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D0000 – General Mechanical

Introduction

The following section provides requirements and guidelines in the design and construction of mechanical and plumbing systems at the University of Colorado-Boulder (UCB). Coordinate mechanical design with other applicable **Facility Standards**.

Standard definitions and abbreviations:

a. Refer to ASHRAE Fundamentals for commonly used abbreviations.
b. EOR – Engineer of Record
c. AHJ – Authority Having Jurisdiction

General Design Considerations

1. Architectural Coordination:
    a. When planning for mechanical space requirements, the campus typically uses a percentage of total square footage based on the selected mechanical system; confirm strategy with UCB. Coordinate space allocation and floor to ceiling heights required for the specified mechanical systems and identify any space planning discrepancies with both UCB Mechanical Engineer and the Architect. **Facility Standard A0021** identifies additional space planning requirements that may affect mechanical spaces.
    b. Insulate all mechanical rooms for sound attenuation and to reduce heat loss to surrounding spaces. Confirm with the project architect that insulation has been included or accounted in some way.
    c. Coordinate with the project architect to provide a curbed floor area for storage of on-site water-treatment chemicals in accordance with the water-treatment consultant's recommendations. Provide a ramp in and out of curbed floor to move chemicals. If located above occupied spaces, the floor will need to be epoxy-coated and bermed along the wall to prevent flooding and spill migrating outside the designated area.
    d. All mechanical rooms located above other floors need to be epoxy coated for flood/water protection.
    e. Entire mechanical room(s) shall be waterproofed including waterproofing under the air handling units on the mechanical pads and up the wall.

2. Utilities and Meters Coordination:
    a. Refer to **Facility Standard G3001** for information pertaining to utility metering.
    b. In general, utilities and mechanical work will extend to the building wall interior. The mechanical and plumbing systems will be considered from the first valve inwards. See UCB Utility Services for details on install requirements and lines of delineation.
    c. Unless otherwise instructed all buildings will be metered for all utilities including electricity, gas, water, steam, steam condensate, and chilled water from central plant.

d. Institutional Knowledge:
   1) UCB requires meters for the metering of building usage of campus utilities, water, and gas. In addition to these utility meters, consideration should be given to the metering of separate user groups for tracking of utility usage by researchers, or to education users for LEED certification purposes. This has happened on many previous building installations. Discuss with UCB Mechanical Engineer and UCB Project Manager during project scope development.

3. Energy Conservation Standards:
   a. Refer to **Facility Standard A0020** for Energy and Sustainability requirements.
   b. For continuous-duty motors, defined as a motor that runs (or expected to run) a minimum of 6 hours a day for infrastructure.
      1) For all motors equal to or over 5 HP, provide Super Premium Efficient type.
      2) For all motors greater than 1 HP, but less than 5 HP, provide Premium Efficient type complying with Xcel Energy Rebates.
      3) For motors 1.0 HP and smaller, provide ECM type.
   c. For intermittent-duty motors
      1) For all motors over 1.0 HP, provide Premium Efficient type
      2) For motors 1.0 HP and smaller, provide ECM type

4. Design Calculation Procedures:
   a. Base calculations on methods and data from the most recent issues of the ASHRAE Handbook of Fundamentals.

Mechanical System Design Requirements

1. System Types and Design Criteria:
   a. Variable Air Volume (VAV) Systems:
      1) VAV Systems are preferred system for controllability and total LCC.
      2) Because cooling loads vary, utilize VAV air distribution systems to vary the airflow rather than falsely loading the system with reheat or mixing at the terminal units. VAV should also allow supply air temperature setback.
      3) To address comfort issues and dew point concerns, utilize heating water baseboard fin-tube radiation (BBR) in conjunction with VAV cooling to offset the transmission heat loss through the walls and glass or other exposed components. Provide perimeter radiators in spaces with large fenestration.
   b. Air Handling Units:
      1) Select VFD drive to best suit design conditions for VAV system.
      2) Utilize air-side economizer in individual air handling units. This will supplement the existing chilled water plant water side economizer.
      3) Select chilled water coils and heating water coils to provide adequate capacity for the space served by the unit.

4) For system redundancy and energy conservation, the addition of evaporative cooling systems is preferred.

c. Control Systems:
   1) UCB utilizes central Building Automation System (BAS) for central control of certain HVAC functions. Coordinate the tie-in of new HVAC systems with the BAS. Refer to Facility Standard D6010 for further requirements.
   2) Occupied-unoccupied programming of systems should be initiated to shut-off HVAC systems wherever possible. Where shut-down of systems cannot be accomplished during unoccupied hours, energy recovery systems should be considered. Each application should be examined independently to determine any special sources for obtaining recovery of usable energy. An economic analysis by the EOR will be required to determine the feasibility of energy recovery systems before the University will render a decision on their acceptability. For an energy conservation strategy, the preferred winter stat set point is 68-71 degrees and summer stat point of 72-75 degrees.

d. Institutional Knowledge:
   1) For laboratory buildings, fan coil units and radiation as supplemental cooling and heating systems are used to decouple these specific loads from centralized air handling systems. This reduces overall fan energy usage as well as provides flexibility for future accommodation of unknown loads. For non-laboratory buildings, VAV is preferred in general. System considerations should be discussed with UCB Mechanical Engineer to account for total cost of ownership not just the initial first costs.

2. <u>Design Criteria:</u>
   a. The energy plants house a central campus heating and cooling plant. The plants provides chilled water to portions of the main campus and will be used to supply air conditioning in some buildings. Confirm if the building under discussion is to be included on this system. Carry the full cost of the air conditioning system in the construction budget regardless of whether the unit is located in the building or chilled water is used from the energy plant.
   b. Design air conditioning systems to meet overall campus energy conservation goals. The use of evaporative cooling systems is preferred. Design systems that adjust to the actual space load conditions to reduce energy consumption at partial space loads rather than falsely load and waste energy.
      1) Institutional Knowledge: The use of evaporative cooling systems at UCB has been traditionally used to maximize the benefit of the local climatic conditions. Specifically, UCB resides within a dry climate where evaporative cooling is a unique approach to minimize energy consumption and provide resiliency.

c. Design all air conditioning systems to have air-economizer cycles. Design systems which have economizer cycles capable of running the cooling equipment independent of the economizer cycle controls by manually overriding the interconnected controls.
    1) Institutional Knowledge: Airside economizers are traditionally used in this climate to reduce the amount of energy consumption and maximize the benefits of our region.
d. Control interior spaces requiring cooling year-round independently from perimeter areas requiring heating during the winter and cooling during summer. Supply interior areas from a variable volume cooling system utilizing an air economizer cycle. Any exterior space that is served by a VAV is to have a reheat coil. The perimeter systems should utilize economizer cycles when cooling is required and minimum ventilation rates when heating is required.
    1) Institutional Knowledge: Perimeter heating systems are preferred, not only for the life cycle cost benefit of the systems, but also when considering the amount of energy used to power a full building heating/cooling/airside system when the building is unoccupied. Perimeter heating systems can be used to condition the building during unoccupied hours to a minimum setpoint and avoid over cycling of major systems. Building pressurization also drive the need for reheat. This should be evaluated on a project-by-project basis as this contributes to increased occupant controllability as well as addressing dew point on full height windows.
e. To take advantage of economizer cooling to the highest temperature possible, minimize return air (RA). Specify RA dampers to be of ventilation air sealing quality, AMCA Pressure/Class 2, for all units handling.
f. Match all air conditioning, heating, ventilating, and exhaust systems to the maximum required performance. The use of variable volume supply and exhaust air systems is encouraged to compensate for diversities in loads and to reduce equipment sizes.
g. Provide aspirating-type space supply air outlets to prevent “dumping” of air into occupied spaces. Displacement cooling may be considered.
h. Pre-reads of supply/exhaust airflows shall be required for any renovation of spaces where the occupancy will change or the occupancy shall increase by a substantial amount.
i. Indoor Humidity: In general, indoor relative humidity is not controlled. UCB or the Laboratory Design Consultant will provide temperature and humidity requirements for specialty areas such as computer rooms and animal areas.
j. Discuss winter design parameters with UCB Mechanical Engineer.

3. <u>Criteria for Selection of Equipment:</u>
    a. For buildings not connected to central plant utilities: Water-cooled or evaporative condensers are acceptable depending upon job requirements and necessities. Water-type cooling towers are preferred, to conserve energy, and are generally expected on systems 80 tons and larger. On units below 80 tons, an economic evaluation, including cost of maintenance, should be made to determine if the condensing unit will be air cooled or water cooled. Cooling tower fan motor loads shall not exceed 0.06 H.P./ton of chiller

capacity. Reduced condenser water temperatures and water-side economizers should be utilized when possible to reduce the chiller electrical consumption.

b. Air-cooled condensers shall be capable of operating at 105°F ambient temperature with 30°F temperature difference between air entering and leaving the condenser. Air-cooled condensers on roofs shall be capable of operating at 105°F ambient temperature.
    1) Institutional Knowledge: Air cooled condensers shall be capable of operating at 105°F due to the micro-climate that the air-cooled condenser is subject to on roofs. The campus has often experienced temperatures elevated above Boulder ASHRAE design conditions on areas of the roof where solar gain is maximized and circulation of air is impeded by buildings and roof configuration.

c. Small water-cooled DX units or research equipment which utilize tap water for condensing, after which the water is disposed of in the drain, is not acceptable. Where economically feasible, tie into a closed loop process chilled water system.

d. VFD's to have 5-year warranty. Preferred selection: ABB, Model ACH580

4. Gauges and Thermometers:
    a. During DD, confirm with UCB where stationary gauges and thermometers will be required, in addition to sensors and instrumentation to avoid unnecessary redundancy. Gauges with dual units (Standard and S.I.) are required.
    b. Stationary locations to confirm and clearly indicate on prime pieces of equipment specified in other Facility Standards include the following:
        1) PRV stations
        2) Heat exchangers
        3) Domestic water heaters
        4) HVAC pumps
        5) Chillers
        6) Condensers
        7) Boilers
        8) Air handling unit coils
    c. Refer to **Table D0000.2** for required gauges and thermometer products:

Table D0000.2

Equipment	Manufacturers	Performance Requirements	Institutional Knowledge
Stationary Pressure Gauges	Crosby; Dwyer; Trerice; U.S. Gauge; Weksler	Select for the operational range they are serving	Solar is preferred
Stationary Thermometers	Weiss; Miljoco or approved equal		

5. Temperature and Pressure Test Plugs:

a. Specify for all locations of equipment or piping where periodic temperature and/or pressure indication is required to test performance of equipment or systems including the following:
    1) Zone Loops
    2) Booster Pumps
b. Determine and specify minimum number of portable thermometers and gauges that will be required for test plugs to monitor any one set of conditions.
c. Provide plugs suitable for vacuum to 600 psig and temperatures of -20°F to 300°F with cap and extension for insulated pipe where required.
d. Refer to **Table D0000.3** for required Gauges and Thermometer products:

Table D0000.3

Equipment	Manufacturers	Performance Requirements
Temperature and Pressure Test Plugs	Fairfaz; Peterson Equipment (Petes Plug); Trerice	Pressure gauges and thermometers in individual shook-proof cases

6. Pipe Hangers, Supports, and Guides:
    a. Specify plated hangers in contact with steel, iron, cast, or ductile iron.
    b. For hot and cold-water lines, 3/4" and smaller, fiberglass insulation with 180-degree metal shield is acceptable.
    c. For piping 1 inch and larger, specify Snappitz or approved equal brand inserts at these hangers and roller support points to prevent insulation damage.
    d. Support plastic piping on continuous galvanized steel through with clevis hanger spacing as indicated for metallic piping of same diameter, or as recommended by manufacturer.
    e. Pipes that run parallel and have similar grade or pitch may be supported on trapeze hangers with spacing determined by smallest pipe.
    f. Provide details for pipe guides and anchors and show locations on drawings.
    g. Re-start hanger spacing measurements after each offset or rise.
    h. Provide support within 1-foot of control valves.
    i. Preferred Manufacturers: B-Line, Grinnell, Michigan, P.H.D., or Tolco.

7. Dielectric Pipe Fitting and Isolators:
    a. Provide brass couplings or threaded valves and copper MIPs at all connections between dissimilar metals in water systems. Brass nipples, copper FIPs, and dielectric unions or waterways are not acceptable as the campus has examples where they are not effective.
    b. Typical locations:
        1) Water heaters
        2) Storage and Pressure tanks
        3) Water conditioning equipment
        4) Changes in service piping materials

c. Institutional Knowledge: Dielectric water ways are not acceptable due to campus experience with failures of the liner separating from the nipple itself. Brass or bronze couplings or brass valves are acceptable means of dielectric separation.

8. Unions:
   a. Provide unions and isolation valves wherever major components need to be removed for repair or replacement and at branch lines. Flanges are required for 2" piping and larger.

9. Floor Sleeves:
   a. Install sleeves 2" above finished floor for all penetrations in rooms with floor drains and for all penetrations in "wet wall" surrounding the rooms: kitchens, mechanical, baths, and breakrooms.
   b. HILTI systems can be substituted as a water dam. For penthouses, waterproof flooring is required and extended up the sides of the walls.
   c. All existing floors that are core drilled in "wet walls" shall comply with above.
   d. Extend all other penetration sleeves 1/4" minimum above finished floor.

10. Access Doors:
    a. Coordinate location, installation, furnishing, and specification for both standard and fire rated access doors with the UCB Campus Architect.
    b. Locate where required for access to valves, shock absorbers and appurtenances.
    c. Refer to **Facility Standard C1010** for additional access door information.

11. Mechanical Identification:
    a. Provide an engraved plastic nameplate for all primary heating and cooling equipment, as well as all terminal devices containing motors or coils. Label all equipment receiving BAS controls or referenced in the contract documents by a tag or scheduled value.
    b. Provide laminated drawings that identify where isolation valves are located, and also provide electronic document in ".pdf" format.
    c. UCB will provide FAMIS barcodes and will be installed by contractor for valve identification and tracking as well as all equipment.
    d. Assign unit identification numbers to operating units of equipment within a class or subclass during the design phase of new buildings, additions, or remodeling of existing structures.
       1) Obtain a class and subclass list from UCB indicating codes to use for the assignment of unit identification numbers. Align identification numbers with BAS labeling.
    e. When new equipment is added to an existing structure, fit the numbering of the new equipment within the existing number scheme. Confirm numbering with UCB.
       1) Institutional Knowledge: Unit identification numbers will be assigned during design for the purposes of BAS addresses for the ease of operations and maintenance when identifying pieces of equipment after the building is occupied. Designers are required to assign these addresses during design so that they are logical and able to be programmed by the BAS Contractor during the submittal phase.
    f. Identify all piping.

1) Use an arrow marker for each pipe-content legend. The arrow shall always point away from the pipe legend and in the direction of flow. Color and height of arrow to be the same as content legend lettering.
2) If flow can be in both directions, use a double-headed arrow indication.
3) Apply pipe legend and arrow indication at every point of pipe entry or exit where line goes through wall or ceiling cut.
4) Apply pipe legend and arrow indication within 3" of each valve to show proper identification of pipe contents and direction of flow.
5) Space markers every 20' and at least once in every room.
6) Lift-Out Ceilings and Access Doors:
7) Provide Kroy, Brothers or similar type adhesive labels on ceiling tee or access door to identify concealed valves, air terminal units, fire/smoke and fire dampers, or similar concealed mechanical equipment which is directly above nameplate in ceiling space.
8) Use the following colors for specified labels:
    i. Fire-protection devices, including dampers:
        a. 3/8" red letters on white background.
    ii. Air-handling terminal devices:
        a. 3/8" black letters on white background.
    iii. Isolation, balancing, and control valves:
        a. 3/8" black letters on white background.
    iv. Isolation valves for plumbing:
        a. 3/8" blue letters on white background.
9) Install label oriented to read towards the ceiling tile that needs to be removed for access, bottom of letters indicate the access panel.

g. Controlled Equipment:
    1) Provide nameplates for magnetic starters and relays to identify connecting or controlled equipment.
    2) Manual operating switched, fused disconnect switches, and thermal over-load switches which have not been specified as furnished with indexed faceplates shall also have nameplates as to "connected" or "controlled" equipment.
    3) Clearly identify automatic controls, control panels, and starters.
h. Pumps:
    1) Identify pumps as to service.
i. Pressure Sensitive Markers:
    1) Provide Brady type 350 flexible vinyl film identification markers and tape, with legend, size, and color coding per ANSI A13.
    2) Apply pressure sensitive markers in accordance with manufacturer's recommendations with a complete wrap around. Replace any markers showing dog ears, bubbles, or other failings.
j. Semi-rigid Plastic Identification Pipe Markers:
    1) Seton Setmark pre-molded (not pressure sensitive) identification markers may be used on service piping which is accessible for maintenance operations (but not on piping in finished spaces).

2) Seaton Setmark with legend, size, and color coding per ANSI A13.1 Direction of flow arrows are to be included on each marker, unless otherwise specified.
   i. Use Setmark Type SNA markers on diameters 3/4" through 5".
   ii. Use Setmark Type STR markers on diameters 6" and larger.

k. Engraved Nameplates:
   1) Attach nameplates with brass screws.
   2) Pressure-sensitive embossed labels are not acceptable.
   3) Provide nameplates bearing the same identifying legend used on the Contract Documents.

12. Insulation:
   a. If more than one type of insulation material is available for satisfying technical requirements, perform value-based analysis to provide best value.
   b. Use full lengths with a clean and neat appearance, not cut pieces of insulation.
   c. Do not insulate cleanouts, access openings or identification plates. Neatly bevel insulation and finishes up to edge of such openings and seal edges as required.
   d. Insulate unions, flanges, valves, control devices and similar items where maintenance access is needed. Thickness to match the thickness required in ASHRAE 90.1, latest edition, based on application. Indicate removable insulation on equipment that needs to be maintained. Specify Teflon-coated, Velcro closure, removable insulation jackets for steam and condensate equipment applications including high-pressure valves, expansion joints, high-pressure strainers, condensate pumps, and regulators.
   e. Refer to **Table D0000.4** for mechanical insulation, adhesives, sealants, and vapor barriers performance requirements:

Table D0000.4

Equipment	Manufacturers	Performance Requirements
Insulation	Armacell; Certain-Teed; Knauf; NOMACO; Owens-Corning; Johns-Manville	Types: Fiberglass; Calcium Silicate; Flexible Closed-Cell
Vapor Barrier Coatings	Foster; Childers; Vimasco	Used in conjunction with reinforcing mesh to coat insulation on below ambient services temperatures. Permeance shall be no greater than 0.08 perms at 45 mils dry.
Reinforcing Mesh	Foster Mast A Fab; Childers Chil Glas #10; Vimasco Elastafab 894	Used in conjunction with coatings/mastics to reinforce. 10 x 10 polyester or fiberglass mesh.

Equipment	Manufacturers	Performance Requirements
Lagging Adhesives	Foster 30-36 Sealfas; Childers CP-50AMV1 Chil Seal; Vimasco 714	Used in conjunction with canvas or glass lagging cloth to protect equipment/piping indoors.
Weather Barrier Mastic	Foster 46-50 Weatherite; Childers CP-10 Vi Cryl; Vimasco 714	Used outdoors to protect above ambient insulation from weather.
Fiberglass Adhesive	Foster 85-60; Childers CP-127; Vimasco 795	Used to bond low density fibrous insulation to metal surfaces.
Elastomeric Insulation Adhesive	Foster 85-75; Childers CP-82; K Flex 373	Used to bond elastomeric insulation.
Elastomeric Insulation Coating	Foster 30-64; K Flex 374; Armacell WB finish	Water based coating used to protect outside of elastomeric insulation.
Metal Jacketing Sealant	Foster 95-44; Childers CP-76; Pittsburgh Corning PC 727	Used as a sealant on metal jacketing seams to prevent water entry.

13. Protection for Insulated Pipes:
    a. When insulated pipes penetrate floors which will be covered with finish flooring, specify installation of a sheet metal protective covering be installed around the insulation jacket.
    b. Sheet metal shall extend 8” above the pipe sleeve to protect the insulation from bumping by polishing machines and vacuum sweepers.
    c. Seal the space between the pipe sleeve and the sheet metal to meet applicable fire rating.

14. Vibration Isolation:
    a. Elastomeric Isolator Pads:
        1) Provide oil and water-resistant neoprene arranged in single or multiple layers, molded with non-slip pattern and galvanized steel baseplates of sufficient stiffness for uniform loading over pad area and factory cut to sizes that match requirements of supported equipment.
    b. Spring Isolators:
        1) Provide freestanding, laterally stable, open spring isolators. Regarding overload capacity, support 200% of rated load without deformation or failure. Provide factory drilled baseplates for bolted to structure and bonded to 1/4” thick, rubber isolator pad attached to baseplate underside.

c. Restrained Spring Isolators:
    1) Provide freestanding, steel, open spring isolators with seismic restraint. Provide steel housing with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4" thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
d. Elastomeric Hangers:
    1) Provide double deflection type, with molded, oil resistant rubber or neoprene isolator elements, steel housings with threaded connections for hanger rods. Color code or otherwise identify to indicate capacity range.
e. Spring Hangers with Vertical-Limit Stop:
    1) Provide combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop. Regarding overload capacity, support 200% of rated load without deformation or failure. Provide adjustable vertical stop. Provide self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.
f. Motor Bearing
    1) All bearings for motors serving fans and pumps shall be unsealed, re-greaseable type. Prefer Zerk fittings. If the motor is not accessible in AHU, provide extended fittings that extend through AHU casing.
g. Pipe Riser Resilient Support:
    1) Provide all-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2" thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig and for equal resistance in all directions.
h. Vibration Isolation Equipment Bases:
    1) Steel Base Type B: Provide factory-fabricated, welded, structural-steel bases and rails.
    2) Mount as low as possible with minimum 1" clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
i. Inertia Base Factory-fabricated, welded, structural-steel bases and rails ready for field-applied, cast-in-place concrete:
    1) Mount as low as possible with minimum 1" clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
    2) Include supports for suction and discharge elbows for pumps.
    3) Concrete thickness:
        i. Thickness of 6" of concrete for all inertia bases unless noted otherwise.
        ii. Minimum thickness of 10" of concrete for pumps greater than 75 HP.
        iii. Provide reinforced bases for large fans such that a 6" thickness of concrete may be used. Concrete thicker than 6" thick is not allowed for larger fans.

15. Documentation Requirements:

a. Refer to **Facility Standard A0010** for detailed requirements for deliverables to UCB. Additional mechanical and plumbing engineering requirements are listed below:
b. Drawings:
    1) Indicate all equipment designations, schedules, and descriptions. Follow UCB BAS naming standards and coordinate with equipment labeling spreadsheet provided by UCB for the project. List all the equipment parameters on the drawings, scheduled in table form. Single, distinct equipment may be described in non-table form. Include two columns indicating what the equipment is used for (exhaust hood, supply air) and room number where located (room 250, first floor).
    2) All drawings should include CU CP # in the project description.
c. Refer to **Facility Standard D0010** for Commissioning requirements.

16. Submittals (Contractor):
    a. Provide submittal for Resonant Speed for the rotating components, including, but not limited to, bearing lubrication and housing, supporting pedestal. Submittal to assume supporting floor and foundation are infinitely rigid.

17. Project Closeout:
    a. Contractor to provide Test and Balance Pre-Balance reports for existing systems to be reconfigured prior to demolition work on a project.
    b. Provide Testing, Adjusting and Balancing (TAB) report.
        1) TAB report shall include
            i. Supply and return/or exhaust values for the space under consideration
            ii. Outside air considerations at the time and outside air damper positions
            iii. Report is to be provided to UCB Mechanical Engineering as well as the EOR for the project.
        2) Approved balancing contractors
            i. Finn and Associates
            ii. Griffith Engineering
            iii. United TAB Services
    c. Provide reports from SMACNA leak tests of all new ductwork. Test all medium pressure ductwork on supply and exhaust and test all ductwork from AHU's to upstream of terminal control devices.
        1) Provide leak testing on Tenant Improvement type smaller projects.
    d. Submit training videos for the project with the record documents.
    e. Complete Wiring and Temperature Control Diagrams (reviewed and accepted Shop Drawings).
    f. Signed-off commissioning checklists.

18. Installation Requirements:
    a. Water Taps Within the Building:

1) Perform all taps by draining the branch piping back to the nearest isolation valve. Coordinate system shut-downs and required outages with UCB prior to work.
2) Provide an isolation valve at the new tap.

b. Anchor equipment by extending anchors through the housekeeping pad or curb into the floor.
c. Contractor qualifications:
    1) Confirm the following with UCB:
        i. Journeyman-to-apprentice ratio
        ii. Welder qualifications including welding certifications
        iii. Plumbing licenses
        iv. Steam Fitter's licenses

D0010 – Commissioning

Introduction

The overall intent of the University of Colorado-Boulder (UCB) is to follow the commissioning guidelines as set forth by the latest version of ASHRAE Guidelines 0 and 1.1. Through a coordinated effort with the subcontractors, ensure that all systems are installed complete, functioning properly, and that facility operators have appropriate system documentation and training.

UCB Requirements

1. Commissioning Process:
    a. UCB Facilities Management, specifically UCB Mechanical and Electrical Engineering, will typically serve as the Commissioning Provider (CxP) for UCB projects.
        1) In some cases, UCB may hire a third-party entity to serve as CxP or to provide portions of Commissioning services.
    b. As early as possible in a project, meet with UCB to define the systems and assemblies, commissioning process activities, team members, and quality-based sampling approach to be included in the Commissioning Process for each project.
        1) Work with UCB to create a Preliminary Commissioning Plan identifying the project-specific scope to be incorporated into the Contract Documents.
        2) The Commissioning Process activities may differ from project to project based on the project delivery method, however, elements of commissioning will be required regardless.
        3) For a minimum of 12 months, a Building Automation System (BAS) Schnyder Electric's analytics platform is required for all capital projects over $2,000,000.

D1010 – Vertical Transportation

UCB Requirements

1. Design Responsibilities:

a. For capital and elevator specific projects, an independent elevator consultant must establish the design parameters.

