensate drainage and temperature control for the unit.

APPROVED MANUFACTURERS:

Not Applicable

SUBSTITUTES ALLOWED?

Not Applicable

ASSOCIATED DESIGN STANDARDS AND CONSTRUCTION SPECIFICATIONS:

- Division 23 Design Standards and Construction Specifications

END OF SECTION