2. Project Requirements and Submittals:
   a. Produce written report addressing geotechnical and soil reports to UCB prior to elevator system selection.
   b. Any elevator installed must be capable of being maintained and serviced by any local licensed elevator maintenance company or qualified UCB elevator maintenance personnel without the need to purchase or lease additional diagnostic equipment, special tools, or instructions from the original equipment contractor.
   c. Provide UCB with the necessary tools, training, documentation, and access to service and maintain the elevator(s) with in-house personnel.
   d. Provide 8 hours of controller diagnostic equipment training to the designated UCB elevator maintenance personnel.
   e. Provide four sets of keys for all switches and control features. Properly tag and mark all corresponding field equipment.
   f. Provide software upgrades and/or revisions during progress of the work, warranty period and a term of 10 years from the date of substantial completion.
   g. Provide electronic copy of as-built drawings including wiring diagrams, parts catalog, and ordering instructions.
   h. Provide Written Maintenance Control Program specifically designed for the equipment included under the contract. Include any unique product specific procedures or methods required to inspect or test the equipment. Identify procedures for all routine maintenance.
   i. Program the emergency telephone within the elevator cab to call the Facilities Management Operations Control Center (303-492-5522).

3. State Registration:
   a. Register new elevators with the State of Colorado before construction of the elevator begins. Coordinate with UCB when completing registration form.
   b. Contractor must obtain and pay for installation and alteration permits from the State of Colorado (Department of Labor and Employment, Division of Oil and Public Safety, Conveyances Section).

4. Inspections:
   a. UCB will hire a third-party elevator inspector.
   b. Coordinate an acceptance inspection with the UCB Fire Systems Group (FSG) Shop Supervisor.

5. Power Back-Up:
   a. Identify the power back-up requirements for elevators that are beyond what is required by code (i.e. accessible means of egress, occupant evacuation, etc.).

6. Cab Interior Finish:
   a. Coordinate the interior finish of cab with the interior design of the facility.

7. Fire Alarm Coordination:
    a. Refer to **Campus Standard D5040** for coordination with Fire Alarm systems.

8. Fire Protection Coordination:
    a. Refer to **Campus Standard D4010** for coordination with Fire Protection systems.

9. Groundwater:
    a. Ensure no ground water will enter the elevator shaft or sump pit. Perimeter or foundation drains shall not have sumps located in elevator shafts.
    b. Hydraulic elevators with in-ground cylinders should be avoided due to concern of potential groundwater contamination.
    c. Refer to **Campus Standard B2010** for additional underground waterproofing information.

10. Wastewater:
    a. Provide an oil-minder sump pump that is plumbed to softscape based on local municipal and state wastewater requirements. Alert CU EH&S if conditions are found where discharge does not go to softscape.
    b. Floor drains are not acceptable in the elevator equipment room or immediately outside of elevator equipment room due to wastewater contamination concerns.

D2010 – Plumbing Fixtures

UCB Requirements

1. General Fixture Requirements:
    a. Provide stop valves for each plumbing fixture.
        1) Provide standard brass-stem, 1/4-turn stops with metal handle.
        2) Plastic handles are not acceptable.
    b. Provide white fixtures with an acid resistant coating.
    c. Provide rigid anchoring for all in wall rough-in to plumbing fixtures and at mid-points in wall.
    d. Provide carriers suitable for fixture for all wall hung fixtures.
        1) Provide 1/2” anchor bolts on all closet carriers; 3/8” anchor bolts are acceptable on everything else.
        2) Wood anchoring or other anchoring plates are not acceptable.
    e. Vacuum Breakers:
        1) Provide a vacuum breaker on any plumbing device which has a hose connection.
    f. Caulking and Sealant:
        1) Caulk all self-rimming sinks.
        2) Caulk wall hung water closets and urinals at the top and sides.
    g. Provide stainless steel edge protectors for all janitor sinks.
    h. Provide minimum 17-gauge for all tubular brass products and use brass slip nuts.
    i. Provide under-lavatory scald protection for ADA fixtures.
        1) Provide pre-molded insulation covers for drains and water supplies.
    j. All electrically controlled fixtures shall be hard wired.

2. Fixture Specification:
    a. Refer to **Table D2020.1** below for acceptable fixtures.
        1) Meet with the UCB prior to the commencement of the design phase to review the fixture tables and confirm fixture selection. Approved equal substitutions may be considered with UCB approval.
        2) Provide all fixtures and trim using a single manufacturer where possible.
        3) Confirm sole source stock and maintenance agreements with UCB.
    b. Coordination with UCB Housing and Dining Services (HDS):
        1) Provide Toto for vitreous china and flush valves for all housing projects. Confirm with UCB HDS.

Table D2010.1

Equipment	Preferred Manufacturers	Performance Requirements
Cast Iron and Vitreous China Fixtures	American Standard; Kohler; Toto Provide Toto for all housing projects, confirm with HDS.	
Stainless Steel Fixtures	Bradley; Elkay; Franke; Just	Type 302, 304, and 316, 18-gauge minimum
Molded Stone	Fiat, Florestone	
Terrazzo	Bradley, Fiat, Florestone	
Chair Carriers	Josam; J.R. Smith; Wade; Zurn	4-bolt
Traps, Stops (All Metal), Supplies, Air Gaps, Drains	American Standard; Brass Craft; Eljer; Kohler; Proflo	
Floor Sinks, Floor Drains, Deck Drains, Garage Drains, Trench Drains, Cleanout Fittings, Air Gap Fittings	Josam; J.R. Smith; Wade; Zurn	
Trench Drains	J-Mark Foundry; Maclear Manufacturing Co.; Neenah Foundry	Heavy duty CI grate and frame

Equipment	Preferred Manufacturers	Performance Requirements
Water Closets	Sloan; Toto; Zurn Provide Toto for all housing projects, confirm with UCB HDS.	Wall hung; Siphon jet; 1.6 GPF dual-flush for Men's Restrooms; 1.28 GPF, dual-flush for Women's Restrooms. Open-front seat, less lid; Certified by an approved agency for operation not exceeding 1.28 GPF.
Flush Valves	Sloan; Toto; Zurn	Diaphragm flush valve
Automatic Flush Valves	Sloan; Toto; Zurn	Hardwire automatic flush valves for urinals and lavatories.
Urinals	Toto Model UT105UG Provide Toto for all housing projects, confirm with UCB HDS.	Wall hung; 1/8 GPF max; Battery operated; 3/4-inch top spud; 2" outlet and wall hanger.
Lavatories		White; Cast iron; 19" round; Self-rimming counter insert. Where tempered water is used, tempered water must flow within 5 cycles of lavatory use.
Kitchen Faucets (Non-Housing)	Chicago Faucet	Single hole; Single handle; Ceramic operating cartridge.
Kitchen Faucets (Housing)		8-inch spacing; Single handle (long); Ceramic operating cartridge.
Laboratory Faucets and Cocks	Chicago Faucet Model 930-GN8BVBE7-317Xk; Zurn	Provide maximum 1.5 GPF flow rate unless special circumstances require greater flow.

Equipment	Preferred Manufacturers	Performance Requirements
Lavatory Faucets (Non-Housing)	Chicago Faucet Model 802-317XKABCP with 0.5 GPM aerator, Zurn Model AquaSpec Z81104 4" Center set	Two-handle wrist blades; 4-inch spacing; Ceramic cartridge; Aerator to limit flow to 0.5 GPM.
Lavatory Faucets (Housing)		Single handle; 4-inch spacing; Aerator to limit flow to 0.5 gpm.
Mop Sink Faucets	Chicago Faucet;	Integral checks.
Mop Service Basin		Pre-cast terrazzo, stainless-steel, drain, stainless-steel caps on all curbs. Check valves shall be installed in an accessible location at all mop sink faucets.
Garbage Disposals	In-Sink-Erator, Evolution Pro Essential; Waste King; Evolution Compact	
Water Fountains	Haws;	Provide one of each pair of water fountains with a water-filler spout in addition to a drinking spout. All single water fountains shall have both. Provide trap on outside of wall.
Electric Water Cooler	Elkay (preferred); Halsey Taylor; Haws Oasis;	Infrared sensing actuation is not acceptable. Provide one of each pair of water fountains with a water-filler spout in addition to a drinking spout. All single water fountains shall have both. Provide trap on outside of wall. Recommend units without water filter as the water quality of the potable water on campus is sufficient.
Emergency Shower and Eye/Face Wash	Desert Assembly Inc.; Haws; Sloan; Water Saver;	Meet ANSI Z358.1

Equipment	Preferred Manufacturers	Performance Requirements
Water Mixing Valve for Eye Washers and Emergency	Haws;	Meet ASSE 1071; Verify water-tight enclosure.
Water Mixing Valve	Powers (preferred); Simmons; Chicago Faucet Model 119-NF (for 1-6 fixtures)	
Coffee Bar Sinks		Stainless Steel with drainboard; Single handle faucet with gooseneck spout.
Grease Interceptors		Stainless Steel Type 316 bolts for interceptor lid access. Cast iron, steel, or brass is not acceptable.
Sand, Oil, and Gas Interceptors		As approved by UCB and in accordance to agreements with Boulder Municipality, EPA and IPC/IAPMO.
Automatic Water Softener	Culligan;	
Deionizer and Accessories	Culligan; Continental;	Stainless-steel with drainboard; Single handle faucet with gooseneck spout.
Filter Equipment and Accessories	AMF CUNO; Culligan;	
Reverse Osmosis and Accessories	Culligan; Continental;	
Pre-Rinse Spray Valves		Provide maximum 1.6 GPM for all pre-rinse spray valves; No pressure specifications are required for pre-rinse spray valves.
Shower Heads		Provide maximum 1.5 GPM @ 60-80 psi for all new showerheads.

3. Kitchen Equipment:
    a. Traps: Chrome plated cast brass 17-gauge
    b. Tailpiece: Chrome plated 17-gauge brass

c. Arms: Chrome plated 17-gauge brass
d. Escutcheons: Chrome plated, cast brass or stainless steel
e. Stops: ¼ turn, chrome plated brass with handle
f. Supplies: Chrome plated type L copper tube or braided flexible
g. Indirect Wastes: "L" copper tube
h. Waste & Vent Piping: Refer to **Facility Standard D2030**.
i. Gas: Schedule 40 A-53 black steel T&C with malleable fittings up to 1-1/2". 2" and larger, schedule 40 A-53 with butt weld steel fittings and couplers
j. Gas Connectors: When specifically required provide Thermo Tech Co. braided flexible connectors with armored shield, approved for gas, and of lengths required for fixed or movable equipment.
k. Joints: Where joints of piping systems are welded, soldered or brazed and are exposed to view or cleaning, buff joints to smooth cleanable surface in accordance with NSF.

4. Sinks and Lavatories:
   a. Provide chrome-plated 17-guage cast brass for traps, trap nuts, tailpieces, and arms.
   b. Escutcheons: Chrome plated, cast brass or stainless steel
   c. Avoid the use of mixing valves as they are maintenance intensive. Two alarms and a hard safety shutoff of the generation devices is required to meet code compliance.

D2020 – Domestic Water Distribution

Introduction

The following section provides requirements and guidelines in the design and construction of domestic water distribution systems within facilities at the University of Colorado-Boulder (UCB).

Refer to **Facility Standard G3001** for additional requirements relating to Utility Metering.

UCB Requirements

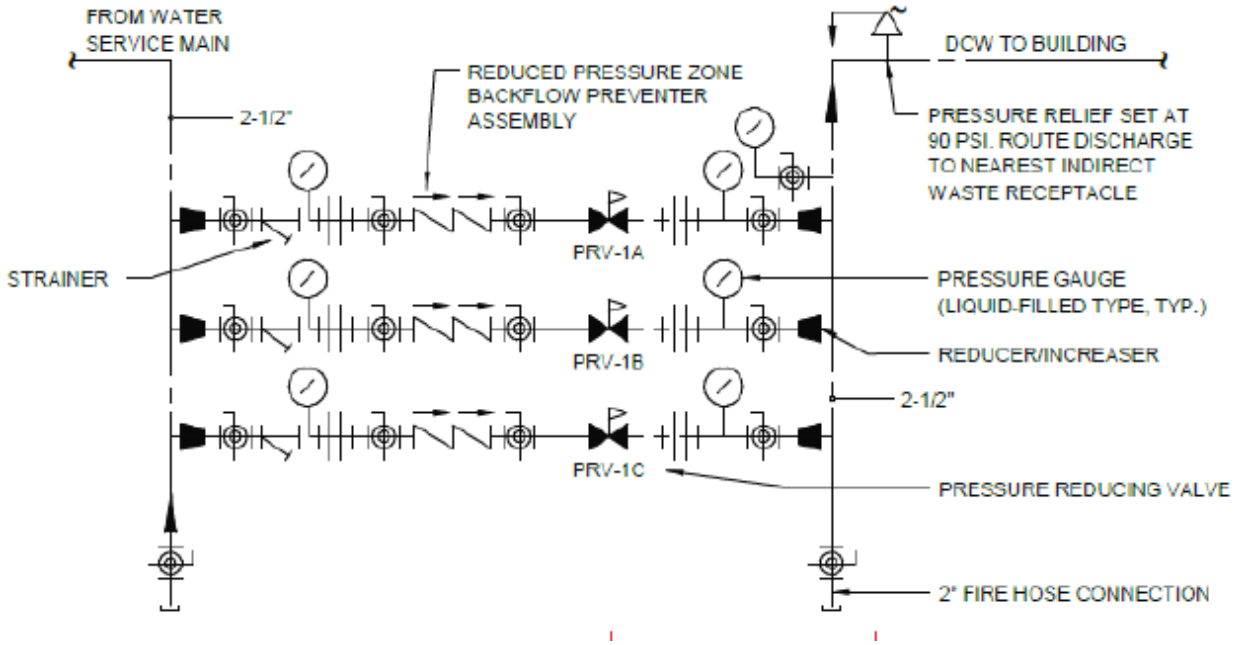
1. Testing (Provide Test Results to UCB):
   a. In addition to cleaning requirements as outlined in the International Plumbing Code (IPC), conduct a bacteriological test report from an independent contractor/laboratory for each floor of each wing. Include testing of lab water and non-potable water.
   b. In addition to testing required by the IPC, test the entire water supply system or scope of work completed and prove tightness under a water test of a minimum of 100 PSI and held for a minimum of 1 hour. Air pressure testing not permitted. Provide Method of Procedure (MOP) for review and approval by the University prior to test.
   c. Conduct a test of all backflow preventers by a certified tester prior to turnover to UCB.

2. Building Connection:
   a. Locate the point of connection from site to building within the foundation of building and provided with a flange.

b. Permanently mark any pipes penetrating the foundation wall indicating service type and direction of flow.

3. General Domestic Water Supply Requirements (from flanged building connection):
   a. Confirm with City of Boulder water supplies that the service supply pressure should be 80 PSI. Design accordingly to provide service within a building that is regulated to a maximum 70 PSI for domestic open loop systems.
      1) Institutional Knowledge: Note that street pressure in City of Boulder varies between 120-140 PSI.
   b. Select water distribution velocities for minimal noise levels while maintaining adequate flow. Provide maximum velocity of 5 ft/sec for piping greater than 1-1/4" and 15 ft/100 ft head-loss for piping 1-1/4" and smaller. During peak demand and through operation of flushometers, maintain system pressure of 30 psi minimum or fixture manufacturer's minimum requirement at the highest or furthest location of a flushometer (whichever is most stringent).
   c. Specify flange connections to valves and for PRV station at each end of the legs, to allow for component replacement. Allow for multiple PRV stations to allow for service on PRV while maintaining water supply. Refer to water entry station detail below.

Figure D2020.1



   d. Locate all branch isolation valves within 2' of main.
   e. Dead legs longer than 4' are not acceptable.
   f. Butterfly valves are not acceptable.

4. Piping Materials:
   a. Provide copper tube 'Type K' soldered to wrought copper fittings or to cast bronze tensile strength fittings.

1) All copper tubing shall be cut with a wheeled tubing cutter and reamed. This includes pre-fab.

b. For tubing less than 2", use low-liquidus/solidus solder, which does not contain lead or antimony, with shear strength equal to or greater than 10,000 PSI.
c. For tubing 2" and larger, use 15% silver solder to braze the fittings.
d. Braze mains in hallways 2" and larger; provide isolators at all clamps that allow for continuous insulation.
    1) Provide brazing or medical gas certification of brazier.
    2) All brazed water mains and hydronic piping to be purged with nitrogen.

5. Water Pressure Regulators:
    a. Average main pressure can be assumed 100 psi and to be reduced to about 70 psi.
    b. Depending on the size of the service, UCB prefers 2" valves. Maximum of 2" PRV's is preferred.
    c. Use self-contained valves with stainless steel seat ring.
    d. Provide valves with bronze bodies rated for 200 psi working pressure.
    e. Use at least three valves, such that the sum of cross-section areas of PRV's matches the cross-section area of pipe that supplies the station.
        1) Arrange in a fashion such that 1 valve is set to 70 psi, second valve set to 68 psi, and third valve set to 66 psi. Reduced pressure for 20 percent valve shall be 70 psi, one of the 40 percent valves set at 68 psi, and the other at 66 psi.
    f. Install a full size "Y" pattern epoxy-coated or brass strainer on the inlet side of the valve assembly.
        1) Multiple 2" valves make it easier to replace a bad valve and are less likely to affect the building water supply.
    g. Install pressure gauges complete with ball valves in inlet and outlet of each PRV station – 0 psi to 200 psi range.
    h. Provide 2" emergency fire-hose hook-up with hose fitting with valve between emergency connection and PRV station.
        1) This allows ability to maintain water in building if there is a break in a main.
        2) Very critical for research and labs.
        3) Fire watch required in housing if water is shut off.
    i. Provide unions for 1-1/2" and under. Provide flanges for 2" and above. Provide stainless-steel for flanges.
    j. Gauge to be house side and on service side of each reducing valve inside of each shut-off valve for each PRV.
    k. All pre-fab to be inspected prior to installation.
    l. Refer to **Table D2020.1** for product requirements:

Table D2020.1

Equipment	Manufacturers	Performance Requirements

Water Pressure Regulation Valves	Mueller; Watts; Apollo	

6. Shock Arrestors for Water Distribution:
   a. Refer to **Table D2020.2** for product requirements:

Table D2020.2

Equipment	Manufacturers	Performance Requirements
Shock Arrestors for Water Distribution	Precession Plumbing Products Co (P.P.P); Zurn; J.R. Smith; Josam; Wade; Sioux Chief	Give careful consideration to the prevention of water hammer in the design phase of water distribution systems; Mount as close to the line or quick-closing valve as possible. Mount shock arrestor directly onto the main; Provide a minimum 20" x 20" access panel centered on each shock arrestor for arrestors that would otherwise be inaccessible; Provide shock arrestors for lavatories with hands-free operation. Only one is required which is properly sized for a gang of fixtures.

7. Reduced-Pressure Backflow Preventers (RPBFP):
   a. Water entry to building Backflow for water entrance shall be located above grade to allow testing and emergency outflow to be drained to grade.
   b. Provide a 2" backflow preventer as a by-pass around new devices installed at the service entrance to buildings. Sizing is dependent on building use, and a larger size may be required. Consult with UCB for approval.
   c. Institutional Knowledge: UCB has gone to a system of multiple 2" PRV's to allow for regulation of low flow conditions and to allow for change-out of pressure regulating valves without having to shut the building down.
   d. Provide RPBFP on all connections between the domestic water system and make-up water to any non-potable system (e.g. water heating, boilers, cooling towers, chiller, solar, humidifiers, etc.).
   e. Anchor backflows in place.
   f. Provide air gap drain assembly and route all backflow preventers to drain.
   g. On the main to the building, install backflow preventers before PRV stations.
   h. Locate isolation valves on the upstream and downstream side of each backflow preventer.

1) Device valves are considered part of device and not isolation valves.

i. Provide unions for backflow preventers 1-1/2" and smaller.
j. Provide flanges for backflow preventers 2" and larger. Provide stainless-steel for flanges.
k. Locate strainer upstream of all backflow preventers.
l. Maximum mounting height is 5' above finish floor. Do not mount above ceilings.
m. Provide a flow sensor in the drain connected to the BAS.
n. For carbonated beverage dispensers:
   1) Install ASSE 1013 listed device with no copper or brass installed downstream of the device, as per the City of Boulder.
o. Materials:
   1) Bronze is preferred, stainless steel is acceptable.
   2) Cast iron is not acceptable.
p. Known Campus Issues: Cast Iron backflow preventers have failed prematurely. Stainless steel backflow preventers are expensive, recommend multiple bronze backflow preventers in parallel for redundancy, maintenance and longevity.
q. Refer to **Table D2020.3** for product requirements:

Table D2020.3

Equipment	Manufacturers	Performance Requirements
Reduced-Pressure Backflow Preventers	Watts for 2-1/2" and larger for containment within buildings; Febco for 2" and smaller	

8. Water Supply for Maintenance:
   a. Provide a service sink with hot and cold water in the main mechanical room(s) of the building and any mechanical room with water treatment areas. If a water-treatment station is located in the mechanical room, locate the sink within 3 feet, and include a combination emergency eye and body washing device.
   b. Provide a freeze-proof hydrant close to cooling towers and condensers, unless a wall hydrant is available within 20 feet of furthest point of tower.
   c. Provide an isolation valve upstream of each hose-bibb.

9. Sill Cocks:
    a. Refer to **Table D2020.4** for product requirements:

Table D2020.4

Equipment	Manufacturers	Performance Requirements
Sill Cocks	Woodford Model 67 Series, B67 series	External freeze-proof sill cock shall be installed as required by code or to meet landscaping or maintenance needs; Mounting height to be 42" above floor in equipment rooms

10. Trap Primers:
    a. Refer to **Table D2020.5** for product requirements:

Table D2020.5

Equipment	Manufacturers	Performance Requirements
Trap Primers	Sloan; Proset	When near a toilet room, provide Sloan trap primer or approved equal tied to the tail piece of the flush valve in order to prime the trap regularly. Provide this where traps in floor drains may dry out and allow sewer gas to escape into build spaces, (e.g. toilet rooms, mechanical rooms, or plenums); When not near a toilet room, provide Proset Trap Guard, SureSeal trap seal, or approved equal.

11. Stop-Valves:
    a. Standard brass-stem 1/4 turn stops with handle, (no plastic).

12. Hose Bibbs:
    a. Refer to **Table D2020.6** for product requirements:

Table D2020.6

Equipment	Manufacturers	Performance Requirements
Hose Bibbs	Chicago Faucet (finished rooms); Woodford (unfinished and equipment rooms)	

13. Spill Resistant Vacuum Breakers:
    a. Refer to **Table D2020.7** for product requirements:

Table D2020.7

Equipment	Manufacturers	Performance Requirements
Spill Resistant Vacuum Breakers	Breaker Watts 008 QT, Watts 008 QTS	For evaporative coolers, cooling towers, and fume hood clusters

D2030 – Sanitary Waste

UCB Requirements

1. General Sanitary Waste Requirements:
    a. Design sanitary waste systems to allow for future addition of laterals to accommodate 20% expansion of system capacity.
    b. Air admittance valves are not allowed, as they can cause indoor air quality issues and require routine maintenance.
    c. Crosses in lieu of double-wye drainage fittings for common drain between lavatories are prohibited. Staggered tees are preferred. If this is not possible, double-wye drains should be specified with each fixture drain vented and a clean-out above the double-wye, above lavatory height.
    d. The use of sewage ejectors is strongly discouraged. However, if needed, specify duplex submersible ejector pumps with a sonic float sensor. Sewage ejectors need a gas-tight lid, and deeper than 5 feet, need stainless steel rail system. Sewage ejectors should be alarm contacted to BAS.
    e. Provide an individual vent for each plumbing fixture.
    f. A floor sink is required in every water entry room for testing RPBFP.

2. Piping Materials:
    a. Buried Pipe: Centrifugally-cast iron soil pipe with cast iron drainage fittings. Joint materials and systems may be bell and spigot with neoprene gaskets and lubricant (preferred), or University-approved no-hub with stainless steel bands, and underground sewer piping shall have “super-duty” no-hub couplings.
    b. Suspended pipe: Systems exceeding band ratings shall be substituted with Schedule 40 galvanized threaded steel pipe or galvanizes Victaulic pipe. Service weight (SV) cast iron pipe “No Hub System” using hub-less cast-iron soil pipe couplings certified to withstand a minimum of 12 psig internal pressure.
    c. PVC Solid Core Schedule 40 piping shall only be used for below grade/slab, gravity flow applications within buildings.
        1) When penetrating a building foundation, use a carbon steel sleeve sized for 1.5 times the pipe diameter and sealed with Link-Seal or approved equal.
    d. DWV copper pipe in not acceptable. Use type ‘L’ copper instead.

3. Testing:
    a. Test sanitary sewer and vents. Perform the required test in accordance with the most current IPC Drainage and Vent Water test.

D2040 – Rain Water Drainage

Introduction

The following section provides requirements and guidelines in the design and construction of rain water drainage systems at the University of Colorado-Boulder (UCB).

Coordinate roof drain design of sloped roof and copper gutters with **Facility Standard B2020**.

UCB Requirements

1. General Rain Water Drainage Design:
    a. Provide Test-Tee connections for all roof drains connected to storm sewers.
        1) Locate at the base of the exterior wall of the building or in the ground immediately outside the building.
    b. Install roof drains with roof sump receiver with under deck clamps or approved equal.
    c. Provide cast iron strainers/domes.
    d. Secure roof drain pans to the structure.
    e. The point of connection is normally inside foundation of the building.
    f. Route exterior copper gutters and downspouts to internal downspouts as identified in **Facility Standard B2020**.
    g. To prevent ice buildup, provide heat trace in the following locations:
        1) All gutters and exterior downspouts.
        2) Storm drains located in unconditioned soffits.
    h. To prevent condensation on the piping, insulate storm drain piping for a minimum of 10’ to the inside of the building from building/site connection.

2. Interior Storm Drain - Piping Materials:

a. Buried Pipe:
    1) Provide centrifugally-cast iron soil pipe with cast iron drainage fittings.
    2) Joint materials and systems may be bell and spigot with neoprene gaskets and lubricant (preferred), or UCB-approved no-hub with stainless steel bands.
    3) Provide "super-duty" no-hub couplings for underground sewer piping.
b. Suspended pipe:
    1) Systems exceeding band ratings shall be substituted with Schedule 40 galvanized threaded steel pipe or galvanized Victaulic pipe. Provide service weight (SV) cast iron pipe "No-Hub System" using hub-less cast-iron soil pipe couplings certified to withstand a minimum of 12 psi internal pressure.
c. Provide No-Hub couplings such as Husky series 4000 or equivalent, for all roof drains.
    1) Transition from No-Hub to mechanical grooved fittings to be machined at shop.
d. Provide Type 'L' copper. DWV copper pipe is not acceptable.
e. PVC and ABS piping is not acceptable for any application within buildings, unless approved by UCB.

3. Downspouts:
    a. Provide 4" minimum downspout.
    b. Terminate with downspout nozzle.
    c. Coordinate required location of splash blocks under every downspout. Refer to **Facility Standard G2030** for additional requirements when draining to grade.

4. Cleanouts:
    a. Select cleanout locations and access for minimum disturbance of occupant functions and building systems operation during cleanout servicing. Coordinate locations with the project architect and obtain approval from UCB Campus Architect for location and appearance.
    b. When applicable, provide cleanouts on gutter downspouts in penthouse.

5. Testing:
    a. Test roof drains with water from discharge of the building up to the nearest roof drain. If there are no roof drains higher than the nearest drain, the section from between these drains shall be tested separately.

D3010 – Heat Generating Systems

Introduction
The following section provides requirements and guidelines in the design and construction of heat generating systems at the University of Colorado-Boulder (UCB).

This section will be expanded to include central steam plant boilers when an expansion or rehabilitation of the existing central plant is required.

Boilers included in this section are intended for facilities which are constructed outside the practical limits of the campus central steam distribution system and have access to natural gas from utility distribution system. Confirm direction with UCB prior to commencement of design.

Consult with UCB regarding existing systems not listed in this section that require modification for a project.

Heat generating systems should be suitable for use with 40% propylene glycol and water heating fluid.

UCB Requirements

1. Boilers:
    a. Condensing boilers are preferred by UCB for new construction. Condensing boilers can be used in combination with non-condensing boilers to provide adequate set back operation in shoulder months.
        1) Other boilers are listed as a reference; confirm with UCB for use of other boilers.
    b. Projects in existing buildings shall have an engineered solution that meeting code and existing conditions.
    c. Design simple hot water hydronics systems to meet building heating requirements.
    d. Consult with UCB regarding insurance requirements for gas train.
    e. Whenever possible, specify the positive-pressure requirements at the collar of forced-draft boilers.
    f. High pressure steam shall not run through occupied spaces because of insurance carrier requirements.
    g. Institutional Knowledge: Condensing boiler ratings, acceptable manufacturers and construction should be consistently evaluated as manufacturers continually adjust technologies and construction materials. Compare these factors against the desired size of boilers which are often a limitation of equipment manufacturers.
    h. Refer to **Table D3010.1** for Boiler Performance Requirements:

Table D3010.1

Equipment	Preferred Manufacturers	Performance Requirements
Condensing Boilers, Hot Water, High Efficiency, Forced Draft	Aerco International; Buderus; Harsco Industrial/Patterson-Kelley; Lochinvar; Weil-McLain	160 psi working pressure; The condensing section of the exhaust manifold shall be corrosion resistant non-ferrous construction; Burner operation to be modulating firing; Boiler to have 10-year warranty from damage to thermal shock.

Equipment	Preferred Manufacturers	Performance Requirements
Inclined Water Tube, Hot Water, Forced Draft	Ace Heaters; A.O. Smith; Carlson; ITT Bell and Gossett	Minimum 80% efficiency; 125 psi working pressure; modulating burner; 20-year warranty. Note: standard warranty for boiler heat exchanger is 10 years, design team to verify manufactures will provide 20-year warranty including thermal shock.
Boiler (Flexible Tube), Hot Water, Forced Draft	Bryan; Superior Combustion; or Pre-Approved Equal	125 psi working pressure; high-low fire or modulating (above 80hp); 20-year warranty including thermal shock; subtle for 50% glycol water heating fluid
Boiler (Cast Iron), Hot Water, Forced Draft	Buderus; Burnham; H.B. Smith; Peerless; Weil-McLain	Section Cast Iron; 30 psi working pressure; 40 psi may be considered if larger expansion tank is provided and complete calculations confirming expansion tank are submitted; modulating burner; 20-year warranty. Note: standard warranty for boiler heat exchanger is 10 years, verify manufactures will provide 20-year warranty including thermal shock.
High-Efficiency Compact Boiler, Hot Water, Forced Draft	Lochinvar Copper-Fin II; Patterson-Kelley	Radial fired; vertical boiler; non-condensing; minimum 85% efficiency; 160 psi working pressure; 10-year warranty including thermal shock.
Boiler (Scotch Marine 3-Pass), Low or High-Pressure Steam	Burnham; Superior	Non-Condensing 80% efficient; Low Pressure at 15# SWP; High Pressure 150# SWP; Modulating burner; 10-year warranty including thermal shock.
Condensing Boiler, Hot Water; Forced Draft	Aerco; Buderus; Lochinvar; Patterson-Kelley; Weil-McLain	160 psi working pressure; Condensing section and exhaust manifold shall be corrosion resistant non-ferrous; modulating burner; 10-year warranty including thermal shock.

2. Breechings, Chimneys, Stacks and Flues:
    a. Refer to **Table D3010.2** for Breechings, Chimneys, Stacks and Flues Performance Requirements:

Table D3010.2

Equipment	Preferred Manufacturers	Performance Requirements
Type B Flue Vents	Ameri-Vent; Dura-Vent; Metal Fab; Metlvent; Selkirk	Double wall gas vents, UL-Listed for Type B
Positive Pressure Chimney and Manifold	Ampco; Metal Fab; Selkirk; Van-Packer	Double wall; UL-Listed for use with building heating equipment burning gas, solid, or liquid fuels as described in NFPA (304 Stainless Steel liner for gas and No. 2 oil)
All Fuel Chimney	Ampco; Dura-Vent; Metlvent; Selkirk; Metal Fab; Van-Packer	Stainless steel double-walled, pre-insulated chimney sections, fittings, and accessories

3. Fuel-Fired Heaters:
    a. Refer to **Table D3010.3** for Fuel-Fired Heaters Performance Requirements:

Table D3010.3

Equipment	Preferred Manufacturers	Performance Requirements
Gas-Fired Unit Heaters	Hastings; ITT Reznor; Lennox; Modine; Trane; Carrier	Requirement for gas fired equipment is limited to structures which are constructed outside the practical limits of the campus central steam distribution system and have access to natural gas from the utility distribution.
Gas-Fired Furnaces	Command Air; Day and Night; Fedders; Lennox; Trane; York; Carrier	Requirement for gas fired equipment is limited to structures which are constructed outside the practical limits of the campus central steam distribution system and have access to natural gas from the utility distribution. Indirect gas fired appliances are preferred.

4. Heating Terminal Units:
    a. Baseboard radiation is preferred for heating the exterior wall of all perimeter rooms. Use radiant ceiling panels only as a last choice.
    b. Use convectors where architectural features cause greater capacity requirements than baseboard radiation can provide in the available space.
    c. Select cabinet unit heaters and unit heaters on low speed capacity of three speeds to provide quiet operation under normal conditions and have extra capacity at higher speeds for extreme conditions. Specify a fan-speed switch.
    d. All fin style heating elements shall be copper tubes with aluminum fins.
    e. Refer to **Table D3010.4** for Heating Terminal Unit Performance Requirements:

Table D3010.4

Equipment	Preferred Manufacturers	Performance Requirements
Fin-Tube Radiation	Dunham-Busch; Rittling; Rosemex; Sterling; Trane; Vulcan; Runtal	Prefer fin tube with sloped enclosure and avoid panel radiators. All fin style heating elements shall be copper tubes with aluminum fins. Baseboard radiation for heating exterior wall of all perimeter rooms. Pressure rating of fin tube should be at least 100 psi. For Runtal, specify high pressure rating for their radiators.
Convectors	Dunham-Busch; Rittling; Rosemex; Sterling; Trane; Vulcan	Use convectors where architectural features cause greater capacity requirements than baseboard radiation can provide in the available space.
Cabinet Unit Heaters	Airtherm; McQuay; Modine; Rittling; Rosemex; Sterling; Trane; Vulcan	Use cabinet unit heaters at building entrances where greater capacity and quick response is necessary to adequately handle rapid changes in space temperature. Floor level, wall mounted CUH recommended to help prevent stratification issues.
Unit Heaters - Hot Water	Airtherm; McQuay; Modine; Rittling; Rosemex; Sterling; Trane; Vulcan	Select cabinet unit heaters and unit heaters on low speed capacity of three speeds to provide quiet operation under normal conditions and have extra capacity at higher speeds for extreme conditions.

Equipment	Preferred Manufacturers	Performance Requirements
Hydronic Panel Radiators	Rittling; Runtal; or Pre-Approved Equal	Minimum pressure rating of 100 psi. For Runtal, specify high pressure rating for their radiators.

5. Electric Heat:
    a. Electric heat is not acceptable unless otherwise approved by UCB.

Known Campus Issues

1. Combustion Air Intake Location:
    a. For direct vent boilers, coordinate orientation of combustion air intake louver with prevailing wind.
    b. Please ensure boilers are sized appropriately to avoid short-cycling. Provide load calculations to CU Boulder upon request.

2. Copper Tube Boilers:
    a. UCB has had several copper-tube boilers fail prematurely.
    b. UCB has also had issues with boilers short-cycling because they are oversized or connected to frequent load (indirect water heater).
    c. Many building heating systems are oversized leading to control issues. Consultants should avoid excessive safety factors.
    d. Provide minimum of 2 boilers for redundancy.

Appendix

1. **Appendix D3020.1** – Steam Diagrams and Details

D3020 – Cooling Generating Systems

UCB Requirements

1. Refrigeration:
    a. CFC and HCFC which are currently banned or scheduled to be banned should not be used in equipment. Such refrigerants include R-11, R-12, R-22, R123 and R134a. Review refrigerant selection with UCB to confirm compliance.
    b. Provide isolation valves in order to allow servicing of major components (e.g., compressor, receiver, condenser, filter-dryer, expansion valve) with no loss of refrigerant; the filter-dryer shall have a 3-valve arrangement with bypass.
    c. Review with UCB if there is a need to include gauges. Equipment-mounted gauges are not acceptable. Provide service points for diagnosis and service.
    d. Notify UCB prior to commencing demolition work of any equipment containing refrigeration. UCB personnel may remove refrigerant from equipment or specifically direct

contractor to remove refrigerant. Remove, recover, and reclaim all refrigerant prior to demolition of any equipment containing refrigerant. Return refrigerant and refrigerator to the UCB.

e. Refrigeration Test Procedures
    1) Pressure test to 1.5 times working pressure up to 600 psi test pressure (or maximum pressure rating of equipment) for 24-hours
    2) Include pressure and vacuum pressures
    3) Vacuum to 250 microns and hold for 24-hours
    4) All tests must be called in as an inspection and witnessed by CU Boulder Inspector
f. Comply with all applicable Colorado Department of Health and EPA rules and regulations regarding the purchase, disposal, and handling of refrigerants.
    1) All handling of refrigerant will be by certified refrigeration technicians as required by EPA.

2. Manufactured Water Chillers:
    a. Description:
        1) Factory-assembled and tested chiller complete with compressor, compressor motor, compressor motor controller, lubrication system, evaporator, condenser, controls, interconnected unit piping and wiring.
        2) Do not disassemble chiller for installation without prior written approval from UCB.
        3) Provide hard-drawn, brazed ACR refrigeration piping. Soft Copper is not allowed in any instance.
    b. Compressors:
        1) Drive: Open or hermetic design using an electric motor as the driver.
            i. Seal drive assembly to prevent refrigerant leak.
        2) Specify purge units to eliminate the non-condensable gases on units using low pressure refrigerants where evaporator pressure is below atmospheric pressure.
        3) Specify a receiver on the condenser and provisions for pumping the full refrigerant charge into the receiver. If condenser will hold the full charge, this is an acceptable alternative.
        4) Compressors of 100-ton capacity and above:
            i. Open or semi-hermetic, centrifugal, or rotary-screw.
        5) Compressors under 100-ton capacity:
            i. Hermetic or semi-hermetic, scroll, or rotary-screw.
        6) Evaporator:
            i. Provide shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from condenser.
            ii. Design to prevent liquid refrigerant carryover from entering compressor.
    c. Air-Cooled Condenser (for Air-Cooled, Packaged, Chiller only):
        1) Plate-fin coil with integral sub-cooling on each circuit.
        2) Direct-drive propeller fans for vertical air discharge.
        3) Provide low ambient control package to allow start-up and positive head pressure control. Head pressure control to be approved by UCB. A simple fan cycling switch may not be adequate.
        4) Provide hail guards on all outdoor condensers.

d. Warranty:
   1) All chillers should have 5-year minimum warranty covering parts, labor, refrigerant and compressor.
   2) Extended 10-year parts and labor warranty on compressor(s) in packaged chillers.
   3) Institutional Knowledge:
      i. UCB prefers extended warranties on both chiller and compressor equipment due to experience with warranty and startup issues; specifically, the pieces of equipment operating as specified after normal warranty period. These extended UCB warranty periods are beneficial to the owner.

e. Refer to **Table D3020.1** for Manufactured Water Chiller Requirements:

Table D3020.1

Equipment	Manufacturers	Performance Requirements
Air-Cooled, Packaged, Water Chiller	Carrier; Daikin; Trane; York	
Reciprocating Water Chiller		Not permitted.
Centrifugal Water Chiller	Carrier; Daikin; Trane; York	Variable speed preferred.
Rotary-Screw Water Chiller	Carrier; Daikin; Trane; York	Variable speed preferred.

3. <u>Cooling Towers:</u>
   a. Specify the following for induced-draft towers:
      1) Single point of connection for main electrical power supply.
      2) Provide manufacturer's level control package.
      3) Basin heater.
      4) Stainless Steel construction preferred. Confirm with UCB.
      5) A propeller type fan, on which blade pitch can be adjusted.
      6) A gear reducer drive for anything beyond 10 horsepower.
      7) Motors situated outside the tower's humid airstream.
      8) Fill manufactured of fire-retardant PVC material (minimum 15 mil. thickness).
      9) Hot return water basin covers.
      10) Oversized sump outlet for gravity flow to inside remote sump.
      11) Stainless-steel hardware and brass or stainless-steel fittings within wet area.
   b. Specify, in addition, for forced-draft towers:
      1) "Baltibond" (Baltimore Air Coil Trademark) or equivalent coating.
      2) Stainless-steel sump with blow-through prevention kit.

3) If installed indoors, provide stainless steel tower throughout, with relief dampers made of stainless steel with stainless steel "knuckles."

c. Remote Sump Tank (for existing retrofit applications only):
   1) For multiple tower configurations, the basin for each tower should have the ability to be isolated from each other.
   2) Allow minimum water level of 4 feet of suction head under operating conditions or greater if required to meet NPSH of pump.
   3) Provide a minimum of 150 percent of drain down storage capacity in addition to above operating level.
   4) Drain down capacity to consist of volume of cooling tower water retention plus all piping exposed to freeze conditions.
   5) Design provisions to use Sonoxide as water treatment with coordination with the vendor. Recommend basket strainers, piped in parallel, individually isolated and each sized for full flow for maintenance. UCB preferred method.
   6) Design vortex breaker and screen at suction outlet.
   7) Provide maximum separation between sump intake and suction outlet to minimize entrained air entering pump suction.
   8) Design overflow drain capacity equal to system drain down flow rate.
   9) Provide for maintenance drain down.
   10) Provide hydrostatic pressure sensor for stable level control for high and low water alarms.
   11) Provide taps on tank for sump filtration cleaning system.
   12) If tower drain pipe to sump exceeds one floor level, provide balancing valve at sump inlet to provide steady flow to minimize pipe vibration, sound, and air entrainment in water flow.
   13) Include inspection ladder on tank to monitor water conditions.
   14) Provide adequate ventilation in sump room to control humidity.

d. Cooling Tower Sump Filtration System:
   1) To improve and maintain good water conditions in condenser water, provide a pumped system to recirculate water from sump through a filter and back to sump.
   2) Sidestream filters are preferred with continuous purge with solids retention vessel. Include Sonoxide water treatment for bio-growth prevention.
   3) Institutional Knowledge: Side stream and Sonoxide water treatment systems are preferred based on campus experience with multiple types of condenser water filtration and treatment systems.
   4) Include use of distribution piping to sweep floor of tower sump towards the outlet.

e. Water meter required for cooling towers per campus metering requirements.

f. Refer to **Table D3020.2** for Cooling Tower Requirements:

Table D3020.2

Equipment	Manufacturers	Performance Requirements

Cooling Tower (Induced Draft, Vertical Discharge)	Tower-Tech; Baltimore Aircoil; Marley; CCT	Capacity rating in accordance with CTI Standards. Include altitude effects.

4. DX Packaged Units and Split-DX Units:
    a. DX Packaged Units and Split DX Units are only to be specified with approved variance request.
    b. For units requiring operation below 0°F, provide low ambient control package to allow start-up and positive head pressure control to -30°F.
    c. Compressors:
        1) Specify purge units to eliminate the non-condensable gases on units using low pressure refrigerants where evaporator pressure is below atmospheric pressure.
        2) Specify a receiver on the condenser and provisions for pumping the full refrigerant charge into the receiver. If condenser will hold the full charge, this is an acceptable alternative.
        3) Extended 5-year parts and labor warranty on compressor(s).
        4) Compressors of 100 to 500 ton capacity:
            i. Open or semi-hermetic, scroll or rotary-screw with sound attenuation.
        5) Compressors under 100 ton capacity and below:
            i. Hermetic or semi-hermetic scroll, or rotary-screw.
    d. Condensers:
        1) Select air cooled condensers with sufficient capacity to compensate for altitude deration of 5,400 feet and 105°F inlet air temperature.
        2) A horizontal blow with a weather protecting shroud designed to prevent possible blade icing and unbalance during cold weather is required.
        3) Arrange water-cooled condensers so that tubes can be rodded without hindrance from walls, piping, or equipment.
        4) Hail guards on all outdoor condensers.
    e. Refer to **Table D3020.3** for DX Packaged Unit and Split-DX Unit Requirements:

Table D3020.3

Equipment	Preferred Manufacturers	Performance Requirements
Water-Cooled Condensers	Daikin; Refrigeration Services; Trane; York; Carrier	
Air-Cooled Condensers	Daikin; Trane; York; Carrier	In units with multiple fans, isolate each fan section.

5. Computer Room Air Conditioning (CRAC):
    a. Provide self-contained factory assembled units with matching accessories.
    b. UCB prefers free cooling from an economizer for the CRAC units. Economizer can be utilized with the different heat rejection types listed below.
    c. Depending on location and user condition, use any of the following types of heat rejection:
        1) Directly to central chilled water system. Confirm with UCB that chilled water can be provided to project location year-round.
        2) DX with air-cooled condenser.
        3) DX with water-cooled condenser.
        4) DX with glycol-cooled condenser.
    d. Specify easily removable panels on all units for maintenance access to equipment. Provide compressor serviceable out of airstream.
    e. Specify solid-state electronic control systems, easily accessible with plug-in modules, out of main electrical panel.
    f. Condensate Pumps:
        1) Provide as an accessory inside cabinets for up-flow condensate drain systems.
        2) Wire condensate pump to unit so that pump failure will switch off the unit and send alarm to BAS.
    g. Isolate air conditioning units from raised floors with adjustable floor stands mounted on vibration isolation pads.
    h. Air Cooled Condensers:
        1) Provide low profile, slow speed, multiple, direct drive propeller fan type.
        2) Specify low ambient control package to allow start-up and positive head pressure control with ambient temperature as low as -30°F.
        3) Outdoor design temperature: 105°F if on roof.
    i. Water Cooled Condensers:
        1) Provide cleanable, shell and tube, counter-flow type with removable heads.
    j. Glycol Systems:
        1) Verify glycol type with existing systems which may require the system be cleaned and flushed for the correct type and percentage of propylene glycol.
        2) If system is ethylene glycol, please provide sizing of system to determine if it may be converted to propylene glycol. Review with CU Mechanical Engineering
        3) Propylene glycol is preferred.
        4) Provide glycol-cooled condenser cleanable, shell and tube, counter-flow type with removable heads.
        5) Specify dry-cooler, low-profile, slow-speed, multiple direct drive propeller fan type.
        6) Provide dual pump package with automatic start on stand-by pump upon failure of lead pump.
        7) Consider glycol “free cooling” economizer coil and all controls necessary to provide winter cooling without compressor operation.
        8) Outdoor design temperature: 105°F if on roof.
    k. Controls:
        1) During preliminary design meetings, confirm with UCB which controls are required.
    l. Server Room Configuration:
        1) Configure all server rooms and data centers in a hot aisle/cold aisle arrangement.

m. Ceiling Recessed Units:
    1) Do not use ceiling recessed units unless otherwise approved by UCB.
    2) If used, provide factory assembled, completely packaged for horizontal ceiling mounting and sized to fit a 2'x4' opening of a standard "T-Bar" ceiling.
    3) Provide air cooled types that have the condenser air (outside air) taken from and discharged to the outside by means of a remote blower pack suitable for duct mounting and having a low limit outside ambient control to operate the unit down to 0°F.
    4) Use of ceiling cavity to reject heat of compression is unacceptable.
n. Compressors:
    1) Provide semi-hermetic for 5-ton units and up.
o. Water-Dumping Units:
    1) Water-cooled types which utilize tap water for condensing, after which the water is disposed of in the drain, is not acceptable.
p. Refer to **Table D3020.4** for Computer Room Air Conditioning Unit Requirements:

Table D3020.4

Equipment	Manufacturers	Performance Requirements
Computer Room Air Conditioning Units	APC; Data-Aire; Carrier; Liebert; Stulz; Trane	

Known Campus Issues

1. Cooling Tower Multiple Tower Basin Isolation:
    a. At UCB Facility C4C the two towers share a basin that was not able to be isolated from each other, thus making shutdown impossible and cleaning and other maintenance very challenging.

2. Chiller Minimum Flow:
    a. UCB has had several problems with variable flow chilled water systems due to control of minimum flow through chillers. Confirm control sequence accounts for minimum flow required by chiller manufacturer.

D3025 – Air Filters, Air Inlets, and Ductwork

UCB Requirements

1. Air Filters:
    a. Filter all air supplied by a forced air type unit or system.
    b. Single filter installation or a pre-filter-intermediate filter combination shall be upstream from the coils and blow-through fans, as well as exhaust energy-recovery units.

c. Provide after-filter, where required, on the discharge side of the fan and downstream from all coils.
d. Identify adequate clearances for cleaning or changing filters.
e. Preferred method where space allows: a pre-filter, MERV 8, and primary filter, MERV 13.
f. Where space allows for only one filter, provide a MERV 13 filter.
g. Media shall be supported to minimize flexing during start-stop fan cycles.
h. Include pre-filters during the construction phase and may be considered for permanent installation where necessary.
i. No differential pressure sensors to measure static pressure drop across the filters. With variable speed fans and varying CFM from units, this form of measurement across filters has become inaccurate and design teams should use differential pressure gauges instead.
j. Specify built-up filter frames to accommodate the replacement media of not less than three filter manufacturers.
k. Design air filtration systems for clean rooms and special clean areas for ease of filter maintenance and minimum interruption of operation.
l. Specify extended surface high efficiency media filters where the filtering of biological organisms is required.
m. Specify HEPA filters where very high efficiency filtering is required.
n. Consider activated carbon filters where odor control is required, or other odor-control systems such as Cosatron (TM).
o. Specify “Extra Stock” to ensure a clean set of filter media is available at project completion.
p. Use the initial set of filter media for testing and trial use and may not necessarily be replaced at project completion.
q. Disposable Panel Pre-Filters:
    1) Media: 2” minimum (4” preferred) fiber blanket, factory sprayed with flameproof, non-drip, non-volatile adhesive, nominal size 24”x24”.
    2) Rating: 500 FPM face velocity, 0.15” WG initial resistance, 0.50” WG recommended final resistance
    3) Casing: Cardboard frame with perforated metal retainer
    4) Holding Frames: 20-gauge minimum galvanized steel frame with expanded metal grid on outlet side and steel rod grid on inlet side, hinged with pull and retaining handles.
    5) Preferred Manufacturers: American Air Filter; Farr; Flanders
r. Extended Surface Retained Media Filters:
    1) Media: Pleated, non-woven cotton fabric, scrim reinforced; supported by welded steel retainer; in 16-gage steel holding frame with corrosion resistant coating; Nominal size 24”x24”x12” deep.
    2) Rating: MERV 13
    3) Preferred Manufacturers: American Air Filter; Farr; ULOK Fiberbond
s. Extended-Surface High Efficiency Media Filters:
    1) Media: Pleated, water-resistant glass fiber with aluminum or kraft separators; in 16-gage steel holding frame with corrosion resistant coating, nominal size 24”x24”x12” deep
    2) Rating: ASHRAE 52: 95 percent dust spot efficiency
    3) Preferred Manufacturers: American Air Filter; Farr; ULOK Fiberbond

t. High Efficiency Particulate Air (HEPA) Filters:
   1) Media: Pleated, water-resistant glass fiber with aluminum separators; ANSI/UL 586; in 16-gage zinc coated steel holding frame; nominal size 24”x24”x12” deep
   2) Rating: 0.3 micron dioctyl phthalate smoke (DOP) to 99.97% efficiency, in accordance with MIL-STD-282 thermal (DOP) penetration test method; 250 FPM face velocity, 1” WG initial resistance, 3” WG recommended final resistance.
   3) Preferred Manufacturers: American Air Filter; Farr; Flanders; Weber

u. Activated Carbon Filters:
   1) Assembly: Galvanized steel unit incorporating extruded aluminum tracks to accommodate filter servicing trays in deep V arrangement arranged for upstream downstream side servicing with disposable panel pre-filter.
   2) Media: Activated carbon density 34 lb/cu. ft. pelletized or granular to 6 by 10 Tyler mesh screen; minimum carbon tetrachloride activity of 60 percent; in thin bed trays, nominal size 24”x24”x12” thick; 9 lbs. of carbon per 2,000 CFM air flow capacity
   3) Rating: 500 FPM face velocity, 0.45 inch WG initial resistance
   4) Preferred Manufacturers: American Air Filter; Continental Carbon Group; Farr

v. Filter Frames:
   1) Fabricate filter frames and supporting structures of 16-gage galvanized steel or extruded aluminum T-section construction with necessary gasketing between frames and walls. Provide welded corners of frames.
   2) Standard Sizes: Provide for interchangeability of filter media of other manufacturers; for panel filters, size for 24”x24” filter media, minimum 2” thick; for extended surface and high efficiency particulate air filters, provide for upstream mounting of panel filters.
   3) Side Servicing Housings: Flanged for insertion into ductwork, or reinforced 16-gauge galvanized steel; access doors with continuous gasketing and positive locking devices on both sides; extruded aluminum tracks or channels for primary filters with positive sealing gaskets.

w. Filter Gauges
   1) Direct Reading Dial: 4-3/4” OD diaphragm actuated dial in metal case, vent valves, black figures on white background, front recalibration adjustment, appropriate ranges of 0.05, 0-1.0, 0-2.0, 0-3.0 or 0-4.0 inch WG, 2 percent of full scale accuracy; Magnehelic Series 2000 manufactured by Dwyer
   2) Accessories: Static pressure tips with integral compression fittings, 1/4” aluminum, stainless steel or copper tubing, 2-way or 3-way vent valves.
   3) Inclined manometers are not acceptable
   4) Preferred Manufacturers: Dwyer

2. <u>Ductwork and Accessories</u>
   a. Ductwork:
      1) Fibrous glass ductwork is not acceptable, except for air-transfer ducts above ceilings not routed through walls, and sound-attenuation elbows.
      2) With larger duct systems, sheet metal cost savings can be realized if the designer specifies different duct pressure classes for the portions of the system that do not

experience as much static pressure due to being farther away from the fan. (Do not specify just one duct pressure class for the entire system if it is a large system with static pressures that are significantly less in parts of the system than the pressures seen close to the fan. But for personnel and equipment protection, design should allow for abnormal or emergency pressure changes as noted in the item above.) Using the SMACNA symbol for "Point of Change in Duct Construction (by the Static Pressure Class)," the designer should indicate on drawings the points in the ductwork system where duct construction should change because of change in duct pressure class.

b. Manufactured Duct Joints:
    1) Preferred Manufacturers: Ductmate Industries, Inc; or pre-approved equal
    2) Transverse duct joints may be made with the Ductmate System, or pre-approved equal, components of standard catalog manufacture
c. Un-Insulated Triple Lock Aluminum Round Ductwork:
    1) Preferred Manufacturers: Flexmaster Triple Lock Type NITL Flexible Aluminum Air Duct; Hercules; Omni-Duct; Thermaire
d. Insulated Triple Lock Aluminum Round Ductwork: Flexmaster Triple Lock Type TL-M Alum. Duct Insulated; Hercules; Omni-Duct; Thermair
e. Flexible Duct:
    1) Specify flexible duct which meets the pressure class requirements.
    2) Specify a maximum length of 6 feet. Design for a maximum velocity of 600 ft/ min.
    3) Preferred Manufacturers: Flexmaster Type-5; Flexmaster Type-8M; Hercules; Omni-Duct; Owens-Corning; Schuller; Thermaflex
f. Flexible Duct Fan Connections:
    1) Specify at least 1" slack in these connections to ensure that no vibration is transmitted from fan to ductwork.
    2) Provide UL Listed fire-resistant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 30 oz. per sq. yd., crimped into metal edging strip.
    3) Provide flex connector with equal length between connected ducts all the way around connector.
g. Plenums:
    1) If masonry plenums or air shafts are used to handle air flow, check for structural design strength which takes into account the maximum design pressure or vacuum, and coat with special materials or line with sheet metal to make them air tight.
    2) Arrangement of return air plenums must be approved by UCB.
h. Sound Attenuation:
    1) Refer to ASHRAE Noise and Vibration guidelines for coordination of duct sound attenuators, acoustical duct and plenum linings and other acoustical treatment of ductwork systems.
i. Air Leakage:
    1) Conform to the duct sealing requirements listed in SMACNA HVAC Duct Construction Standards. For all duct systems, provide SMACNA seal Class A, regardless of pressure class. Construct special exhaust systems, including ductwork attached to ERV's, to the same leakage standard as supply duct.

2) Provide pressure testing of ductwork in the 3" and higher Duct Pressure Classes. Refer to the SMACNA HVAC Duct Leakage Test Manual for information on leak test procedures. Provide leak testing on large and small projects.
3) Adhere to SMACNA advanced level duct cleanliness.

j. Volume Control Dampers:
1) On the construction drawings, show all required locations for volume control dampers in the ductwork where required for air balancing. Avoid locating dampers where it is obvious they won't be needed because of the inherent pressure drops in the system due to duct layout, longest runs, etc.
2) Do not install a volume damper with a frame that protrudes into an airstream due to resulting excessive noise and pressure drops. Use a damper downstream of a 45° take-off or enlarge the duct at the point of damper location as potential solutions.
3) Specify locking; indicating quadrant regulators on these volume control dampers.

k. Take-offs:
1) Provide conical take-offs with a manual damper if warranted. If the main duct is not deep enough for a conical fitting, specify a 45° fitting with a round collar.
2) Take-offs to VAV terminal units shall not have manual dampers.

l. Fire and Smoke Dampers:
1) Indicate all fire and smoke dampers on the construction drawings.
2) Coordinate locations with UCB during design process.
3) Drawing notes or specifications indicating fire damper or fire/smoke damper locations to be "where required by code" are not acceptable. Clearly indicate location and type of all dampers.
4) Specify electrical actuators requiring 120 V. Provide an actuator with an auxiliary switch to monitor full-closure of the smoke damper through the BAS.
5) Fire and smoke dampers in small ducts (under 16" in height) can cause excessive pressure drop and noise due to insufficient fee area. Potential solutions:
i. Increase the duct size with gradual sheet metal transitions to increase the free area at the damper location.
ii. Specify a damper frame style that does not impinge on the duct's cross-sectional free area.
6) Provide ceiling-type fire dampers where HVAC components penetrate fire-rated ceiling membranes. Standard fire dampers are not acceptable in this application.
7) Combination fire/smoke dampers are often used in applications where both a fire damper and a smoke damper are required.
8) Where both a fire damper and a smoke damper are required by code at a ceiling penetration, various types of combination fire/smoke dampers are available which are listed by UL as acceptable for a ceiling penetration. Coordinate the selection of a ceiling-type combination fire/smoke damper with the rated ceiling construction. The alternative to a ceiling-type combination fire/smoke damper is to have a separate fire damper (appropriate for the type of ceiling construction) and a separate smoke damper (the smoke damper must be within a certain distance of the ceiling penetration).
9) Specify only "dynamic" rated fire dampers, which provide more positive closure than "static" rated fire dampers. "Static" rated fire dampers are not acceptable.

10) Institutional Knowledge: In many instances with research facilities on campus, fire/smoke dampers near shafts with fume hoods and other research equipment directly adjacent to the shaft often yield inaccessible conditions to the fire/smoke dampers. Identify the amount of infrastructure around fire/smoke dampers and have a specific plan for maintenance personnel to access these dampers for routine maintenance and testing.

m. Backdraft Dampers:
   1) Specify motorized backdraft dampers for positive closure of air duct on exhaust systems where stack effect would open gravity type dampers.
   2) Backdraft dampers of flexible materials are not acceptable.
   3) Preferred Manufacturers: Air Balance; American Warming and Ventilating; Arrow United; Louvers and Dampers, Inc.; Pottorff; Ruskin
   4) Backdraft dampers, furnished with air moving equipment, may be air moving equipment manufacturer's standard construction.

n. Access Doors:
   1) Specify duct access doors for inspection, maintenance, and cleaning at all automatic dampers and fire and smoke dampers.
   2) Specify access panels (sheet metal covers with hemmed edges and gaskets) upstream of duct turning vanes in return air and exhaust, and before all booster (heating, reheat, cooling) coils. Provide panels with sheet metal covers that have hemmed edges and gaskets screwed over the opening (do not seal).
   3) Access doors with sheet metal screw fasteners are not acceptable.

o. Access Door Hardware:
   1) Preferred Manufacturers: Duro Dyne; Ventfabrics Ventlok Series

p. Elbows:
   1) Use radius elbows with throat radius (measured at inside surface) equal to duct depth wherever possible. Rectangular and adjustable elbows are prohibited.
   2) If rectangular elbows are necessary, specify single-wall turning vanes, with intermediate support rails if the length of the vanes exceeds 36". Edges of the turning vanes shall be parallel with the sides of the elbow. Provide 2" wide rails for elbows up to 12", and 4" wide rails for elbows above 24" in the dimension perpendicular to the vanes.

q. Transitions:
   1) Diverging transitions exceeding 15° per side are not acceptable.
   2) Converging transitions exceeding 30° per side are not acceptable.

r. Chemical Fume Hood Exhaust:
   1) Provide stainless-steel or PVC-coated ductwork. PVC-coated exhaust duct is preferred unless stainless steel is considered necessary or truly better.

s. General Exhaust:
   1) Provide galvanized metal

t. Materials:
   1) All duct materials shall be non-combustible or conforming to requirements for Class 0 or Class 1 air duct materials, as per UL 181 with limitations as noted in NFPA 90A.
   2) General exhaust ducting in labs shall be galvanized steel from grille to lab air valve. Downstream of lab air valve, the duct shall be PVC coated or stainless steel.

3) Steel Ducts: ASTM A525 or ASTM A527 galvanized steel sheet, lock-forming quality, having zinc coating of 1.25 oz. per sq. ft. for each side in conformance with ASTM A90
4) Aluminum Ducts: ANSI/ASTM B209; aluminum sheet, alloy 3003-H14
5) Aluminum Connectors and Bar Stock: Alloy 6061-T6 or of equivalent strength
6) Stainless Steel Ducts: ASTM A167, Type 304
7) For many applications, PVC-coated exhaust duct for chemicals may be used or even preferred in place of stainless steel.
8) Sealant: Non-hardening, non-asbestos, water resistant, UL classifies as fire resistive, compatible with mating materials. Foster 32-19, Childers CP-146 UL duct sealant mastic. Confirm sealant material with UCB when sealing ducts in exhaust systems that will come into contact with chemicals.
9) Duct liner in evaporative cooling systems: Manville Permacote Linacoustic Duct Liner, or equally-coated duct liner installed per manufacturer's recommendations. Alternate: Armacell AP Armaflex or Armacell AP Coilflex elastomeric duct liners.

u. Damper-Operator Hardware:
1) Preferred Manufacturers: Duro Dyne; Ventfabrics Ventlok Regulators

v. Installation:
1) Secure all flexible ductwork to collars with metal bands. Plastic bands are not acceptable. Do not exceed 6' length, and support every 3' minimum.
2) Cable hangers with fasteners are not allowed.

w. Testing:
1) Test fire and smoke dampers under the supervision and approval of UCB's representative.
2) Activate fire dampers and reset under the supervision of UCB's representative.
3) All new ductwork in new systems is to be pressure-tested per SMACNA, from AHU's to upstream of terminal control devices (e.g., VAV boxes).

3. <u>Air Inlets and Outlets:</u>
a. Include provisions for balancing air flow from outlets or into inlets in the specifications and indicate on the construction drawings.
b. Identify air quantities and distribution pattern on the construction drawings.
c. Identify outlet and inlet types on the construction drawings using the following basic code recognitions:
1) Supply (S)
2) Exhaust (E)
3) Return (R)
4) Transfer (T)
5) Diffuser (D) for air pattern control (include damper for volume control).
6) Grille (G) no volume control, inlet or outlet.
d. When more than one type is used, add a schedule item reference number after the code name, i.e. SD-1, ER-2, etc.
e. Specify balancing dampers and indicate on the construction drawings on duct take-off to diffusers, grilles and register, regardless of whether dampers are specified as part of the

diffuser, grille or register assembly to minimize acoustical problems in balancing air flow. OBD not permitted.

f. Provide bird screen on the outside of air-intake louvers and the inside of relief/exhaust louvers (with access to clean them). All outside air and exhaust/relief air louvers shall be constructed of rust resistant materials. All dampers shall be insulated (air foil type and gasketed).
g. It is important to locate unprotected vertical plane intake louvers on the South or East side of buildings, opposite prevailing winds, unless approved by UCB.
h. Specify stationary, drainable type louvers and provide sufficient distance or directional change of fresh air between the outside air intake louver and the dampers and the filters to eliminate or at least minimize snow and rain being carried to the air filters. Do not exceed manufacturer's recommended inlet velocities to also help minimize snow and rain. Hurricane or sand louvers are not allowed.
i. Minimize roof type intakes or relief and are only acceptable where no other solution is possible. Where the design solution requires roof type intakes or reliefs, design and specify hoods with hinges and quick-release fasteners for ease of access to dampers.
j. OBD not permitted. These often create excessive noise and work themselves free over time.

Table 3030.1: Air Inlets and Outlets Performance Requirements

Equipment	Manufacturers	Performance Requirements
Ceiling Diffusers	Anemostat; Carnes; Krueger; Metal-Aire; Price; Titus; Tuttle & Bailey	
Ceiling Registers and Grilles	Anemostat; Carnes; Krueger; Metal-Aire; Price; Titus; Tuttle & Bailey	Can cause a fair amount of noise. Should be used only where strictly necessary.
Ceiling Slot Diffusers	Anemostat; Carnes; Krueger; Metal-Aire; Price; Titus	Not permitted, we have found these to be unreliable in VAV systems due to their tendency to dump, so we prefer not having them.
Ceiling Linear Exhaust and Return Grilles	Anemostat; Carnes; Krueger; Metal-Aire; Price; Titus	
Wall Supply Registers and Grilles	Anemostat; Carnes; Krueger; Metal-Aire; Price; Titus	

Equipment	Manufacturers	Performance Requirements
Wall Exhaust and Return Registers	Anemostat; Carnes; Krueger; Metal-Aire; Price; Titus	
Liner Wall Supply Registers and Grilles	Anemostat; Carnes; Krueger; Metal-Aire; Price; Titus	
Linear Floor Supply Registers and Grilles	Anemostat; Carnes; Krueger; Metal-Aire; Price; Titus	
Floor Supply Registers and Grilles	Anemostat; Carnes; Krueger; Metal-Aire; Price; Titus	Heavy duty service only
Louvers	American Warming/Air Balance; Arrow; Dowco; Greenheck; Krueger; Louvers and Dampers, Inc; Penn Ventilator; Ruskin	Screen for intake louvers installed on outside of louver for self-cleaning purposes. Debris will fall off when fan is off.
Louvered Penthouses	American Warming; Arrow; Dowco; Greenheck; Louvers and Dampers, Inc; Penn Ventilator; Ruskin	
Gravity Roof Hoods	Acme; Carnes; Greenheck; Louvers and Dampers, Inc; Loren Cook; Mallory; Penn Ventilator	
Gravity Roof Ventilators	Acme; Carnes; Greenheck; Loren Cook; Mallory; Louvers and Dampers, Inc; Penn Ventilator	
Goosenecks		Provide removable screen in discharge. Discharge to be cut back 45 degrees. Opening of discharge shall not face north or west.

Equipment	Manufacturers	Performance Requirements
Return-Air Grilles	Anemostat; Carnes; Krueger; Metal-Aire; Price; Titus	Perforated-face RA grilles for ceiling applications. Any other type of grille requires UCB approval.

4. Known Campus Issues
    a. Duct sealant in exhaust ductwork for dish machines:
        1) C4C building has had problems with chemicals in the dish machine exhaust corroding the duct sealant. Provide welded duct for commercial dishwasher applications
    b. Velocity through louvers:
        1) Face velocity through louvers located on exterior walls should be lower than standard practice to prevent snow entrainment.

    c. General Ductwork Design:
        1) Much of the duct distribution standard revolves around a low pressure drop design to minimize fan horsepower energy usage and energy usage by fans. A designer should take pressure drop into consideration when sizing and duct distribution system. This includes takeoffs, elbows, duct velocity and transitions. The guidelines that designers often use a maximum pressure drop per 100 feet or a maximum velocity do not translate into a duct system that passes the current energy code requirements with respect to fan horsepower. A designer should consider the overall duct system and construction, not just rules of thumb for distribution systems. UC Boulder requires 500-750 fpm minimum standard on intakes.

D3030 –Distribution Systems

Introduction

The following section provide requirements and guidelines in the design and construction of distribution systems at the University of Colorado-Boulder (UCB).

UCB Requirements

2. Hydronic Piping and Specialties:
    a. Isolation valves:
        1) Provide for all zones, risers, branches, terminal devices, and other mechanical equipment.
        2) Locate at the mechanical room or equipment room, in addition to isolation at individual units of equipment.
        3) Install within 5 feet of the unit served. If the branch line serving the unit is greater than 10 feet long, an isolation valve shall be installed at the branch connection.

b. Three-way diverting valves are preferred over bypass. Discuss with UCB Mechanical.
c. Locate valves in accessible locations with adequate clearance around hand wheels or levers for easy operation.
d. Specify and clearly indicate service valves for all equipment, risers, branches, and zones on drawings.
e. Specify unions or flanges downstream of valves and at equipment and apparatus connections.
f. Specify manual air vents at all changes in elevation downward in direction of flow with full size air chamber and pipe down to accessible location. Use 1/2" hose-end ball valve with cap.
g. Specify diaphragm-type compression tanks, and where glycol is to be used in the system, specify a diaphragm which is compatible with glycol.
h. Expansion Tanks:
    1) Bladder expansion tanks are allowed.
    2) Plain steel expansion tanks are unacceptable.
i. Specify flow measuring and balancing device combinations of orifices, venturis, throttling valves, and temperature and pressure taps to provide accurate flow measurement for manual balancing of hydronic systems. Test ports shall be on one side of the valve or be provided with a shut-off valve on the pressure side of the balancing valve. Balancing valves shall have full shut-off capability and memory stop. They shall be installed upstream of balancing ports to allow cleaning of ports. They shall have packing glands.
j. For BBR, in order to achieve adequate heat transfer, turbulent flow is necessary. Therefore, do not specify a flow rate below that which is necessary for turbulence in the specified BBR pipe size. Specify flow in GPM at all locations of balancing devices.
k. Pressure-independent control valves are required for both chilled water and heating water. Automatic pressure-compensating variable-orifice type regulating valves to balance flow are unacceptable as substitutes for manual balancing of hydronic systems.
    1) Preferred Manufacturers (Manual Balancing): Flow Design (Flowset); Flowpac; Gerand; Griswold (Quickset); Nibco (globe-style with isolation valve); Tour & Andersson
    2) Provide the following text into the project specifications: "Mechanical contractor shall obtain approval in writing from balancing contractor for all balancing devices."
    3) Specify balancing valves to have test ports on one side of the valve.

l. In hydronic systems subject to freezing, UCB requires "pumped coils". Pumps should be decoupled from supply pump and only run during freezestat trip sequence. Coils should not have inline pump for freeze protection. Inhibited propylene glycol antifreeze solution is preferred for use when systems subject to freezing. Design engineers shall evaluate existing systems to verify glycol type and determine feasibility for conversion from ethylene to propylene glycol.
m. Glycol Systems:
    1) For initial fill, specify and require metering of volume to determine correct mix for specified concentration.
    2) System fill shall be performed by means of a temporary fill tank totally isolated from domestic water system. Fill connection shall be a female hose-end ball-valve.

Supply shall be with a removable hose which can be connected to a male hose-end valve connected to a backflow prevention device.

3) Provide the following system glycol concentrations:
    i. Chilled Water System: 35 percent
    ii. Hot Water System: 40 percent
    iii. Heat Reclaim or Energy Recovery Loop System: 40 percent
    iv. Solar Thermal Water System: 40 percent
    v. For existing systems the percentages may vary based on type of glycol used.
4) Specify that all components exposed to glycol shall be compatible with the specified glycol (especially the seals and gaskets).
5) Drain all pressure relief valves into feeder tank (if present) or relief reservoir. Add isolation valve and air bleeds for automatic air vents.

n. Provide temperature gauges across coils and pressure gauges across pumps. P&T taps are not sufficient. Use brass piping. Black iron is not acceptable because it rusts and plugs up. Specify shut-off valves at gauges.
o. Specify that test and balance ports in chilled-water systems be long enough to extend beyond insulation. Cutting back the insulation or covering the ports is not acceptable.
p. Identify process cooling systems to avoid water-wasting cooling.
q. For process cooling systems, specify hose-end drain cock between equipment connector and return shut-off valve (this is to purge air after connecting equipment). De-couple process cooling systems from main chilled water system via heat exchanger.
r. When specifying multiple/stacked chilled-water coils, specify reverse-return manifolds. This has proven to be necessary at low-flow conditions where using balancing valves has allowed freezing conditions because the valves are not linear for all flow conditions.
s.
t. Pipe:
    1) Black steel, Schedule 40, standard fittings. Use ASTM A53 for carbon steel piping and ASTM A234 for all weld fittings. Use ASTM A197 malleable iron threaded fittings.
u. Tube:
    1) Provide Type K, hard copper for open loops, Type L for closed loops. Solder fittings (for pipe sizes less than 2") with antimony-free and lead-free solder with shear strength not less than 7,250 PSI. Allstate, "Aquasafe" or equal. Pipe diameters of 2½" and above, braze with filler material of minimum 15% silver and purge while brazing with nitrogen gas.
        i. Note: Exceptions to the 2" brazing requirement to be approved by variance request. Applies to hydronic heating and cooling systems only.
    2) Provide full insulation for all piping where clamped.
v. Mechanical grooved pipe is not approved for use on hydronic piping.

w. Relief Valves:
    1) Bronze body, Teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labeled.
    2) Preferred Manufacturers: Kunkle; Lunkenheimer; McDonnell and Miller; Watts
x. Diaphragm Type Compression Tanks:

1) Tested and stamped in accordance with Section 8D of ANSI/ ASME Code.
2) Preferred Manufacturers: Amtrol; Bell and Gossett; John Wood Co.; Taco
3) Institutional Knowledge: Diaphragm type compression tanks are preferred for expansion compensation. Bladder and steel tank types are not preferred.

y. Air Separators:
1) Prefer Spirotherm only. Contractor shall make arrangements through TM Sales to get air separators with a 0.60 cost multiplier of list price when buying them from local distributors for UCB Projects.

z. Strainers:
1) Provide strainers with full-port hose-end valves with SS ball and stem.
2) Basket Strainers: Duplex, quick-opening covers, stainless-steel baskets, single-handle or hand-wheel operation of valve.
3) Preferred Manufacturers: Armstrong; Cash Acme; Boylston; Hoffman; ITT; Keckley; Mueller;

aa. Pump Suction Fittings:
1) Fitting to match specified pump.
2) Preferred Manufacturers: Allis Chalmers; Armstrong; Aurora; Bell and Gossett; Crane; Peerless; Taco

bb. Flow Indicator Switches:
1) Preferred Manufacturers: McDonnell and Miller; Mueller;

cc. Inhibited Glycol
1) Preferred Manufacturers: Dow Chemical Company, or pre-approved equal
2) Preferred Products:
i. Dowtherm 4000 Heat Transfer Fluid (Ethylene Glycol) for existing hot water systems that already use Ethylene Glycol.
ii. Dowtherm SR-1 for existing chilled-water systems that already have ethylene gycol.
iii. Dowfrost HD (Propylene Glycol) may be used if authorized or required due to concerns about cross-contamination or toxicity. Propylene glycol required for all new systems that do not connect to existing ethylene glycol systems.

dd. Stationary Pressure Gauges:
1) Preferred Manufacturers: Dwyer; Trerice; U.S. Gauge; Weksler

ee. Stationary Thermometers:
1) Vari-angle Digital Thermometer with light-sensitive electric cells.
2) Preferred Manufacturers: Weiss; Miljoco; or pre-approved equal

ff. Temperature and Pressure Test Plugs:
1) Plugs suitable for vacuum to 600 psig and temperatures of -20°F to 300°F with cap and extension for insulated pipe where required.
2) Pressure gages and thermometers in individual shock-proof cases.
3) Preferred Manufacturers: Fairfax; Peterson Equipment (Pete's Plug); Trerice

gg. Pipe Hangers, Supports, and Guides:
1) Preferred Manufacturers: B-Line; Grinnell; P.H.D.; Tolco

hh. Dialectric Pipe Fittings and Isolators:

1) Provide brass couplings or bronze valves. Dielectric fittings, flanges, unions, and waterways are not acceptable, except dielectric flanges for large piping where there is no other solution.

ii. Flexible Connectors:

1) Only flexible connectors with stainless-steel braided shielding are acceptable. Rubber flex connectors are not allowed on campus as the rubber connectors fail and cause water damage.
2) Flexible connectors are not allowed on terminal devices.
3) Flexible connectors on gauge piping on pumps.
    i. Rector Seal #5 Pipe dope.

3. Valves:

a. Institutional Knowledge: UCB prefers Keystone series 36 K-LOCK butterfly valves for all shut-off applications on hydronic piping. This is a response to wear characteristics and the ability to fully shut-off later in life. This specific lesson-learned has been acquired from years of trial of multiple models and types of valves.

b. Provide ball valves with stainless steel ball and trim, Teflon seats, seals, and gland nuts, or high-quality butterfly valves instead of gate valves.

1) Specify and clearly indicate service valves for all equipment, risers, branches and zones on the construction drawings.
2) Install isolation valves within 5’ of the unit served. If the branch line serving the unit is greater than 10’ long, install an isolation valve at the branch connection.
3) Ball Valves (bronze body, tunnel balls):
    i. Blowout-proof stem with packing nut
    ii. Full ball port with Teflon seals and seat, as specified
    iii. Solid, bored-hole, stainless-steel ball and stem. *NOTE: For all bronze valves, specify the following: Body = ASTM B61, B62, or B584 Bronze*
    iv. Three-piece ball valve if 2-1/2” or greater
    v. Preferred Manufacturers: Apollo; Bray; Dynaquip; Hammond; Jamesbury; Jomar; Milwaukee; Nibco (industrial duty); Watts; Worcester
4) Non-Lubricated Eccentric Plug Valves:
    i. Preferred Manufacturers: DeZurik; Keystone; Milliken
5) Lubricated Plug Valves:
    i. Not allowed on steam or hydronic piping.
6) Bronze Pressure-rated Valves (Comply with MSS-SP-80):
    i. Ball valves only
    ii. Preferred Manufacturers: Crane; Hammond; Milwaukee; Nibco (industrial duty); Powell; Stockham
7) Iron Body Pressure-rated Valves (Comply with MSS-SP-70):
    i. Preferred Manufacturers: Crane; Kennedy; Lunkenheimer; Milwaukee; Mueller; Powell; Stockham; Walworth
8) Gate and Globe Valves – Class 800:
    i. Not allowed on hydronic systems
9) Swing Check Valves:
    i. Bronze bodied class 800 with bronze disc and stainless steel hinge pin

ii. Preferred Manufacturers: Crane; Stockham; Mueller Milwaukee

10) Spring Check Valves:
    i. Preferred Manufacturers: DFT; Armstrong; or pre-approved equal
11) Wafer Check Valves:
    i. Designed to fit between two flanges. Stainless steel construction for body, disc, spring and spring retainer
    ii. Operating rate of 1/2psi or less
    iii. Preferred Manufacturers: DFT; Spirax/Sarco; Mueller; Marlin
12) Safety Relief Valves:
    i. Steam rated valve with cast iron body
    ii. Bolted bonnet design
    iii. Seats lapped to optical flatness with dual control rings
    iv. Bronze semi-nozzle trim
    v. If pipe run is longer than 10', the pipe size must increase one pipe size.
    vi. Preferred Manufacturers: Leslie; Spence; or pre-approved equal

4. Heat Exchangers:
    a. This section does not apply to domestic hot water.
    b. Flat-Plate Heat Exchanger:
        1) Allow for glycol, if used.
        2) Specify insulation for both hot and chilled-water applications.
        3) Incorporate Y-strainers prior to heat-exchanger inlets.
    c. Air Coils:
        1) Except where special design requirements might dictate, provide copper tube coils with aluminum fins, permanently bonded.
        2) Provide access areas on inlet and discharge sides of coils for maintenance purposes.
        3) Provide for coil pull space and specify full track support for easy installation and service.
        4) Specify all water coils to be drainable type.
        5) Provide drain piping and air venting at all water coils.
        6) Specify all coil ratings to be ARI Standard 410 certified.
        7) Specify fin spacing to be based on heating, cooling, dehumidification, and pressure drop.
        8) As a measure to improve indoor air quality as per ASHRAE 62-2016: design coil drain pans and drip troughs at the bottom of coils to slope to drain to minimize standing water in the air handling unit, plenum, etc. (stagnant water is prime habitat for microorganisms).
        9) Specify working pressures and temperatures for coils. Be sure to allow for the static head that a coil will see due to the height of the building.
        10) Specify type and percent of glycol in water.
        11) Provide good mixing of return and outside air streams upstream of coil to minimize stratification and possible coil freeze-up.

12) Provide flexibility in piping where connected to the coil if the coil is not isolated from fan or other vibrating equipment.

d. Chilled Water Coils:
   1) Design for full counter-flow of water and air with water inlet at the bottom of the supply header and outlet at the top of the return header.
   2) Specify stainless-steel condensate pans.
   3) Specify stainless-steel frames and blank-off spacers between coil frame and housing. Use stainless-steel hardware to fasten blank-offs and frame.

e. Direct Expansion Refrigerant Coils (by variance approval only):
   1) Direct expansion coils may be used on small systems; piped and installed in accordance with factory recommendations.
   2) Stainless steel drain pan and casing is required for DX coils.
   3) Additional design precautions shall be taken, or a field refinement procedure shall be included in the specifications, on those installations not covered by the manufacturer's guide.
   4) Specify full face active coils in applications involving variable airflow through the coils such as multi-zone or VAV systems.
   5) Specify face split coils for constant volume or where humidity control is required.

f. Hot Water Coils:
   1) Design for full counter-flow of water and air with water inlet at the bottom of the supply header and outlet at the top of the return header.

g. Steam Coils:
   1) Provide Centri-Feed type; vertical flow
   2) Tubes: Minimum 12-gage carbon steel
   3) Fins: Minimum .020 thick aluminum (imbedded type)
   4) Header: Minimum schedule 40 carbon steel pipe.
   5) Connections: Minimum schedule 80 carbon steel pipe
   6) Casing: Minimum 14-gauge galvanized steel
   7) Weld tubes, headers, and connections to form monometallic joints

h. Coils in Built-Up Plenums:
   1) When cooling coils are stacked one above the other, design and specify drip troughs on the downstream side of each of the upper coils to eliminate drip into the air stream of the bottom coil. Slope drip troughs to drain.
   2) Condensate drain piping should incorporate a P-trap with the height of its water seal correctly sized to prevent trap from being sucked or blown dry by the static pressure differential between the inside and outside of air handling unit.

i. Steam Coil Installation:
   1) Support coils and piping individually to prevent undue strains on the steam and condensate connections.
   2) Install a drip trap prior to the coils (and before the control valve) on installation where the steam main is higher than the control valve or the control valve is more than 5 ft. from the steam main.
   3) Install strainers with blowdown valves before all control valves and traps.
   4) Install a vacuum breaker in the steam piping prior to the coil and on the downstream side of the coil before the trap.

5) Trap all coils individually. Locate trap as close as possible.
6) Install only inverted bucket traps with large vent buckets on any coil that will see temperatures below 32 degrees F.
7) Install a dirt pocket prior to the steam trap.
8) All condensate to be gravity drained.
9) Check air pressure drop.
10) Install coils with sufficient drop to ensure coils completely drain of condensate.
11) See Appendix: Typical piping for steam coil.

j. Trap Sizing:
   1) Modulating:
      i. 0-15 psi steam pressure – use a 2 to 1 safety factor at a 0.5 psi differential.
      ii. 16-30 psi steam pressure –use a 2 to 1 safety factor at a 2 psi differential.
      iii. Above 30 psi steam pressure – use a 3 to 1 safety factor at half of maximum differential.
      iv. Preferred: F&T trap
   2) Constant pressure:
      i. Use a 3 to 1 safety factor at operating pressure differentials.
      ii. Preferred: inverted bucket trap

k. Preferred Manufacturers: Armstrong

5. Humidifiers:
   a. Clean steam is preferred for humidifiers. Production of steam will be considered on a case by case basis by UCB.
   b. The use of steam humidifiers is discouraged. However, where design requires duct type steam humidifiers, specify injection type steam humidifiers; but using central steam is not allowed due to chemicals being used for water/steam treatment. Provide a dedicated steam generator with reverse osmosis water, or use packaged electric steam generators.
   c. Specify downstream ductwork to be soldered water tight, without duct liner, with external duct insulation, for the length of duct expected to be moist (absorption zone). Provide drain for this section of ductwork. Drain to sanitary drain, do not drain to roof drain or storm drain.
   d. High-limit safety humidistat in duct in series with space humidistat to prevent over-saturation in duct. Specify airflow switch to confirm fan operation.
   e. High-Pressure Mist Humidifier:
      1) Recommend using high pressure mist systems only for greenhouses or energy recovery. Not allowed anywhere else.
      2) Direct-drive stainless-steel pump
      3) Automatic flush cycle
      4) Self-draining manifolds
      5) Droplet size: 10-40 microns (not less than 95% 15 microns)
      6) Noise insulation of pump
      7) Preferred Manufacturers (in order): Nortec; Dri-Steam
   f. Injection Type Steam Humidifier:

1) Provide completely assembled with steam separator, control valve which discharges through a drying chamber, silencing chamber, steam-jacketed distribution manifold, steam trap, and strainer upstream.
2) Preference for systems with steam humidifier grid or panel similar to Dri-Steem Ultra-Sorb or Pure Insty-Pac.
3) Manifold full duct width and furnished with mounting flange.
4) Provide integral warm-up control to prevent liquid discharge at start-up.
5) Preferred Manufacturers: Armstrong; Dri-Steem; Nortec; Pure

6. Natural Gas Piping and Specialties:
   a. Identify that the utility company will run gas service up to and including the meter.
   b. Use tapered couplings. Do not use thread protectors provided with piping.
   c. Review all existing and new gas requirements to verify adequacy of gas supply (pressure, pipe size and meter size), and indicate on the construction drawings.
   d. All welded natural gas piping should be properly inspected to pressure vessel standards.

Table 3030.2: Natural Gas Piping and Specialties Performance Requirements

Equipment	Manufacturers	Performance Requirements
Natural Gas Piping		Schedule 40. Size 1/2” to 1-1/2”: Threaded malleable iron. Size: 2” and over: Butt weld fittings. 150lb forged steel weld neck flange unions. Interior concealed, non-accessible piping and fittings shall be welded.
Gas Solenoid Safety Valves	Automatic Switch Company (ASCO)	Provide in kitchens. Kitchen valve de-energized when fire suppression system is activated. Reset of kitchen valve only possible after fire suppression system has been reset, re-charged and in "ready" mode. Not in plenums.

Equipment	Manufacturers	Performance Requirements
Flexible Hose Gas Connectors and Quick Couplers	Thermo-Tech Products Co.; Hansen Manufacturing CO	Provide flexible stainless steel connectors with full size quick coupler for all kitchen and heavy movable gas appliance equipment. Connectors of lengths required to displace equipment for complete cleaning under and around gas appliance. Provide valve at service connection on equipment branch and quick coupler at service end of flexible hose connector. Provide union connection on appliance or manifold end of hose connection.
Gas Isolation Valves		Provide isolation valves at all floors and branches.

2. Pumps:
    a. A primary-secondary pumping system is preferred, where practical.
    b. Design pumping systems so the available positive head at the pump intake will be larger than the required net positive suction head at the highest possible water temperature at the pump intake.
    c. The pump curve representing flow-head relationship shall intersect the system curve at design operating point.
    d. Select pumps to operate at optimum efficiency as the primary selection criteria.
    e. Base friction head calculations on Hydraulic Institute Standards for:
        1) Chilled water systems: new pipe
        2) Hot water systems: 15-year old pipe
        3) Steam condensate: 15-year old pipe
    f. When pump redundancy is necessary, provide parallel pumping (with check valves) instead of two pumps with automatic change-over.
    g. Select pump motor as non-overloading over the entire pump curve shown by the manufacturer. Consider option of pump operation reset based on reference temperature.
    h. UCB prefers pumps with direct drive.
    i. Specify mechanical shaft seals. Gland seals are not acceptable.
    j. Wet rotor pumps preferred.

Table 3030.3: Equipment Performance Requirements

Equipment	Manufacturers	Performance Requirements
Base-Mounted Pumps	Armstrong; Aurora; Bell and Gossett; Crane; Paco; Peerless; Taco; Wilo	Mechanical seals are required. Gland seals are not acceptable. Complete flushing arrangement for mechanical seals and packing. Vent, drain plugs and pressure gauge on pump casings. Guard on coupling. For primary pumping, split case centrifugal are preferred over end-suction.
Horizontal Split-Case Pumps	Aurora; Bell and Gossett; Crane; Paco; Peerless; Taco; Wilo	Double row outboard ball bearings.
In-Line Pumps	Armstrong; Bell and Gossett; Grundfos; Taco; Wilo	Housing prefers only Grundfos

Known Campus Issues

1. Steam Condensate in Coils:
    a. Multiple instances of tripping freeze stats due to condensate not being able to evacuate coil. Ensure all coils are sloped to allow condensate to completely drain.

D3035 – Building Steam Distribution Systems

Introduction

The following section provides requirements and guidelines for use in the design and specification of steam distribution system within buildings at the University of Colorado-Boulder (UCB).

a. The UCB Central Power Plant supplies high-pressure, saturated steam to the campus community through a system of inter-connected tunnels and direct-bury piping. The steam pressure in the mains runs approximately 140 psig and may potentially be raised as future need arises. For this reason, before pressure is reduced for consumer use, we use valves, fittings, pipe, and flanges that are designed to safely carry pressures of at least 250 psig steam at 406°F.
b. Steam pressure is generally regulated in each individual building and may include multiple pressure reductions, depending on the equipment be served. Typical reduced steam pressures vary from 65 to 5 psig. Steam use in buildings include direct radiant heating, forced air heating using steam fan coils, heating hot water generation, humidification, food service preparation and clean up, laundry processes, filter cleaning, drying, and other

miscellaneous process. In addition, the central Power Plant uses high-pressure steam to generate all campus electrical needs.

c. The campus steam system and all steam sub-systems are under the direct control of UCB Utility Services. Steam and condensate valves are to be operated by Facilities Operations personnel only, no exceptions. Any work that either directly or indirectly impacts the system must be approved by, and coordinated with, a Utility Services representative. Meetings scheduled with Utility Services personnel for site visits, inspections, spec/print reviews, etc., must be made 72 hours in advance and attended in a timely manner. Failure to show for an appointment may result in lost time being charged to the job. The 72-hour notification requirement may be waived as urgency dictates and time permits.

UCB Requirements

Design teams are to utilize the sample steam specification in **Appendix 3020.2** as a minimum guideline to incorporate applicable steam requirements into their project. The project design team is entirely responsible for ensuring all steam standards and specifications are applicable to their individual project.

D3040 – Terminal and Package Units

Introduction

The following section provides requirements and guidelines for use in the design and specification of terminal and package units at the University of Colorado-Boulder (UCB).

UCB Requirements

1. Fans:
    a. Place all major mechanical equipment within a mechanical room. Only small units may be roof-mounted, and shall be made as inconspicuous as possible by placing as far away as possible from edge of roof, painting, screening, or a combination of these. UCB approval is required for roof-top units.
    b. Keep use of propeller fans to a minimum; typically used only for destratification.
    c. Specify that scroll-type fans are required to have a continuously-welded housing (spot or tack-weld or lock-seam construction is not acceptable). State bearing life to be L50 life of 200,000 hours at the maximum speed for the class of fan provided.
    d. Specify each type of fan separately.
    e. Provide statically and dynamically machine balanced fans that have solid shafts.
    f. Obtain UCB approval for systems selected for operation above 6 inches static pressure.
    g. Motors:
        1) For all belt-drive motors over 5 HP, provide dual push-pull adjustment screws for the motor mounts. For retrofits, the motor mounts must be replaced if not of this type.
        2) Refer to **Facility Standard D0000** for efficiency standards.
    h. Institutional Knowledge:

1) Preference is for utility set fans be direct drive fans wherever possible.

Table 3040.1: Fan Requirements

Equipment	Manufacturers	Performance Requirements
Utility Set Fans	Acme; Cook; Greenheck; New York Blower; PennBarry; Twin City; Trane	When only design solution requires exposure to weather, specify weather-covers with quick release fasteners for ease of access to belts and bearings. UCB prefers that utility set fans be direct drive fans wherever possible.
Central Centrifugal Fans	Acme; Buffalo; Cook; Greenheck; New York Blower; Pace; Twin City; Trane	Motors 5HP or over shall have bearings of the split pillow block, double row roller, or ball, grease lubricated type with pedestal-type supports.
In-Line Tubular Centrifugal Fans	Acme; Chicago Blower; Cook; Greenheck; New York Blower; Twin City	University approval for use of these fans will require careful acoustical design treatment to the barrel casing, flexible connections, and inlet and discharge conditions.
High-Plume Dilution Exhaust Fans	MK Plastics; Strobic; Greenheck	Not preferred. Wind study should be provided to confirm utility fans with stacks provide adequate exhaust. High-Plume fans are typically more expensive than a wind study.
Vane Axial Fans (Fixed-Pitch Only)	Chicago Blower; Flakt; Greenheck; Joy	
Propeller-Type Ventilation Fans	Acme; Aerovent; Carnes; Cook; Greenheck; PennBarry	

Equipment	Manufacturers	Performance Requirements
Power Roof Ventilators	Acme; Carnes; Cook; Greenheck; Jenn-Air; PennBarry	The use of power roof ventilators is acceptable only if fan can be screened from view and is not used to exhaust toxic fumes; Wall-mounted power ventilators are strongly discouraged.
Ceiling Type Exhaust Fans	Acme; Carnes; Cook; Greenheck; Jenn-Air; PennBarry (Zephyr Model)	Specify motor speed not to exceed 1150 RPM; Specify housing of heavy gauge steel completely insulated internally with acoustical material to deaden sound.

2. Drives:
    a. Do not specify single belt drives on equipment with 1 HP motors and above. Direct drive fans to be used where possible. Belts to be used only if equipment does not come with direct drive and prior UCB approval.
    a.
    b. Locate motors on their respective motor bases allowing for 1/6 of the total motor base travel for installation of new belts with remaining 5/6 of the travel available for belt tightening.
    c. Arc of contact on the smaller sheave: minimum 120 degrees.
    d. Ratios of sheaves: maximum 8 to 1.
    e. Belt speed: maximum 5,000 feet/minute.
    f. Specify OSHA-approved belt-drive covers with tachometer access, with side made of expanded metal.
    g. Provide drives rated for 150 percent (minimum) of fan motor power.
    h. Before allowing or specifying synchronous drives such as the Gates Poly Chain, verify that all associated equipment (fan, motor, fan mountings, etc.) is designed to handle the stress of starting up with this type of drive where there is absolutely no slippage.
    i. Refer to Electrical Standards for VFD information and requirements.

3. Air Handling Units with Coils:
    a. For medium and high velocity draw-through and built-up systems, provide transitions to achieve velocity energy recovery.
    b. Specify maximum sound levels at the discharge, return, and from casing.
    c. Variable Volume:
        1) Select VFD drive to best suit design conditions of air flows and static pressure with budget and energy conservation requirements for project.
    d. Casings:
        1) Provide access for cleaning all coils, including re-heat coils.

2) Specify access door handles to be safety latch type. Thumb screws are not acceptable.
3) Specify stainless-steel drain pans for cooling coils and humidifiers to be extensive enough to catch condensate leaving coil at highest catalogued face velocity. Slope bottom to drain to minimize standing water.
4) Specify deep traps for condensate lines from drain pan to prevent either draw or blow through conditions. Specify proper depth dimension.
5) Specify LED light bulbs with "marine jars" in accessible sections, factory wired to one switch mounted on casing exterior. Switch shall have pilot light in handle.
6) Downstream of evaporative or humidifier sections, specify marine lights with sealed wire-and-glass.
7) Specify viewports on all AHU sections including: evap-pad, filter, fan, damper, and humidifier sections.
8) Specify double-wall construction, with perforated panels in fan section(s).

e. Fan Section:
1) Provide fan array and minimum 2 VFD's to control array for resiliency. The use of a two-fan wheel housing assembly in a common section can be a cause for shaft flexing due to length, and should be evaluated before specifying.
2) Provide lifting beam in fan section for fan motor removal.
3) Change original drive sheaves when required by balancing tests.
4) Specify solid steel fan shafts.
5) Specify externally accessible fittings for lubrication.
6) Provide grease zerk fittings in easily accessible locations of maintenance.

f. Vibration Isolation (only if required after consultation with UCB):
1) Specify entire fan, motor, and drive assembly to be internally spring mounted at the factory, together with fan discharge flexible connection and thrust restraint springs.
2) Internal factory selected and installed vibration isolation is preferred over an alternate design requiring external field installed deflection springs, pipe and duct flexible connections, thrust restraint springs, and spring type pipe hangers on all pipes direct connected to the unit.

g. Coil Sections:
1) Provide grommets to maintain gap between pipe and housing walls. Pipe through casing shall be insulated.
2) Provide lifting beam in coil section to facilitate removal of coils.
3) Size chilled-water coils for 48°F entering water temperature. The Delta-T across the building chilled-water should be 16°F. Consider both the design-sensible and design-enthalpy day.
4) Allow for removal of coils for non-cleaning maintenance. For cleaning of coils, space coils to allow for cleaning them without removal.
5) Specify differential pressure gage across coils.
6) Maximum steam coil width: 6'
7) Where coils are exposed to all outdoor air, use Centifeed or Tandem type steam preheat coils, to allow full flow of heating medium at or below freezing conditions (with modulation of steam flow above freezing). Downstream coils, if required, can then be modulated to provide desired supply air temperature.

h. Damper Sections:
    1) Provide insulated, thermally broken dampers for outside air and exhaust/relief dampers
    2) Bronze bearing is preferred, nylon bearings are acceptable.
    3) Blades:
        i. Mechanically secured to control rods.
        ii. Provide neoprene gaskets to seal against entire stop.
    4) Leakage rate not to exceed Class 1A or 1.
i. Filter Section:
    1) Capable of accepting standard 2" thick pre-filters and a combination of 4"x24" and 24" extended-surface retained-media filters.
    2) Provide hinged access doors on both sides for filter replacement.
    3) Provide upstream of all coils, including heat recovery.
    4) For constant volume systems, provide differential pressure gauges across filter banks.
j. Casing Section Lengths:
    1) Indicate minimum lengths for access to filters, coils, and dampers.
k. Mixing Boxes:
    1) Provide equal sized flanged openings capable of handling full air flow.
l. Zone damper sections are not acceptable in new construction.
    1) Coordinate requirements with UCB for work on existing equipment.
m. Spray coil assemblies are not acceptable.
n. Research facilities having a substantial amount of exhaust have a propensity to overcool during the cooling season due to minimum settings on air supply. Provide appropriate make-up air and energy recovery from the exhaust stream to the make-up air systems. Depending on the hazard of the exhaust, select the appropriate system to prevent cross contamination of airstreams. Exhaust energy recovery systems will need to be coated.
    1) Institutional Knowledge: Convectors with adjustable louvers are preferred on campus for increased occupant control a well as the assistance in achieving LEED points for system controllability.
o. Refer to **Table D0000.1** for required design temperatures for heating and air conditioning systems:

Table D0000.1

Season	Indoor air design conditions	Outdoor air design temperature
Summer	73°Fdb, 63°Fwb	105°Fdb, 59°Fwb when air-intake is above a roof 94°Fdb, 59°Fwb with high air-intake
Winter	68°F	-20°F

p.
q. Direct Evaporative Cooling Section:
    1) Evaporative-cooling section shall be downstream of all coils.

2) Specify stainless steel sumps and housings (i.e., all surfaces subjected to continuous wetting). Extend sump a minimum of 6" upstream and 12" downstream of face of media to avoid splashing out of the sump under low airflow conditions.
3) Specify stainless steel fasteners and brackets within, as well as dielectric gaskets between housing and rest of AHU.
4) Provide stainless steel pump with low-water pump cut-off switch in other than residential-type evaporative-cooling systems. Specify a means to disconnect the pump within the unit and an external J-box.
5) Specify automatic controls to schedule daily drying-out of evaporative media and weekly sump drain-down. In exterior applications, specify automatic drain-down to avoid freezing.
6) Specify Glasdek media. Celdek is not acceptable.

r. Indirect Evaporative Cooling:
1) Is encouraged, either where direct evaporative cooling is being designed or in conjunction with backup/complementary "mechanical air-chilling" coil.

s. Humidifiers:
1) When required, specify steam grid type to inject steam into air stream. Do not use steam from Central Plant.

Table 3040.2: Air Handling Units Requirements

Equipment	Manufacturers	Performance Requirements
Air Handling Units with Coils	Aerosonics; Alliance; Annexair; ClimateCraft; Dunham-Bush; Energy Labs; Engineered Air; Governair; Haakon; Johnson Controls/York, Mammoth; McQuay; Pace; Scott-Springfield; Temtrol; Trane	Specify that AHU's shall be started only when authorized by UCB staff.

4. <u>Packaged Roof-top Heating/Cooling Units (Information only: not allowed without UCB approval):</u>
a. Because of problems with appearance, packaged roof-top units are not to be used without special authorization from the UCB.
b. Gas units AGA approved specifically for outdoor installation.
1) RTU manufacturer-specific (e.g., Carrier) gas trains and controls are not acceptable.
c. Take special care to minimize sound and vibration transmissions to structure by locating units symmetrically over columns and beams.
d. Specify a 115-volt convenience outlet on unit sized to handle a small power load or service light.
e. On large units, specify lights with wire guards in accessible sections, factory wired to switch mounted on exterior of casing.
f. Provide complete calculations to show:

1) Catalogued capacity rating of packaged unit for standard conditions.
2) Correction factors that have been applied to Sensible Heat Capacity for actual entering dry-bulb temperature conditions.
3) Actual leaving dry-bulb temperature.
4) Indoor fan motor heat has been included.
5) Deration of total unit capacity for 5,400 feet altitude using 105°F temperature for air/ entering condenser.

g. Coordinate painting to include painting HVAC Roof-Top Units an approved color if units are to be exposed to view.
h. Specify units with "economizer" cycle with motorized fresh, return, and exhaust air dampers, automatically controlled and pre-wired at the factory.
i. Specify hail guards for packaged DX cooling coil units.

Table 3040.3: Packaged Roof Top Units Requirements

Equipment	Manufacturers	Performance Requirements
Single Zone Packaged Roof-Top HVAC Units	Carrier; McQuay; Trane; York	Not allowed without specific UCB authorization
Central System Packaged Roof-Top HVAC Units	Carrier; Energy Labs; Engineered Air; Mammoth; McQuay; Pace; Temtrol; Trane; York	

5. Air Terminal Units:
    a. Because cooling loads vary, use variable volume air distribution systems to vary the air flow rates rather than falsely loading the system with reheat or mixing at the terminal units.
    b. By having the heating system independent of the cooling system, between-season change-over cycle problems are minimized and economies of operation can be obtained by shutting off the air cooling system during unoccupied hours.
    c. A simple-system design using zoned perimeter baseboard to fin-tube radiation (BBR) to offset the transmission heat loss through the walls and glass or other exposed components and a separate VAV cooling system to balance the heat gain from solar, lights, equipment and people is preferred, with each VAV zone interlocked with the corresponding BBR.
    d. Since there are several types of VAV Systems, manufacturers, and proprietary features, review the proposed design and qualify manufacturers with UCB prior to finalizing design.
    e. VAV Cooling System Design Criteria:
        1) A 100 percent outside air economy cycle.
        2) Maintenance or service requirements in the occupied space should be minimal.
        3) Accomplish all air filtering requirements in the central station equipment.
        4) The amount of air balance required to make the system operate should be minimal.
        5) Multiple static pressure sensors for control may be required based on ductwork and building layout.
        6) Space air outlets should be aspirating types to prevent dumping of air into occupied spaces at minimal volumes.
        7) Design for flexibility to revise zoning with only minimal changes in ductwork and controls.
        8) Specify control provisions to open units to full ventilation volume if required for life safety smoke control.
        9) Provisions should be made to always provide at least the required minimum outside air (ventilation air) for an occupied space, even when the supply air flow rates are reduced because of decreased cooling load.
    f. VAV Terminal Unit Design Criteria:
        1) Show terminal unit size and design airflow rate setting on each terminal unit on the construction drawings.

2) Include damper control section and sound attenuation section as a complete factory assembled unit. Specify damper control outside of units.
3) Provide insulation lining in accordance with NFPA Standard 90A requirements.
4) Specify units capable of handling minimum 5 inches static pressure.
5) Specify units independent of pressure variations and capable of operating satisfactorily throughout their range, from minimum to maximum air flow.
6) Calibrate volume control to identify air volume in increments of percent of maximum air flow.
7) Specify terminal unit performance and sound rating tested and rated in accordance with ARI 880 "Industry Standard for Air Terminals" and bearing the ARI certification seal.
8) Specify that VAV units in full compliance with UL 181 and NFPA 90A, meeting bacteriological standards of ASTM C665.
9) If VAV unit is to be used in a healthcare, clean room, or lab facility, specify a special VAV unit liner as required to minimize the amount of liner erosion. Follow healthcare facility standards as required.
10) Select VAV units so required RC sound levels in various spaces are not exceeded at 1.5" w.g. inlet pressure. Consider both unit-casing radiated sound levels (as attenuated by ceilings when present) and discharge sound levels.

Table 3040.4: VAV Terminal Unit Requirements

Equipment	Manufacturers	Performance Requirements
VAV Terminal Units	Anemostat; Carnes; Carrier; Environmental Technologies; Krueger; Metal-Aire;Price; Titus; Tuttle and Baily; Trane	

6. Special Exhaust Systems:
   a. Laundry Dryer Exhaust:
      1) For dryer vents providing shared exhaust of multiple dryers, provide appropriate exhaust fan. Locate fans to be easily accessible for service and easily cleanable.
      2) The shared exhaust vent shall have a 'Lint Collection Box' installed inline, upstream from the exhaust fan. It shall be easily accessible for maintenance, and made of corrosive resistant materials with an in-line filter material and a differential-pressure sensor with contacts for remote alarming.
   b. Kitchen Exhaust
      1) Install kitchen exhaust systems in accordance to code requirements.
      2) Kitchen exhaust duct to be made of welded stainless steel. Minimize horizontal distance of grease duct.

Known Campus Issues

1. VAV box and terminal unit locations:

A. VAV boxes and terminal units should be placed in locations that are accessible.
B. Locate boxes to minimize access door requirements and coordinate accessible locations with architectural plans.

D4010 – Fire Protection

Introduction

This section of the Facility Standards provides requirements and guidelines for the design and construction of fire protection systems at the University of Colorado-Boulder (UCB). The University is the Authority Having Jurisdiction (AHJ) for Fire Sprinkler Systems on campus. Any interaction or coordination with the City of Boulder Fire Department will be performed or approved by UCB.

It is the intent of UCB that all campus buildings, new or existing, be fully sprinkled. Renovation projects may require a fire protection system to be included in scope of work.

All fire protection systems shall be wet pipe systems.

UCB Requirements

1. UCB Review:
    a. Meet with the UCB Fire Marshal prior to the commencement of the design phase to determine scope and type of fire sprinkling system expected for each project, including equipment for new building construction, replacement of existing systems with new systems in existing buildings, and modifications to existing systems.
    b. If there is overlap in or conflicts between the requirements of the codes, laws and ordinances and this standard, use the requirement which provides the highest level of safety.

2. General Design:
    a. Design Method:
        1) The 'Room Design Method', 'Small Room Rule', or 'Extended Heads' is not an acceptable means of design. Using these design methods allows less flexibility for future renovations. Consultants and contractors should utilize standard heads (i.e. ordinary temperature and standard spray) and spacing in their layout.
    b. The consultant is responsible for the performance requirements of the fire protection system. The final layout can be delegated to the installing contractor; however, the consultant is responsible for providing enough information for the contractor to properly meet the design intent and the UCB Standards.
    c. Flexible pipe drops are only allowed in cloud ceiling systems.
    d. For renovation projects involving relocation of existing sprinkler heads, the design must require that all existing sprinkler heads be replaced with new in the entire project space unless the existing heads can be shown to be in service for less than 10 years.
    e. All sprinkler drains shall be routed to exterior softscape with splash block draining away from the building.
    f. The following items need to be provided by the consultant:

1) Main system pressure calculations to determine incoming pipe size and need for fire pumps.
2) Coordinate and show the main pipe entry and fire pump room.
3) Coordinate and show bulk main leaving fire entry and routing to standpipes in building.
4) Coordinate and show standpipes with zone control valves and zones.
5) Identify on the plans the hazard classifications for all spaces in the building.
6) Complete UL/FM system design, including actuating devices and control panels for dry and pre-action systems.
7) Specification of all materials, products, and manufacturers use on the project.
    i. For ease of maintenance and replacement, equipment needs to be a product type or from a manufacturer that is readily available and locally obtainable.
    ii. Provide equipment and materials from the same type and manufacturer throughout project; no mixing of manufacturers on same project.
    iii. It is preferred that the equipment selected should match existing installations on UCB campus.

g. The delegated design to the contractor may be the branch pipe layout and sizing, hydraulic calculations, final fire pump sizing, final main and standpipe sizing, sprinkler head placement and final coordination with fire alarm contractor.
h. Unrelated systems or conduit, including fire protection systems, are not allowed to pass through IT rooms.

3. Water Source:
    a. Confirm source of water and obtain available water supply from the University and include in specifications.
    b. Identify a full hydrant water flow test is required by contractor for installations that incorporate more than 15 newly added sprinkler heads.

4. Hydraulic Calculations:
    a. Use a safety factor of 10 percent or 10 psi whichever is less in hydraulic calculations.
    b. Use the more conservative water supply test results in hydraulic calculations.

5. Zoning:
    a. Accomplish system sub-section zoning by providing individual zone water flow detection, zone control valve, zone drain, gauge, and inspectors test connection.
    b. Provide separate zone for each floor of a building.
    c. Locate the test connection in a location that will allow elimination of as much trapped air as possible.

6. Systems Integration:
    a. Each fire protection system is to be monitored by the building fire alarm system.

7. Wet Pipe Systems:
    a. Antifreeze systems are not acceptable due to concerns about discharge, additives, reduced

pressure backflows, drain sizes, etc.

8. Dry Pipe and Pre-action Systems (by variance approval only):
    a. To reduce the likelihood of microbiologically induced corrosion (MIC), use nitrogen in place of air for all pre-action and dry systems.
    b. All new dry pipe or pre-action systems shall be provided with a nitrogen generator.
    c. Evaluate sprinkler rooms containing nitrogen systems in consultation with UCB EH&S for the need of an oxygen monitoring system designed to warn of an oxygen deficient atmosphere. If required, provide alarm notification on the exterior of the sprinkler room (near entrance).
    d. Provide automatic, field adjustable, and high-pressure reducing-type nitrogen maintenance device.
    e. Provide all-gravity drain to daylight separate from pressurized drain.
    f. Use flush seal gaskets on all dry and pre-action systems.

9. Mitigation of Corrosion:
    a. Piping:
        1) USA manufactured steel Schedule 10 or 40 and shall have an Antibacterial Formula – II ® (ABF – II ®) coating or approved equal.
        2) All fittings shall be of the same type throughout the project.
        3) Pipe Diameters 2 1/2” or Larger: Schedule 10
        4) Pipe Diameters 2” or Smaller: Schedule 40
        5) All pipe 2” and smaller shall have threaded fittings. The only exception to this requirement is at locations where unions would be required, grooved fittings may be used in place of unions. The number of grooved fittings for 2” and smaller pipe shall not exceed 1% of the total number of fittings installed on the system.
    b. Dry and Pre-action system Piping:
        1) Schedule 40.
        2) Pipe Diameters 2 1/2” or Larger: Cut-groove the pipe for grooved fittings. Roll grooved pipe is not acceptable on thin wall pipe.
    c. Drain Pipes
        1) Pipe Diameters 2 1/2” or Larger: Galvanized Steel Schedule 10 or 40.
        2) Pipe Diameters 2” or Smaller: Galvanized Steel Schedule 40; threadable thin-wall pipe may be used only if the threaded Corrosion Resistance Ratio is greater than or equal to 1.0.
    d. Fittings:
        1) Pipe Diameters 2 1/2” or Larger: Ductile iron grooved fittings of the same type throughout the project. For the pre-action systems, provide grooved fittings and gaskets that are listed for dry-pipe systems. Grooved fittings shall be of a type that does not require field lubrication; Victaulic Vic-Plus or approved equal.

10. Existing Equipment:
    a. Before considering existing equipment or piping systems for integration with a new project, test and inspect all such equipment or systems to assure their operational integrity and compliance with current codes. Verify if the existing equipment is compatible with the

proposed new equipment, and recommend to UCB if the existing equipment needs replacement.

b. For renovations that are adjacent to existing fire protection systems, new equipment will match the same manufacturer, make and model, as the existing, including:
    1) Sprinkler heads
    2) Pipe schedules
    3) Fittings
    4) Electrical devices
    5) Specialty valves
c. If existing equipment or piping is deemed unusable, remove in its entirety, i.e., abandoned pipe shall not be left in the building.

11. Valves, Sprinklers, Switches, Gauges:
    a. Locate valves in a manner that they are easily accessible and operable for ease of maintenance and operations.
    b. Concealed sprinklers shall not be specified.
    c. If sprinklers are not specified to be quarter point, install in a manner to allow easy removal of ceiling tiles.
    d. Temperature rating shall be the lowest rating allowed by code for occupancy.

12. Fire Department Connections:
    a. For new fire department connections, provide double 2-1/2" Siamese connection with (NH) threads, compatible with Boulder Fire Department threads.
    b. Provide drain facilities, piped to the outside of the building for fire department connection piping.
    c. Buildings shall have a single fire department connection.

13. Backflow Preventers:
    a. Fire lines shall be protected with an approved double check valve backflow prevention assembly at the base of the system riser downstream of the domestic water supply tap.
        1) FEBCO 850 is preferred.
    b. Provide complete assemblies including manufacturer's installed control valves.

14. Fire Department Hose Valves for Standpipes:
    a. Standpipe hose valves shall be in an accessible location without the need of a key

15. Drain and Test Valves:
    a. Discharge all main drains to the building exterior softscape with splash block through a properly sized drain riser. Engineer to determine and specify means and routing of drain discharge.
    b. If the fire protection piping is located at a lower elevation than the adjoining building grade, an outside drain installed to conduct main drain tests and a system auxiliary drain piped to a floor drain is required. An extra valve installed on the system drain piping may be necessary to isolate the system drain during tests of the 2" main drain.

c. Provide sight glasses on all inspector's test connections where discharge cannot be seen while valves are operated.
d. If an inspector's test connection is required, terminate at a 45-degree elbow with a sprinkler which has the frame and strut assembly removed; other restricted orifices listed for the same purpose may be acceptable. Pipe to the building exterior at grade level. If installed on the building interior, include a restricting orifice and discharge to an acceptable drain with adequate capacity. Specify the orifice size to be the same as the smallest sprinkler installed on the system.
e. Provide a concrete splash block with a minimum length of 4' to direct the drain or test discharge water so as not to disturb adjacent landscape.
f. Provide drain valves which are accessible and operable from the floor.

16. Switches:
    a. Supervisory Switch Criteria:
        1) Provide automatic reset capabilities.
        2) Capable of being wired in normally open/closed position.
        3) Provide cover with tamper resistant screws.
        4) Minimum contact ratings: 0.25 A @ 24 VDC
    b. Automatic Water Flow Detector Criteria:
        1) Provide electronic vane type or pressure activated.
        2) Built-in retard device, field adjustable from 0-70 seconds. Set for a time delay of thirty (30) seconds. Exception: pressure switches
        3) Automatic self-reset capabilities
        4) Tamper proof
        5) Minimum contact ratings: 0.235 A Q 24 VDC
        6) Capable of initiating a distinct water flow alarm signal at the Fire Alarm Control Panel (FACP) by zone.

17. Hydraulic Calculations:
    a. Do not exceed 16 ft./sec. velocity in underground water mains.
    b. Do not exceed 20 ft./sec. velocity in above ground sprinkler system piping.

18. Elevator and Electrical Equipment:
    a. Review elevator type, quantity, shaft construction and other related building systems to determine required fire protection for elevators, shafts, and equipment rooms.
    b. Protect each bank of elevators and associated equipment rooms by an independent zone unless determined otherwise by the design consultant and approved by the UCB Fire Marshal.
    c. Confirm need for back-up sump pump with UCB.

D4020 – Fire Protection Specialties

Introduction

This section includes requirements when specifying Fire Protection Specialties at the University of Colorado-Boulder (UCB). Fire extinguishers at UCB are maintained by an external vendor.

UCB Requirements

1. Fire Extinguishers:
    a. Specification of any Fire Extinguisher other than type A, B, or C requires UCB Fire Marshal approval.
    b. Provide Fire Extinguisher locations as required by code.

D5000 – General Electrical Requirements

Introduction

This section identifies the general electrical system introduction, instructions, codes and references which apply to all **D50** series of the Facility Standards.

All electrical components, devices, terminations, and accessories installed shall be listed and labeled as defined in NFPA 70 (NEC), Article 100, by Underwriters Laboratories and marked for intended use. Always comply with current codes and regulations, NFPA, NEC and all other applicable building codes.

The latest edition of the following codes and standards apply to all services:

a. National Fire Protection Association (NFPA)
b. NFPA 70, National Electrical Code (NEC)
c. Occupational Safety and Health Act (OSHA)
d. Underwriters Laboratory (UL)
e. Institute of Electrical and Electronics Engineers (IEEE)
f. Illuminating Engineering Society of North America (IESNA)
g. National Electrical Manufacturers Association (NEMA)
h. American National Standards Institute (ANSI)
i. FM Global

The following abbreviations are used throughout the electrical standards:

a. AV – Audio/Visual Systems: Refers to any systems requiring additional power, conduit, or box rough-in to support systems such as speakers, microphones, televisions/monitors, projectors, and other audio/visual systems.
b. EOR – Engineer of Record

c. IT – Information Technology: Refers to low voltage data and phone systems including their head end equipment, cabling, and end of line devices and/or ports.
d. UCBEE – University of Colorado Boulder Electrical Engineer

UCB Requirements

1. General:
    a. Electrical Rooms:
        1) Keep all systems foreign to the electrical from entering or passing through electrical rooms. Foreign systems serving the electrical room may enter, but all equipment, such as transfer fans, fan coil units, etc. must be located outside electrical room.
        2) Post a full size, laminated, set of one-line diagrams in electrical rooms of all new buildings.
    b. Switched Receptacles:
        1) The use of manually switched receptacles are not preferred on campus.

2. Product Data and Shop Drawings:
    a. Submit product data and shop drawings for the following products to verify that material standards are being satisfied. Create 1/4" scale shop drawings for all equipment room layouts and 1/8" for all device/controls layouts. Provide shop drawings for fault calculations and coordination study by selected gear vendor. Include equipment wiring diagrams indicating circuit arrangements, bussing, size, electrical ratings, equipment dimensions and weights, equipment arrangements, housing and proposed finishes, and NEMA rating.
        1) Circuit and motor disconnects including fuses
        2) Low voltage distribution equipment with equipment layout
        3) Switchboards:
            i. Contractor submittals must include front and side views of enclosures with overall dimensions shown; conduit entrance locations and requirements; nameplate legends; size and number of bus bars per phase, neutral, and ground; switchboard instrument details; instructions for handling and installation of switchboard; and electrical characteristics including voltage, frame size and trip ratings, withstand ratings, and time-current curve (TCC) graphs of all equipment and components, including fuses and circuit breakers provided.
        4) Panelboards
        5) Low voltage conductors
        6) Contactors
        7) Wiring devices
        8) Luminaires
        9) Lighting Controls, including zone schedules and shop drawings
        10) Generator, paralleling gear, and transfer equipment
        11) Battery power systems, including UPS systems
        12) Cabinets and enclosures
        13) Cabinets, enclosures, and supporting systems
        14) Electrical systems control
        15) Short circuit and coordination studies

b. Scaled drawings (1/4”), panelboard and switchboard submittals, and fault calculations is one inclusive submittal. Any submittal missing one of these parts or not complete for the project will be considered incomplete and will not be reviewed.
c. Permanent power will not be energized until the following are complete and verified by an independent testing agency, design engineer and facilities management.
    1) Coordination study has been submitted, reviewed and all breaker settings are set.
    2) The correct CT’s and PT’s are installed, metering is installed correctly per standards in Utility Metering section.
    3) Ground system is installed and tested, ground fault levels are properly set, and all the above is verified by an independent testing agency, the design engineer, and the University.
    4) Arc flash study has been submitted, reviewed and all labels are installed.
    5) Transformer primary cable testing has been performed and reports submitted to UCB Utility Services.
d. Provide a new circuit breaker coordination study of a building’s distribution system for all buildings where a feeder breaker is added. The independent testing agency shall give, in writing, all settings to the Contractor. Verify the settings at the time of final inspection.

3. <u>UCB Panelboard, Equipment, and Circuit Naming Conventions:</u>
    a. Incorporate the following Panel naming conventions, if applicable:
        1) Wing (A, B, C, etc.)
        2) Level (1, 2, 3, etc.)
        3) Panel Type (R-Receptacle, L-Lighting, M-Mechanical, C-Communications, S-Standby, E-Emergency) Panel Quantity (1, 2, 3, etc.)
    b. Room numbers are required on all panel schedules and circuit directories.

4. <u>Design Consultant Submittal Requirements:</u>
    a. Schematic Design (SD):
        1) Narrative that outlines the design, including load shed strategic plan.
        2) Electrical room drawings showing equipment sizing and layout (typical)
        3) One-line drawing(s)
    b. Design Development (DD):
        1) All lighting and devices, including all control devices, laid out but not circuited, or the circuitry beginning to be developed
        2) Low voltage one-line diagram and preliminary fire alarm riser
        3) Luminaire schedule, equipment schedule(s), and typical panelboard schedules
        4) Specifications – Full book specifications
        5) Medium voltage system one-line diagram
        6) Lighting control schedules
    c. Construction Documents (CD) submittal shall be complete and used as a review set for the comments by UCB:
        1) All lighting and devices laid out and completely circuited.
        2) All control devices and schedules laid out and defined.
        3) Completed power one-line diagram and fire alarm risers.

4) Completed medium voltage three-line diagram.
5) Completed luminaire, equipment, and panelboard schedules.
6) Completed specifications.
7) Completed energy code compliance report.
8) 1/4" scaled drawings of electrical equipment room(s).

d. Bid Drawings (used only as a back check of all previous review comments):
   1) Lighting
   2) Power/Communications/Fire Alarm
   3) Communications/Systems (if needed)
   4) One-line diagrams
   5) Risers
   6) Schedules, legends, details

e. The drawing review process includes written review comments to be delivered to the consultant from multiple UCB departments as necessary for full input. Respond to all comments in writing.
   1) A meeting is recommended between the consultant and commenting parties when needed to ensure that all comments are picked up.

5. Load Shed Capabilities:
   a. Provide load shed capabilities on all new buildings and all large projects encompassing the majority of any floor with building generator support. Provide means to shed non-essential loads, and other such items as established with UCBEE. The load shed signal shall be a remote signal and remotely controlled.

6. Craftsman Regulations:
   a. Include no more than one indentured apprentice per journeyman electrician. Apprentices are required to be under the direct supervision of a licensed electrician at all times.

7. Construction Requirements:
   a. Contactor will have available at the job site current information on the following at all times:
      1) Construction Plans and Specifications
      2) Addenda
      3) Change Orders
      4) Submittals
      5) Inspection Reports
      6) Test Results
      7) Outage Information and Requests:
         i. Electrical outages must be held to a minimum. The contractor must submit a request for the outage to the owner detailing the reasons for the outage, areas affected, sequence of procedures to accomplish work, estimated maximum length of time, the date and time of day outage will occur. The contractor must obtain written authorization from the owner fourteen (14) calendar days prior to all outages. Due to the critical implications of power outages, the owner may direct the contractor as to the time of day or night

and the date an outage may take place. The contractor will be responsible for any temporary power required.

8) As-built Drawings (showing all changes)

8. Maintenance:
   a. As part of the service and instruction manuals for the project, submit schematic diagrams and point-to-point wiring diagrams for the following systems. Ensure the submittal is electronic and searchable.
      1) Lighting/Dimming Control System
      2) Motor Control System
      3) Electrical Systems Control
      4) Medium Voltage Equipment

9. Project Closeout:
   a. Operating and Acceptance Tests:
      1) Hire an independent testing agent to conduct operating and acceptance tests on new electrical system components and all existing devices which are impacted by the project.
      2) The Testing agent shall prepare written reports of values of all test readings and procedures. Include in reports all circuit breaker settings and modifications to one line and three-line diagram drawings.
      3) The Testing agent shall furnish all equipment, instruments, and personnel required to conduct the tests.
      4) Test will be defined in the individual section describing the equipment or system.
      5) Complete thermographic survey is required for all installed equipment. Testing must meet current ANSI.NETA ATS thermographic survey requirements. Surveys should be performed during the periods of maximum possible loading, no sooner than 6 months after substantial completion. Refer to ANSI/NFPA 70B.
   b. Clean all electrical equipment (such as switches, panelboards, luminaires, etc.) of construction dirt, dust, paint smears, etc., and touch-up or repaint all scars, blemishes, rust spots, etc. to original or approved other state of finish.
   c. Compile a complete list of product data and shop drawings, acceptance tests, warranties, certificates, sub-contractor, and supplier information (i.e. name, address, and phone no.).
   d. Furnish a formal warranty covering the electrical system installed under the project contract, to be free from defective materials and workmanship for a period of one year after date of acceptance of installation by Owner. During this period provide all labor and new materials required to repair or replace all defects to the satisfaction of the Owner at no cost to the Owner.
   e. Provide campus EE with full set of record drawings updated from final contractor red-lined set. Accurately record exact locations of neutral and equipment grounding points and ground electrodes.
   f. Commission all emergency lighting systems. Commissioning will be performed by UCB electrical engineer and contractor by walking areas of emergency egress lighting during non-

daylight hours and taking foot-candle measurements. Where areas do not meet code, emergency lighting shall be added at no cost to the University.

D5010 – Electrical Service and Distribution

Introduction

This section includes requirements for electrical service equipment, conduit and raceways, boxes and supports, panelboards and switchboards, transformers, receptacles and similar devices, grounding, and other distribution equipment. This section excludes medium voltage requirements which can be referenced in **Facility Standard G3060**.

UCB Requirements

1. Raceway:
    a. Use of the following materials is prohibited:
        1) Aluminum conduit
        2) Extra-flexible, non-labeled conduit
        3) Electrical Non-Metallic Tubing (ENMT)
        4) MC Cable
        5) All non-steel fittings (steel fittings required for all conduit)
        6) Use of ceiling hanging wire to support raceways and boxes
    b. Underfloor Duct Design Criteria:
        1) Steel with corrosion resistant finish.
        2) System may be of either trench or duct header type. Review selection with UCB Electrical Engineer prior to design.
        3) Coordinate type of service fitting (flush, surface, etc.) and type of trim ring and fitting material (plastic, brass, aluminum, etc.) with UCB Electrical Engineer.
    c. Coordinate surface wire-way finishes and material with UCB Electrical Engineer:
        1) Design for aluminum/noncorrosive raceway materials in wet laboratory spaces only.
        2) All surface mounted conduit routing must be submitted to the UCBEE for review and approval prior to installation. There will be no cost to the University for rework if installed without written approval of the UCBEE.
        3) Paint all surface mounted conduit to match surface mounted upon. Use paint appropriate for conduit application.
    d. Minimum conduit size shall be 3/4” in all buildings.
    e. Size conduit (for receptacle circuits, motor circuits, other circuits delivering power to devices whose utilizations is not producing light, and panelboard feeders only, to meet requirements of the National Electric Code insulation type RH, RHW, RHH. Lighting circuits shall comply with appropriate insulation fill tables.
    f. Provide rigid support for all raceways (i.e. with all thread or better).
        1) Use of ceiling support wire is prohibited for the support of raceways and boxes due to maintenance. By supporting with a more solid material, such as all thread, the boxes and raceways are less subject to swaying while being maintained.
    g. Specify Rigid Metal Conduit (RMC) for the following locations:

1) Corrosive and/or hazardous locations. Provide plastic jacket or coating in corrosive installation and coming out of slabs.
2) Surface mounted conduits on pads or floors of mechanical rooms and for a distance of 6'-0" AFF.
3) All 90-degree elbows installed in the slab or underground shall be PVC coated.
4) Specify suitable expansion fittings where conduits cross expansion joints.

h. General Requirements for Underground Raceways (Ducts) 600V or less:
1) Install Small Underground Raceways (Branch Circuits) conduit a minimum of 24" below finished grade.
2) Establishing minimum of 24" below grade prevents lighting conduits from being damaged.

2. Wire and Cable:
a. Conductors #10 AWG and larger shall be stranded copper; conductors smaller than #10 AWG shall be solid copper except in UCB Utility Facilities where all conductors must be stranded.
1) Exception: All control wire associated with UCB Utilities Central Plant shall be stranded, confirm locations with UCB.
b. Install all control and signal cables in conduit.
c. Where a circuit extends through a receptacle, all conductors shall be pigtailed so downstream load does not go through receptacles.
d. Wire Sizing and Voltage Drop:
1) Minimum wire size of #12 AWG for power and lighting circuits
2) For 20A 120V circuits longer than 75', specify #10 AWG conductors
3) For 20A 277V circuits longer than 150', specify #10 AWG conductors
4) For branch circuits with ampere load other than 20A and for distances greater than listed above, calculate voltage drop and size conductors for maximum 3% voltage drop. Show voltage drop for feeders at less than 2% on single line diagrams at Construction Document submittal and later issuances, may be listed in table format on the side of drawings. Voltage drop calculations to be made at 80% of feeder circuit breaker rating for consistency.
e. Wire Color Coding:
1) 208/120V – 3Ø Conductors:
i. Phase A: Black
ii. Phase B: Red
iii. Phase C: Blue
iv. Grounded (Neutral) Conductor: White
v. Grounding Conductor: Green
2) 480/277V – 3Ø Conductors:
i. Phase A: Brown
ii. Phase B: Orange
iii. Phase C: Yellow
iv. Grounded (Neutral) Conductor: Gray
v. Grounding Conductor: Green with Yellow Strip

f. All multiwire circuits require dedicated neutrals. No multi-branch circuit breakers are permitted.
g. Provide a grounding conductor(s) in all branch circuit raceways.
h. Require continuity and insulation (megger) resistance testing of all feeders, minimum four (4) megaohm.
i. Perform HI-POT test for the integrity of all poles and vacuum bottles in medium voltage installations.

3. Heat Trace Cables and Controls:
   a. This section includes gutter freeze protection and de-icing heat trace cable as well as controls for heat trace.
      1) Snow melt and custom rooftop systems are excluded and to be designed per project and submitted as a package from single manufacturer.
      2) Design and submit pipe freeze protection under mechanical scope of work.
   b. Heat trace cable for gutter de-icing/snow melting:
      1) The heating cable shall be UL and CSA listed specifically as electric gutter de-icing and snow-melting equipment.
      2) The heating cable shall be of parallel resistance construction capable of being cut to length and terminated in the field.
      3) The heating cable shall consist of two parallel nickel-plated coper bus wires embedded in a radiation cross-linked self-regulating conductive polymer core specifically designed for snow and ice melting. The heating cable shall include a polyolefin dielectric jacket rated 300 VAC at 105°C, a tinned-copper braid (14 AWG equivalent wire size), and a UV stabilized polyolefin over jacket.
   c. Controls for Gutter De-Icing/Snow Melting Heat Trace:
      1) All new construction shall be controlled by Andover weather station.
      2) Existing buildings:
         i. Provide dual controls for gutter de-icing/snow melting.
         ii. Provide controls consisting of both temperature and moisture sensing. Temperature must be 34°F or lower and moisture must be present in the gutter for heat trace to operate. If moisture is not present and temperature is below 34°F heat trace is not to operate. Both conditions must be met for heat trace to operate.
         iii. Controller shall be Environmental Technology, Inc. Model APS-4 snow switch or approved equal by UCBEE sized for the application, i.e., number of zones controlled.
         iv. Controller must be tied to the building BAS system.
   d. Testing of All Gutter De-Icing/Snow Melting Heat Trace Cabling and Gutter De-Icing/Snow Melting cables:
      1) Test heating cable with a megohmmeter (megger) between the heating cable bus wires and the heating cable metallic braid. While a 2,500VDC Megger test is recommended, the minimum acceptable level for testing is 500VDC. Perform this test a minimum of three times:
         i. Once prior to installation while the cable is still on the reel(s).

ii. Once again after installation of heating cable and completion of circuit fabrication kits (including any splice kits) but prior to installation of thermal insulation.
iii. And finally, after installation of thermal insulation, but prior to connecting cable to power.

e. Install gutter/downspout heating system in accordance with the manufacturer's requirements. Any deviations shall be reviewed and approved by the manufacturer and UCBEE.
   1) Coordinate system with requirements identified in **Facility Standard B2020**.
f. Priority of location for installations:
   1) All north facing gutters
   2) All gutters above entry ways
   3) Areas where ice dams will occur
g. For all projects, test the heating cables and submit results to UCBEE for review and approval. For final inspection, turn the system on and have UCB personnel verify that heat trace is operating.

4. <u>Boxes:</u>
   a. Prohibited boxes and installations:
      1) Boxes for buried flush grade locations.
      2) Box extensions for new construction:
         i. One extension is permitted on remodel work to extend existing installations. Where more than one box is needed to flush out installation, provide a large (i.e. 6"x6") box to flush out the existing box and nipple over to a new box.
      3) Back-to-back outlet boxes in finished walls.
      4) Use of ceiling hanging wire to support raceways and boxes.
   b. Specify galvanized steel sheet metal pull and junction boxes. Minimum size: 4 square, 2 1/8" deep.
   c. Boxes for outdoor and wet locations shall be flat flanged, surface mounted, UL Listed as raintight, galvanized cast iron box, and cover with neoprene gasket and stainless-steel cover screws.
      1) Metal boxes are required over plastic as plastic boxes are typically noted on campus to be damaged in less than one year.
   d. Separate boxes by a minimum of 6" horizontal in standard walls and a minimum of two (2) feet horizontal in acoustical walls so as not to create sound issues from back to back outlet boxes.
   e. Provide back supports for all boxes in metal stud walls.
   f. Rigidly support boxes (i.e. with all thread or better).

5. <u>Wall Switches, Receptacles, and Device Cover Plates:</u>
   a. Provide wall switches, receptacles, and cover plates from the same manufacturer. (Hubbell, Leviton, Arrow-Hart, Eagle, Pass & Seymour).
   b. Wall Switch Preferred Manufacturers:
      1) Hubbell Incorporated; Wiring Device-Kelems

2) Leviton Mfg. Company Inc.
3) Cooper Wiring Devices; a division of Cooper Industries, Inc.; Arrow-Hart
4) Pass & Seymour/Legrand; Wiring Devices and Accessories

c. Provide switches in accordance with **Table D5010.1**:

Table D5010.1

DEVICE	HUBBEL CATALOG #
Single Pole Switch	1221
Single Pole Switch with Pilot Light (120V – load on)	1221-PLC
2 Pole Switch	1222
3-Way Switch	1223
4-Way Switch	1224
3 Position Switch (momentary contact)	1557
3 Position Switch (momentary contact) (locking)	1557-L
Single Pole Switch (locking)	1221-L
2 Pole Switch (locking)	1222-L
3-Way Switch (locking)	1223-L
4-Way Switch (locking)	1224-L
Single Pole Switch with Pilot Light (277V – load on)	1222-PL7
3 Position Switch (maintained contact)	1385
3 Position Switch (maintained contact) (locking)	1395-L

d. Install switches as indicated on drawings, arranged singular or in gangs and within 18” of the door jam on the strike side of the door openings. Coordinate locations with door swings identified on the architectural drawings prior to rough-in.
e. All switches in mechanical rooms, electrical rooms, and other similar rooms shall be a lighted handle single pole light switch(es) as required.
f. Receptacles Preferred Manufacturers:
    1) Hubbell Incorporated; Wiring Device-Kelems
    2) Leviton Mfg. Company Inc.
    3) Cooper Wiring Devices; a division of Cooper Industries, Inc.; Arrow-Hart
    4) Pass & Seymour/Legrand; Wiring Devices and Accessories

g. Provide receptacles shall be in accordance with **Table D5010.2**:

Table D5010.2

DEVICE	HUBBEL CATALOG #
Duplex Receptacle, 20A, 125V	5362
Duplex Receptacle, 20A, 125V, Isolated Ground	IG-5362
Duplex Receptacle, 20A, 125V, Ground Fault	GF-5362
Single Receptacle, 50A, 250V, Locking	CS-6370
Single Receptacle, 15A, 125V	5262
Single Receptacle, 30A, 125V, Ground Fault	IG-9308
Single Receptacle, 20A, 125V	5361
Single Receptacle, 60A, 250V	9460
Single Receptacle, 30A, 125V	9308
Single Receptacle, 30A, 125/250V	9430
Single Receptacle, 30A, 250V	9330
Single Receptacle, 50A, 250V	9367
Single Receptacle, 50A, 125/250V	9450

h. Provide heavy duty, specification grade, grounding type receptacles in all areas.
i. Receptacles shall have a one-piece brass strap.
j. Mark isolated ground receptacles with an orange triangle.
k. Provide hospital safety grade receptacles in all areas associated with children.
l. Cover Plate Materials:
    1) Smooth Metal: Stainless steel in back-of-house areas, docks, mechanical/electrical rooms, storage. All other spaces cover plate materials up to the architect/designer.
    2) Smooth Lexan: In all locations unless otherwise directed.
    3) Wrinkle Finish: Steel, finish to be painted, color to be ivory unless removed, primed with gray enamel.
    4) Gaskets: Resilient rubber or closed cell foam urethane.
    5) Weatherproof: Cast metal or aluminum, gasketed; provide spring loaded gasketed doors. All devices in areas subject to frequent use shall be “in-use” type of covers.
m. Provide ivory color switch and receptacle unless otherwise specified, cover plates to match. Verify color with project architect prior to ordering.
n. Provide red color switch and receptacle for life safety circuits.

o. Provide circuit and panelboard identification on outside of switch and receptacle cover plates as noted in Electrical Identification requirements.

6. Cabinets and Enclosures:
   a. Hinged Cover Enclosures:
      1) Provide NEMA rated enclosures, steel, suitable for environment in which installed, with enamel finish.
      2) Provide continuous hinge with key lock latch (matching key/lock National #C413A). Match the cover material and finish to the enclosure.
      3) Steel gage of enclosure shall be suitable (minimum 14) for mounting electrical components, terminal blocks, etc.
      4) Enclosure cabinets over 12" in any direction shall also have quarter turn latches.
   b. Terminal blocks and accessories shall be rated 600V for power terminals, rated 300V for control terminals, and UL listed for application and load carried.
   c. Require protective pocket inside front cover with schematic diagram, connection diagram, and layout drawing of control wiring and components within enclosures.

7. Supporting Devices:
   a. Specify stud bridges at top and bottom of cabinets and enclosures which are flush mounted in hollow drywall walls.
   b. Use of Caddy 8/ZMB/8 to support conduit is prohibited.

8. Electrical Identification:
   a. Phenolic Nameplates:
      1) Provide engraved three-layer laminated plastic, black letters on white background.
      2) Life safety and emergency nameplates: white letters on red background.
      3) Locate nameplates on outside face of panelboard doors in finished locations.
      4) For engraving, identify the name of the device, panelboards, etc. The "voltage, loads served" line also shall include the name of the feeding panel, switchboard, etc.
   b. Electronic Printed Labels:
      1) Electronic labels are permitted only for identification of disconnects, individual wall switches (in unfinished areas), control station devices and starters, and on the outside face of receptacles and wall switch plates.
      2) Provide circuit and panelboard identification on the outside of all receptacle plates with embossed tape, or electronic label maker.
   c. Wire Identification:
      1) Provide wire markers on each conductor at points of termination in panelboards, outlet and junction boxes, and at load connections. Identify with branch circuit or feeder number for power and lighting circuits and with control circuit number for control wiring. Install wire markers in panelboard between dead-front and edge of can.
   d. Switchboards, Motor Control Centers, Panelboards, and Transformers:
      1) Identification:
         i. 1/2" high letters

2) Source (fed from equipment):
    i. 1/4” high letters
3) Voltage, Loads Served (feeding equipment):
    i. 1/4” high letters

e. Switches, Starters, Receptacles:
1) Electronic tape on outside faceplate in finished areas.

f. Pull and Junction Box Labeling:
1) For ease of identification during maintenance and remodeling, mark all junction box covers, exposed and concealed, with a minimum of 1” high letters on high quality (non-generic labels, intention is to last for years on cover plates), white sticker paper attached to cover:
    i. Panel and circuit number(s) in box (for power/lighting circuits)

9. Service Entry:
a. The main service ground shall be terminated on a 1/4"x4”x2’-0” section of copper bus on stand-off supports, located in main electrical equipment room, adjacent to main switch gear. Verify requirement with UCBEE.
1) Ground terminations to this bus shall be by means of exothermic welding, in accordance with IEEE-80, Chapter 9, “Selection of Conductors and Joints.”

10. Switchboards:
a. Preferred Manufacturers:
1) Main Distribution Switchboards:
    i. GE Electrical Distribution & Control (ABB)
    ii. Eaton Corporation; Cutler-Hammer Products
    iii. Siemens Energy & Automation, Inc.
    iv. Square D; Schneider Electric
2) Fuse:
    i. Bussmann; Cooper Industries; Eaton
    ii. Ferraz Shawmut Fuses; Mersen Electrical Power
    iii. Littelfuse, Inc.

b. Main and Distribution Switchboard Construction and Rating:
1) Switchboard systems shall be factory assembled, dead front, metal enclosed, self-supporting, and conforming to NEMA PB2.
2) Depending on the rating of switchboard, provide for front only accessibility or front and rear accessibility. Switchboards 2000A and below shall have front access, switchboards above 2000A shall have front and rear access.
3) Bus material shall be copper. The switchboard shall be designed for future expansion of one full rated additional section, with full size horizontal bussing throughout and extension stub outs. Coordinate bus short circuit rating with available fault current calculation. Size switchboard in accordance with NEMA PB2.
4) Bus connections shall be bolted with provisions for accessibility of joints after switchboard is installed.
5) Provide code sized copper ground bus throughout switchboard.

6) Spaces designed for future devices shall have full capacity bus and be equipped with bus connection. Brace an insulate spaces for available fault current.

c. Overcurrent Protective Devices:
   1) Fusible Switch Assemblies Below 800 Amperes:
      i. Quick make, quick break, load interrupter enclosed knife switch with externally operable handle. Provide override release screw to permit opening front cover with switch in the "on" position. Handle lockable in the "off" position. Fuse clips to accommodate fuse class required by fault current availability.
   2) Fusible Switch Assemblies 800 Amperes and Larger:
      i. Bolted pressure contact switches or HPC (High Pressure Contact) switches. Fuse clips to accommodate fuse class required by fault current availability.
   3) Molded Case Circuit Breakers:
      i. Provide with integral thermal and magnetic trip in each pole.
   4) Solid-State Molded Case Circuit Breakers:
      i. Provide with electronic sensing, timing, and tripping circuits for adjustable current settings; ground fault trip, instantaneous trip, and adjustable short-time and long-time trip. The instantaneous shall be capable of being turned on and turned off on the main breaker only.
      ii. All main devices shall have the adjustments per above. These adjustable settings shall also be provided on all devices feeding MCC's or large motor loads.
   5) Insulated Case Circuit Breakers:
      i. Provide factory assembled, low voltage insulated case circuit breakers. Include electronic sensing, timing, and tripping circuits for adjustable current long-time delay, long time pickup, ground fault operation, short trip, and instantaneous trip and turned off on the main breaker only.
   6) Arc Energy Reduction:
      i. Devices where the highest continuous current trip setting for which the actual device installed in a circuit breaker is rated or can be adjusted is 1200A or higher, provide documentation per NEC 240.87 and approved method to reduce clearing time.
      ii. Maintenance switch located on the equipment is required to comply.
   7) Type of overcurrent device to be used shall be coordinated with UCB Electrical Engineer.
   8) A coordination study must be provided at the contractor submittal review state which verifies devices and fuse selection. Include time current curve (TCC) graphs and device settings. This is required for all 13.2kV, 480V, and 208V system additions or modifications.
   9) As a minimum, all research buildings shall be provided with surge and noise protection via Surge Protective Device (SPD).
   10) Ground Fault Relay and Sensor:
      i. Zero sequence sensor with adjustable ground fault relay. Adjustment from 200 to 1200 amperes, time delay adjustable from 0 to 15 seconds. Provide

with monitor panel and lamp to indicate relay operation, “TEST” and “RESET” control switches.

11) All breakers to be 100% rated.

d. Mount switchboards on 4” high, full sized housekeeping pad extended no less than 2” past plan dimensions of equipment.
e. Specify a framed Record Drawing showing final arrangement, modifications, and capacities of switchboard and system one-line drawing for easy reference, mounted on main electric room wall as noted in **Facility Standard D5000**.
f. Provide battery powered or emergency lighting in main switchboard rooms.
g. Switchboard configuration at design and construction shall meet the following requirements:
    1) Load balance switchboards to within 10% phase to phase.
    2) 25% spare equipped spaces.
    3) For lab, data center, and research buildings the service entrance switchboard(s) shall be double-ended with tie breaker provisions. (Provide provisions for kirk key or electronic interlock system.) Confirm correct operation and sequencing of system.
    4) Specify spare lugs on load side of all main circuit breakers or switches. Capacity of lugs shall be full amperage rated up to a maximum size of 4-#4/0 AWG.
h. Testing Requirements shall be as follows:
    1) Require measurement of resistance of switchboard insulation after assembly is complete. Test voltage shall be 1000V. Acceptable minimum resistance 100 mega-ohms all sections, phase to phase, and phase to ground with other phases grounded.
    2) Provide ground fault testing in accordance with NETA ATS.
i. Require the following adjustments and cleaning after installation:
    1) Touch up scratched or marred surfaces to match original finish.
    2) Adjust trip and time delay settings on adjustable devices. Indicate setting values on the construction drawings.

11. <u>Disconnect Switches:</u>
    a. Safety Switch Manufacturers:
        1) General Electric (ABB)
        2) Westinghouse/Cutler-Hammer (Eaton)
        3) ITE/Siemens
        4) Square D Company
    b. Fusible and non-fusible disconnect/safety switch assemblies (NEMA KS-1) shall be heavy duty rated, quick-make, quick-break, load interrupter enclosed knife switches with externally operable handle with override screw to permit opening of front cover with the switch in the “on” position. Switch handle is to be lockable in the “off” position. Fuse clips to be Class R rejection style, designed to accommodate required fuses.

12. <u>Secondary Grounding:</u>
    a. All ground rods shall be copper encased steel, 3/4” diameter, and minimum 10’ in length.

b. Provide a separate full sized insulated equipment grounding conductor in all feeder circuits. Terminate each end on a ground lug, bus, or bushing.
c. Require connection of grounding electrode conductors to metal water pipe. Connections are to be made to flange piping at the street side of the flange. Require bonding jumper around water meter.
d. Provide minimum #3/0 AWG copper conductor in conduit for communications service grounding conductor terminated at building grounding electrical system.
e. Bond all panelboard enclosures to its respective grounding bus. Bond all metal boxes to the grounding conductor.
f. Ground Bus:
    1) Provide a grounding bus in all electric rooms in the Facility. Connect the ground bus by the proper sized grounding conductor and directly connect it to the building's main grounding system.

13. <u>High Efficiency Dry Type Transformers:</u>
    a. Include outline and support point dimensions of enclosures and accessories, unit weight, voltage, kVA, and impedance ratings and characteristics, loss data, efficiency at 25, 50, 75, and 100 percent rated load, sound level tap configurations, insulation system type, and rated temperature rise.
    b. Preferred Transformers Manufacturers:
        1) GE Electrical Distribution & Control (ABB)
        2) Eaton Corporation; Cutler-Hammer Products
        3) Eaton Corporation; Sola/Hevi-Duty Electric
        4) Siemens Energy & Automation, Inc.
        5) Square D; Schneider Electric
        6) Mirus International Inc.
        7) Powersmiths Socomec Group
    c. Distribution transformers requiring cooling fans and/or have automatic shutdown are not acceptable.
    d. All transformers shall be floor mounted atop concrete housekeeping pads at least 4" larger than the foot print dimensions of the unit and 4" high, with neoprene isolation pad between transformer feet and concrete base.
    e. Performance Criteria for Dry Type Transformers:
        1) Efficiency:
            i. Transformers installed on campus shall meet the current requirements of DOE minimum efficiency ratings, ANSI/NEMA Standards TP-1 and TP-2, and shall not be back-ordered stock of lesser efficiency.

ii. Minimum efficiency requirements listed in **Table D5010.3**:

Table D5010.3

kVA Rating	Watt Losses (W)	Efficiency
15	75	97%
30	115	98.25%
45	150	98.39%
75	225	98.6%
112.5	320	98.74%
150	400	98.81%
225	560	98.5%
300	710	99%
500	1100	99.16%

2) Insulation and Temperature Rise:
   i. Transformers 15kVA and below: Class 185 insulation and 80°C temperature rise
   ii. Transformers above 15kVA to 500kVA: Class 200 insulation and 115°C temperature rise
3) Winding Taps:
   i. Transformers below 15kVA: Two (2) 5% below rated voltage, full capacity taps on primary winding.
   ii. Transformers 15kVA and above: Two (2) 2-1/2% above rated voltage, four (4) 2-1/2% below rated voltage, full capacity taps on primary winding.

4) Sound levels:
    i. Maximum sound levels are listed in **Table D5010.4**:

Table D5010.4

kVA RATING	SOUND LEVEL
0-45	42 dB
75-100	47 dB
225-300	52 dB
500	57 dB

5) Capacity:
    i. Design of transformer capacities should allow a minimum of 25% growth capabilities of electrical loads served by transformer.

f. Transformer winding assemblies shall be isolated from housing by vibration isolation mounts.
    1) Specify minimum of 2' and maximum of 3' flexible conduit for transformer connections.
    2) Require standard manufacturer vibration isolation mount s for all connections between structure and housing of transformer.

g. Windings shall be continuous copper to optimize efficiencies at 115°C temperature rise and qualify for 25-year warranty.

h. K-Rated Transformers:
    1) In areas with heavy computer loads, K-Rated (non-linear) transformers shall be provided. Only computer loads shall be connected to the transformer.
    2) Electrostatic shielding shall be provided for minimum 60 dB attenuation.
    3) Standard warranty shall be 25 years.

14. Busway:
    a. Busway and Plug-In Units Manufacturers:
        1) GE Electrical Distribution & Control (ABB)
        2) Eaton Corporation; Cutler-Hammer Products
        3) Siemens Energy & Automation, Inc.
        4) Square D; Schneider Electric
    b. Indoor Plug-In Busway:
        1) Single or 3-phase with number of low impedance copper busses as required, 120/208V or 277/480V rated, 60 Hz. Provide with non-ventilated housing with plug-in openings 24" on center, each side. Provide with hinged doors to protect unused openings. Busway to have full sized neutral and integrated ground bus. Joints to be single bolt type with silver plated contact surfaces.

c. Indoor Feeder Busway:
    1) Single or 3-phase with number of low impedance or copper busses as required, 120/208V or 277/480V rated, 60 Hz. Provide with ventilated housing, full sized neutral, and integrated ground bus. Joints to be single bolt type with silver plated contact surfaces.
d. Plug-In Units for Plug-In Busways:
    1) All units to have hinged door and operating handle for stick or chain operation.
    2) Molded case thermal-magnetic circuit breaker protection to be provided with integral thermal and instantaneous magnetic trip in each pole.
    3) Fusible switch protection assemblies to be quick make, quick break, load interrupter enclosed knife switch with externally operable handle, lockable in "off" position. Fuse clips for Class R fuses.
e. Bus joints shall be tightened using a calibrated torque wrench.
f. Provide adequate space in busway riser layout to allow for tap box to be connected within electrical room for temporary bypass of a failed busway section.
g. Support bus duct horizontal runs with threaded rod suspension hangers at intervals not to exceed 5' on center. Provide horizontal sway bracing when busway contains operable plug-in units.
h. Provide adequate space near spare spaces for future bus switch installations.
    1) It is recommended to show spaces as future on drawings for clarity/coordination.

15. Panelboards:
    a. Panelboard Manufacturers:
        1) General Electric (ABB)
        2) Westinghouse/Cutler-Hammer (Eaton)
        3) ITE – Siemens
        4) Square D Company
    b. Prohibited Installations:
        1) "Piggyback" circuit breakers are not permitted.
        2) Load Centers are not permitted.
        3) Sub-feed circuit breakers are not permitted (except in remodel projects).
    c. Panelboard Performance Specifications:
        1) Panelboard assembly shall be bolt on, circuit breaker type, cabinet front with concealed trim clamps, door in door hinged trim construction with flush lock (see detail in Appendix), finished in manufacturer's standard gray enamel. Provide with copper bus rated at 120/208V or277/480V, 1Ø or 3Ø. Also, provide ground bus and full size neutral bus.
        2) Lighting and receptacle branch circuit breakers shall be minimum 20 Ampere.
        3) Provide minimum 25% future circuit spaces for total connected circuit breakers in panelboard.
        4) Specify maximum of 42 poles per panelboard. If more are required, specify two-section panelboards. Where two-section panelboards are required, use full capacity sub-feed lugs. Both sections shall be the same size (ampacity and number of circuit breakers). All panelboards shall be full of breakers.

5) Provide a schedule of panelboards in the construction drawings which clearly indicates the following:
    i. Panelboard type
    ii. Number of poles
    iii. Main bus ampacity
    iv. 100% rated Main circuit breaker with LSIG adjustability
    v. Quantities of each size of circuit breaker
    vi. Flush or Surface mounting
    vii. Total Connected Load and Demand Load
    viii. Design Load
    ix. Panelboard short circuit rating
    x. Calculated available short circuit at panelboard. If within 10% of available shown, provide next highest AIC rating.
    xi. Each circuit shall have its load in Watts shown and description of what/where the circuit feeds.
    xii. On remodel projects, provide a full panelboard schedule with all existing devices and loads shown, and note the vacated/reused circuits. A load study is still required on remodel projects and depending upon the project size, a load change calculation ((total existing load x 125%) – removed load + new load) may be acceptable.
    xiii. Require phase balancing and show on the drawings of completed panelboard installation to within 20%.

d. Provide flush or surface cabinet front as required.
e. All panel door locks to be keyed alike.
f. Two section panelboards shall be constructed in the same manner as stand-alone panelboards. The hinged covers shall not cover the adjacent panelboard.
g. Non-linear load panelboards shall be provided in areas with heavy computer loads and all lab areas. These panelboards shall be provided with double neutrals and be fed from K-Rated transformers.
h. Panelboards shall be fully rated, the use of series rated panelboards is prohibited.
i. Provide full-size, bolt-on, 100% rated, molded case circuit breakers with integral thermal and instantaneous magnetic trip in each pole.
j. Mounting height to the top of all panelboards shall be 6’-6”.
k. Provide directory cards, typed, showing each branch circuit load with spares and space written neatly in erasable pencil. Do not include VA on schedule.
l. For every three (3) unused spaces and/or three (3) spare circuit breakers, stub one (1) 3/4” empty conduit out of flush mounted panelboards into accessible areas.
m. Where main circuit breakers are required, they shall be bolted to the ends of the main busses. Back connected breakers and branch mounted breakers are prohibited.

16. <u>Motor Control:</u>
    a. Motor Control Manufacturers:
        1) General Electric (ABB) CR306 series starters
        2) Eaton Class A200 or type AN16 series starters

3) Siemens Class 14 starters

b. Manual Motor Starters, AC, general purpose, Class A manually operated full-voltage controller for induction motors rated in horsepower, with Class 10 overload relay, red pilot light and toggle operator. Number of poles as required. Enclosure rating as required. Housing finished in manufacturer's standard enamel.

c. Variable Frequency Motor Controllers:
   1) Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79" above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding rack.
   2) Floor-Mounting Controllers: Install VFCs on 4" nominal thickness concrete base.
      i. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18" centers around the full perimeter of concrete base.
      ii. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
      iii. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
      iv. Install anchor bolts to elevations required for proper attachment to supported equipment.
   3) Roof-Mounting Controllers: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than 79" above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.
   4) Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.
   5) Startup service and/or commissioning is highly recommended to be by a factory-authorized service representative.
   6) Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      i. ABB
      ii. Danfoss
   7) VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
   8) Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General-Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both".

9) Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors".
10) Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
11) Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

17. Lightning Protection Systems:
    a. Lightning Protection System Design Requirements:
        1) Design consultant to perform NFPA lightning probability calculation to determine if NFPA recommends a lightning protection system.
        2) Lightning protection systems will reference Lightning Protection Institute (LPI) and NFPA. Specify the features and the requirements for a complete UL master labeled lightning protection system. Indicate the requirement for bonding roof mounted mechanical equipment, structural elements, vents, etc.
        3) Specify that shop drawings show layout of air terminals, grounding electrodes, and bonding connections to structure and other metal objects. Information to include terminals, electrodes, conductor sizes and connections, and termination details. The shop drawings shall be master label stamped.
    b. Lightning Protection System Performance Requirements:
        1) Manufacturer and installer shall be a company specializing in lightning protection equipment with minimum of three years documented experience and a member of the Lightning Protection Institute. Require the installer to be a licensed master installer.
        2) Materials:
            i. Air Terminals – Copper
            ii. Grounding Rods – Copper clad steel
            iii. Ground Plate – Copper
            iv. Conductors – Copper cable
            v. Connectors and Splices – Bronze, Exothermic
            vi. Ground Well – For accessible connection for testing
        3) Installation:
            i. Require that the complete installation be inspected and certified by Underwriters Laboratories, Inc. (UL) to obtain a master label. Label to be attached to building at location directed by UCB Electrical Engineer.
            ii. Require that installation be coordinated with the project architect to provide concealment of down conductors, air terminals, etc., to obtain an acceptable installation.

18. Transient Voltage Suppression, Surge Protective Devices (SPD) – Selenium Enhanced SPDs:
    a. Listed in this section are requirements for a high energy, dual-listed, surge arrester and Surge Protective Device (SPD) (formally known as transient voltage surge suppressor (TVSS)) electronic filtering system used to protect AC electrical distribution from the effects of

lightning, utility switching events, temporary over voltages (TOV), and impulses generated internally within the facility.

b. Specify unit to be designed, manufactured, tested, and installed in compliance with the following standards:
    1) ANSI/IEEE C62.41-1991 and C62.45-1992
    2) ANSI/IEEEE C62.1 and C62.11
    3) Canadian Standards (CUL)
    4) Federal Information Processing Standards Publication 94 (FIPS PUB 94)
    5) National Electrical Manufacturers Association (NEMA LS1-1992 Guidelines
    6) National Fire Protection Association (NFPA 70 [NEC], 75, and 78)
    7) Underwriters Laboratories (UL 96, 198, 248-1, 489, 1283 and 1449-Second Edition)
c. Submittals:
    1) Product Data: Provide complete product data detailing manufacturer's model number, specifications, features, and options. Substitute/alternate products require pre-approval, and shall only be considered if the **D5010 Attachment 1 SPD Submittal Compliance Form** is fully completed and submitted at least fourteen (14) days prior to bid date.
    2) Test Data: Certified documentation shall be provided of the product's UL 1449 Second Edition listing, clamping values (to include ratings with internal disconnects, if applicable), surge current fuse testing, independent test lab single pulse surge current capacity testing, and minimum repetitive surge current capacity testing.
    3) Shop Drawings: Provide electrical and mechanical drawings that include detail on unit dimensions, weights, field connections, and mounting provisions.
    4) Installation, Operation and Maintenance Manuals: Provide one copy of the installation, start-up, and operation and maintenance data for each unit supplied.
d. Acceptable Manufacturer:
    1) These specifications detail performance requirements for selenium-enhanced suppression system manufactured by Current Technology. Substitute, value-engineered, or alternate products shall meet all performance and reliability aspects of this specification. The surge suppression and noise filtering unit shall be as follows:
        i. Service Entrance Location: Current Technology Model #SL2-150, or pre-approved equal
        ii. Panelboard Location(s): Current Technology Model #TG100, or pre-approved equal
e. Substitution Pre-Approval Procedure:
    1) Manufacturers requesting approval of their products shall identify the full model number and submit product data, specifications, and complete the **D5010 Attachment 1 SPD Submittal Compliance Form** at least fourteen (14) days prior to bid date.
f. Warranty:
    1) Provide a manufacturer's warranty providing a fifteen (15) year warranty from the date of shipment against failure when installed in compliance with applicable national/local electrical codes and the manufacturer's installation, operation and maintenance instructions.

g. Local Service Support:
   1) A dedicated support organization shall be located within 150 miles of the project location, and shall have experience supporting at least twenty other projects of similar complexity within the last three years. Personnel shall perform a start-up service to verify correct installation of the filters, perform transient voltage tests for reliability and performance using appropriate surge generating test equipment, and respond on-site to investigate user concerns.

h. Product Performance Requirements:
   1) High Performance Suppression System:
      i. The suppression system shall incorporate a hybrid design of selenium cells (for service entrance location only), metal oxide varistor (MOV) arrays, and filtering capacitors. These components shall optimally share surge currents to ensure maximum performance and long-term reliability. The system shall not utilize gas tubes, spark gaps, silicon avalanche diodes, or other components that might short or crowbar the line, thus leading to power interruption.
   2) UL Dual Listed – Surge Arrester and Surge Suppressor:
      i. The system shall be UL listed as category XUHT (UL1449 Second Edition, manufactured after February 2009) and CUL approved as a transient voltage surge suppressor, as well as UL listed as category OWHX (UL 96) as a secondary surge arrester, and UL listed as category FOKY (UL 1283) as an electromagnetic interference filter.
   3) Unit Operating Voltage:
      i. The operating voltage and configuration shall be 277/480V grounded wye for service entrance location and 120/208V grounded wye for panelboard locations.
   4) Maximum Continuous Operating Voltage (MCOV):
      i. The MCOV shall be greater than 115 percent (%) of nominal voltage, but no greater than 130 percent (%). Test and evaluation shall be as outlined in NEMA LS1-1992, paragraphs 2.2.6 and 3.6.
   5) Protection Modes:
      i. Per the definitions in NEMA LS1-1992, paragraph 2.2.7, all modes shall be protected (e.g., line-to-line, line-to-neutral, line-to-ground, and neutral-to-ground).
   6) Rated Single Pulse Surge Current Capacity:
      i. Calculations for single pulse surge current capacity shall use the component manufacturer's individual component rating multiplied by the respective number of per mode components. Documentation shall be provided with submittals on the Attachment 1 SPD Submittal Compliance Form. Component manufacturer's ratings shall be derived using the ANSI/IEEE C62.41-1991 Category C1 8X20 sec, 3000A current waveform. The per mode single pulse surge current rating shall be calculated based upon the component manufacturer's catalog rating for each device. The minimum rated single pulse surge current capacity per mode shall be as identified in **Table D5010.5**:

Table D5010.5

Rated Single Pulse Surge Current Capacity				
Location	L-N	L-G	N-G	L-L
Service Entrance	150,000 A	150,000 A	150,000 A	150,000 A
Panelboards	100,000 A	100,000 A	100,000 A	100,000 A

7) Tested Single Pulse Surge Current Capacity:
    i. The suppression filter system shall be single pulse surge current tested in all modes at rated surge currents by an industry-recognized independent test laboratory. Units with surge current capacities of 200,000 Amps or less shall be tested as a unit, not individual modules. Due to industry test equipment limitations, units with surge capacities greater than 200,000 Amps shall be tested as a unit to 200,000 Amps; and certified for surge current ratings above 200,000 Amps by testing individual components or sub-assemblies within a mode. Units that sustain any component or overcurrent device failure or degradation are unacceptable.

8) Minimum Repetitive Surge Current Capacity:
    i. Per ANSI/IEEE C62.41 and ANSI/IEEE C62.45-1992, every mode of the suppression filter system shall be designed to survive multiple Category C3, 20 KV, 10 KA impulses. Test documentation shall detail the unit's ability to survive the following number of events (at one-minute intervals) without any performance degradation. See **Table D5010.6** below:

Table D5010.6

Repetitive Surge Current Capacity – Number of Impulses				
Location	L-N	L-G	N-G	L-L
Service Entrance	>12,000	>12,000	>12,000	>12,000
Panelboards	>4,500	>4,500	>4,500	>4,500

9) Swell Voltage Rating:
    i. For service entrance locations only, suppression components shall be capable of withstanding continuous overvoltage events (swells). Based on a source impedance of 0.7 Ohms, the unit shall withstand an overvoltage of 200 percent (above RMS nominal voltage) for at least 60 cycles, without component failure (including fuses).

10) High Frequency Extended Range Filter:
    i. EMI-RFI noise rejection/attenuation (per NEMA LS-1-1992 and MIL-STD-E220A 50-ohm insertion loss methodology) shall be as identified in **Table D5010.7**:

Table D5010.7

Attenuation Frequency	**50 KHz**	**100 KHz**	**1 MHz**	**10 MHz**	**100 MHz**
Insertion Loss (dB)	50	41	31	35	53

    ii. For installations that install multiple downstream filters, the filters shall be coordinated to provide minimum noise rejection/attenuation as identified in **Table D5010.8**:

Table D5010.8

Attenuation Frequency	**50 KHz**	**100 KHz**	**1 MHz**	**10 MHz**	**100 MHz**
Insertion Loss (dB)	85	83	68	67	84

    iii. NOTE: Insertion loss data shall be based on a minimum of 100 feet of #4 AWG conductor between filters.

11) Suppression Voltage Rating:
    i. In compliance with procedures outlined in NEMA LS 1-1992, paragraphs 2.2.10 and 3.10, the maximum suppression voltage rating (with integral fused disconnect) will follow **Table D5010.9**:

Table D5010.9

System Voltage	**Mode**	**6KV/500A Comb. Wave**	**B3 Ringwave**	**B3/C1 Comb. Wave**	**C3 Comb. Wave**
120/208	L-N L-G N-G L-L	325 325 325 625	350 425 375 475	425 500 475 825	725 800 750 1200
277/480	L-N L-G N-G L-L	725 750 700 1375	5752 875 700 750	850 850 900 1675	1150 1175 1200 2100

12) Redundant Overcurrent Protection:
    i. Each suppression element shall utilize individual UL 248-1 recognized, 200 KAIC tested fuses to ensure that the failure of a single suppression component, or operation of any single fuse does not render the entire mode, phase, or product deficient by more than 10 percent (10%). At service entrance locations only, in the event a catastrophic or swell voltage occurrence causes the failure of all the MOV elements, the fusing for the selenium cells shall be independent to provide redundancy. The filter shall withstand the rated single pulse surge current capacity without fuse failure.
13) Internal Connections:
    i. Internal surge current paths shall utilize low-impedance copper bus bar. No plug-in modules or quick-disconnect terminals shall be used in the surge current-carrying paths.
14) Built-In Field Test Capability:
    i. The unit shall incorporate an integral test point for off-line diagnostic testing to verify operational integrity of the suppression filter system. Testing shall include injection of an impulse at least two times the nominal system voltage, and provide metering to indicate the resultant clamping voltage. The unit shall also include an integral test point for a secondary test meter that displays the status of the internal fusing, to include indication of partial degradation of surge current capacity capability.
15) Enclosure:
    i. The service entrance unit shall utilize a NEMA 4 metallic enclosure.
16) Additional Features/Equipment:
    i. Advanced monitoring feature, a battery-powered audible alarm with the event counter display and two sets of form C dry contacts (N.O. or N.C.) shall be provided. The alarm shall indicate single or multiple phase failure of the filter.
17) Installation:
    i. The service entrance and panelboard filters shall be installed external to the switchgear/panelboard as close as possible to the connection point following the manufacturer's recommendations for conductor size and minimal bends.
18) Equipment Manual:
    i. Provide an equipment manual that identifies installation, operation, and maintenance instructions for the filter. Information shall include unit dimensions, weights, mounting provisions, connection details, and a layout diagram.

D5010 – Attachment 1 - SPD Submittal Compliance Form (Service Entrance)

Performance/Feature	Specification Requirement	Proposed
UL Labeled and Listed	Yes	
Single Pulse Surge Rating Per Mode	150 KA L-N 150 KA L-G 100 KA N-G	_____ L-N _____ L-G _____ N-G
Single Pulse Surge Rating Per Phase	300 KA L-N + L-G	_____ L-N + L-G
Number of Components Used for Above Rating (Attach Component Manufacturer's Product Data)		Number of MOV's/Mode L-N _____ L-G _____ N-G _____
Documentation of Rating	Independent Test Reports	
Warranty for Damage to TVSS Due to Lightning	20 years	
Dispatch Location for Local Support and Start-Up	Within 150 Miles of Project	
Maximum Continuous Operating Voltage (MCOV) For All Suppression Components	Greater than 115 percent and less than 130 percent	
Temporary Overvoltage Capacity	200% for ≥ 60 Cycles	
Protection Modes Provided	L-L, L-N, L-G and N-G	
Category C3 Repetitive Surge Current Capacity	> 14,000 impulses	
High Frequency Noise Filtering Attenuation	54.6 dB	____ dB
Internal Surge Current Path	Copper Bus Bar	
Field Test Capability with Surge Generator and Multi-Color Indicator Lights?	Required? ___ No X Yes	Provided? ___ No ___ Yes If Yes, How? _____ _____ ____

Individually Fused Elements Individual Fuse Surge Current Rating	Required? ___ No X Yes _____ Transient Amps	Provided? ___ No ___ Yes _____ Transient Amps
Alarm & Disturbance Counter	Required? ___ No _x_ Yes	Provided? ___ No ___ Yes
Microprocessor-Based Diagnostics	Required? ___ No _x_ Yes	Provided? ___ No ___ Yes
Enclosure	Metal NEMA 4	

D5010 - Attachment 2 - SPD Submittal Compliance Form (Panelboards)

Performance/Feature	**Specification Requirement**	**Proposed**
UL Labeled and Listed	Yes	
Single Pulse Surge Rating Per Mode	50 KA L-N 50 KA L-G 50 KA N-G	_____ L-N _____ L-G _____ N-G
Single Pulse Surge Rating Per Phase	100 KA L-N + L-G	_____ L-N + L-G
Number of Components Used for Above Rating (Attach Component Manufacturer's Product Data)		Number of MOV's/Mode L-N _____ L-G _____ N-G _____
Documentation of Rating	Independent Test Reports	
Warranty for Damage to TVSS Due to Lightning	10 years	
Dispatch Location for Local Support and Start-Up	Within 150 Miles of Project	
Maximum Continuous Operating Voltage (MCOV) For All Suppression Components	Greater than 115 percent and less than 130 percent	
Protection Modes Provided	L-L, L-N, L-G and N-G	

Appendices

Appendix D5010.1: Panel Cover Detail

D5020 – Lighting and Branch Wiring Requirements

Introduction

This section includes basic requirements for all electrical installations as they apply to lighting at the University of Colorado-Boulder. All lighting designs should comply with International Dark Sky Association guidelines. Light pollution is a serious detriment to campus astronomers.

Having the campus lighting designed effectively with an integrated appearance will improve safety, security, campus image, and nighttime space definition. Better continuity in luminaire spacing, fixture types suited to the pedestrian, and improved lighting of buildings and night destinations is needed.

In all new buildings and all major renovations projects, install a lighting control system to meet the current IECC and ASHRAE 90.1 requirements as well as local requirements. Interior and exterior lighting design shall comply with current ASHRAE 90.1 lighting power densities.

UCB Requirements

1. General Luminaire Design Criteria:
    a. Classrooms/Auditoria:
        1) For general classroom and auditorium lighting, provide LED luminaires at or below 3500K CCT. No acrylic or other plastic lenses. Use 1% Dimming 3-way and/or front-back zone switching. When used, it is recommended the use of wall wash systems to create visual interest.
        2) Provide lighting for chalk board, white board, and projection screen in all classrooms. Luminaires to match general lighting luminaires as closely as possible and be located with respect to the chalk/white board(s) so as to provide proper vertical illuminance, with no veiling reflections or direct glare. Coordinate requirements with **Facility Standard C1021**. Provide separate switching for chalk/white boards(s) or projection screen.
    b. Offices:
        1) Provide general office lighting utilizing LED luminaires at or below 3500K CCT. No acrylic or other plastic lenses in offices; standard luminaire is direct/indirect.
        2) Task lighting at desks is strongly encouraged and should be used where possible.
    c. Interior Illumination Levels:
        1) Design to the recommended minimum illumination levels for the type and use of area. Illumination levels are not necessarily average levels over an entire space. Task oriented lighting is encouraged where its use will not adversely affect general appearance of space. For all areas, refer to the most current issue of the IES Lighting Handbook for illumination requirements. All levels indicated are maintained illumination levels.
    d. Stairwells:

1) Luminaires in stairwells that are not accessible from the landing require excessive maintenance and scaffolding, hence stairwell lighting is preferred at the landings.

e. Maintenance Access:
   1) Provide 4" minimum aperture size to access and replace luminaire equipment, drivers, etc.

f. Exterior Illumination Levels:
   1) The quality of light is more important than the quantity of light.
   2) Provide proper brightness and glare control. Excessive light levels, or light that is poorly directed can cause a loss of visibility.
   3) Provide uniform light. Existing light levels are often more than sufficient for providing a safe environment. Improvements in the quality of the lighting will result in more secure environments and will improve campus image. For example, reducing lamp wattages for existing area lighting and adding pedestrian-scale luminaries will reduce overall system energy use and will improve the uniformity of light, resulting in less glare and better visibility. Lighting levels shall not exceed uniformity ratios of 8:1.
   4) The best approach to exterior lighting is to light vertical exterior surfaces like building facades. If only the side walk or street pavement is lighted, it is often difficult to detect an approaching person. When an individual's face is lighted, then detection and recognition can happen much more readily, even at great distances.
   5) The illuminance levels around campus should vary in response to people-use and potential hazards. The levels of illumination identified in **Tables D5020.1 – D5020.3** should be maintained for each of the specified locations:

Table D5020.1

Recommended Maintained Horizontal Illuminances for Parking Lots

	General Parking & Pedestrian Areas		**Vehicle Use Area (only)**	
Level of Activity	**Foot-candles (Min. on Pavement)**	**Uniformity (Avg./Min.)**	**Foot-candles (Min. on Pavement)**	**Uniformity (Avg./Min.)**
High	0.9	4:1	2	3:1
Medium	0.6	4:1	1	3:1
Low	0.2	4:1	0.5	4:1

Table D5020.2

Recommended Maintained Horizontal Illuminances for Pedestrian Areas

Location of Pathway	Avg. Illuminance Levels in Foot-candles (at Ground Level)	Uniformity (Avg./Min.) (Not to Exceed)
Sidewalks along major streets	0.6	5:1
Nodes	0.4 to 1.8	4:1
Primary Pathways	0.5	5:1
Secondary Pathways	0.2	5:1
Tertiary Pathways	0.2	10:1
Residence Halls	0.2	5:1

Table D5020.3

Recommended Luminance Ratios for Exterior Lighting Effects

Lighting Effect	Maximum Luminance Ratio (Max./Min.)
Blending in with surrounds	1:2
Softly accented	1:3
Accented	1:5
Strongly Accented	1:10

g. Place posts and standards along walks, streets, and bikeways so that they do not present hazards to pedestrians or vehicles.
h. Install glare shields in new and old fixtures to minimize the amount of light directed by the luminaire into the sky.

2. Lighting Controls:
   a. Lighting control systems shall communicate with the BMS system for occupancy sensor ventilation controls integration.
   b. Lighting Control Systems Performance Requirements:
      1) Provide a completely networked distributed lighting control system. This system shall provide a method to uniformly turn the lights on and off in the space.

2) CAT-5e or similar low voltage communication cable shall be yellow and black striped to avoid confusion with other building communication and data systems.
3) Provide daylighting harvesting, occupancy/vacancy sensors, and scheduling of the lights while also providing local access to temporarily override the system.
4) All enclosed rooms shall be configured with a vacancy sensor with exception of restrooms which shall be configured as occupancy sensor.
5) In order to reduce obstruction from furniture, equipment, etc., ceiling mount all occupancy/vacancy sensors, with low voltage override switch as required. Wall box occupancy/vacancy sensors are prohibited.

3. Contactors:
   a. Contactor Manufacturers:
      1) ASCO
      2) Zenith
      3) General Electric (ABB) - (300 series)
      4) Square D Company
   b. General purpose contactors shall be electronically or mechanically held as required by control function. 120V, 60Hz operating coil. NEMA size as required by function. Contacts 600V rated with number of poles and amperage as required.
   c. Lighting Contactor Performance Requirements.
      1) Mechanically held with 120V or 277V, 60Hz operating coils. Contacts 600V rated with amperage rating and number of poles as required by function. Solderless pressure wire terminals.

4. Exterior Luminaire Controls:
   a. Provided by photocell for dusk-to-dawn operation only. Connect all exterior lighting to a single panel and control with a single photocell contactor system. Contactor shall be electrically held, non-latching type. Systems shall include a photocell bypass switch for daytime maintenance and troubleshooting. In order to facilitate safe paths around campus, there shall not be any dimming or occupancy sensor operation for parking lot and pedestrian pole exterior lighting.

5. Interior Lighting:
   a. In general, new and renovation design lighting should be 100% LED for interior and exterior lighting.
   b. Replacement Lamp Manufacturers:
      1) Fluorescent Lamps:
         i. General Electric (ABB)
         ii. Philips
         iii. OSRAM/Sylvania
         iv. Others only by approval by UCB
      2) Fluorescent Lamps for Re-Lamping Existing Luminaires:
         i. Linear fluorescent lamps shall be F32 energy saving with 3,500K corrected color temperature (CCT) only and with a color rendering index (CRI) of 80 or

greater. All fluorescent lamps shall be low mercury type. Other lengths of lamps may be specified only by University written approval and if special conditions require them.

3) HID Lamps:
   i. OSRAM/Sylvania
   ii. General Electric (ABB)
   iii. Philips
   iv. Others only by approval of University

c. Replace all lamps/luminaires used during construction for greater than six months before final certificate of occupancy is issued. All lamps in new buildings shall have less than 100 hours of burn time or use.
d. Temporary construction lighting shall be controlled to be off at night.

6. Light Emitting Diodes (LEDs):
   a. LED lamps shall have minimum CRI 80 and color temperature between 2700k to 3500k and have a lifetime of at least 50,000 hours at 70% lumen maintenance. The efficacy of the lamp should be at least 40 lumens/watt. For lamps greater than 5 watts, the power factor must be 0.70 or better.
   b. Submit LED fixture types for approval by UCB.
   c. LEDs in indoor lamps and luminaires shall be Cree or equivalent and documentation showing the LED manufacturer and model number shall be provided to UCB and have at least a 5-year warranty.

7. Luminaires:
   a. Acrylic lenses shall have a minimum of 0.125" thickness.
   b. Exit Signs:
      1) Light Emitting Diodes (LED), low wattage type with long life, maintenance free battery, require programmed discharge under load, self-testing and self-diagnostics. Green letters on white background. When used in a building with an emergency generator, batteries are not required other than the electrical room(s), mechanical room(s), and ATS and generator locations.
      2) Preferred Manufacturers:
         i. e^3 Lighting; Isolite, LPDC Series
         ii. Others only by approval of University
      3) Exit signs containing tritium are prohibited under all circumstances, with no exceptions.
      4) Exit signs are to be green letters on white background.
      5) Provide self-testing (the unit shall perform battery tests in accordance with NFPA), and self-diagnostic (the unit shall perform self-diagnostics and indicate problems discovered via LEDs) units.
   c. Egress/Emergency Lighting Units:
      1) Preferred Manufacturer is DualLite, MV Series; unless approved otherwise by UCB.
      2) Provide self-testing (the unit shall perform battery tests in accordance with NFPA) and self-diagnostic (the unit shall perform self-diagnostics and indicate problems discovered via LEDs) units.

8. Exterior Lighting:
    a. All exterior luminaires must meet the Full Cutoff IESNA Classification.
    b. The maximum candela value of all exterior lighting shall fall within the property.
    c. Any luminaire within a distance of 2.5x its mounting height from the property boundary shall have shielding such that no light from that luminaire crosses the property boundary. Exterior lighting must have a maximum initial luminance of 0.20 horizontal and vertical foot-candles at the site boundary and a maximum 0.01 initial horizontal foot-candles 15 feet beyond the intending lighting area.
    d. Step lights are not permitted to be installed outdoors on campus.
    e. Provide all exterior lighting circuits with minimum 1" conduit.
    f. Standard Exterior Luminaires:
        1) Campus standard pole mounted luminaires are CREE Edge fixture.
        2) Luminaires shall be in full compliance with the UCB Site Lighting Master Plan and the following:
            i. Luminaires shall be rectilinear style, cut-off type, for LED lamps; shall be of totally enclosed style with extruded aluminum mast-arm; shall be rain-tight, dust-tight, and corrosion resistant; shall have housing sides and lens frame made of anodized extruded aluminum with mitered corners, or on-piece cast aluminum housing.
            ii. Campus standard walkway luminaires are dome top luminaires with the same construction as above.
        3) Luminaires must meet the following design criteria:
            i. Luminaires shall be full cut-off.
            ii. No candlepower shall be present at or above 90° from nadir.
        4) Approximate fixture sizes shall be 40-60 LED used for 10-20' fixture mounting height for building, landscape, plazas, and walk ways. 60-80 LED fixtures for 20-30' mounting height for roadway and parking lot lighting. A light study shall be performed to verify adequate lighting for each application prior to fixture selection.
        5) Fixture arm shall be a one-piece rectangular aluminum extrusion 0.125" minimum thickness with centering guides. Exposed fasteners or welds are not allowed on luminaire-to-pole assembly. All steel or cast-iron parts shall be hot-processed galvanized and red prime painted.
        6) All electrical components shall be UL Listed and be an integral part of the luminaire. Driver components are to be integrated on a single mounting plate, as a self-contained sub-assembly
    g. Poles:
        1) Use 20-35' poles for roadway and parking lot lighting, 16-20' poles for large plaza areas, and 12-15' poles for pedestrian lighting. Pole shall be tapered steel shaft of a single piece construction; continuously welded top and bottom. A reinforced handhole with cover and ground lug shall be provided 18" up from base. Complete standard bole base and base cover shall be provided including four 1" stainless anchor bolts with eight nuts and washers and a pressed wood base and bolt circuit template. All poles shall have weathertight caps.

2) Supply poles with a round base plate cover that completely covers the anchor bolts and base plate. The cover shall be drilled and tapped to allow attachment of the cover to the pole. Avoid drilling and tapping holes in poles when possible to minimize sites for corrosion.
3) Arm assembly, luminaire, and pole shall be reinforced as required in order that complete assembly shall withstand 150 mph wind loading.

h. Luminaire, Arm, and Pole Finish shall receive integral color, Aluminum Association Architectural Class I anodizing (Duranodic® or kalcolor®) after fabrication, black. Pole should be provided with paint to match luminaire anodized color. A three-stage finishing process consisting of: (a) acid etching, (b) priming, and (c) baked enamel finish, 5 mils thick, shall be considered an acceptable alternate to anodizing.
i. Concrete Pole Bases shall be with rebar reinforcement and with embedded anchor bolts. Coordinate design with the project structural engineer for wind loading. Provide one additional 1" empty conduit stub extending beyond the base of the pole such that it can be easily located for future use.
j. Require ground conductor attached to ground stud on pole and connected to rebar in pole base for all pole mounted assemblies. In addition, a green insulated ground wire shall be required back to panelboard.
k. Require shimming of pole base to maintain luminaire in true vertical position.
l. Require aiming at night of directional floodlighting luminaires.
m. UCB discourages the use of bollards, direct burial, and ground mounted flood luminaires, and only used with written UCB approval.
n. In-ground J-boxes are not permitted. Design shall include pole to pole installation of conduit and wire.

Appendices:

- **Appendix D5020.1:** Pedestrian Light Standard Detail

D5030 – Emergency and Standby Electrical Systems

Introduction

This section includes basic requirements for all electrical installations at the University of Colorado-Boulder (UCB) as they apply to special equipment such as emergency power generation, battery inverters, and ancillary equipment installations.

UCB Requirements

1. Standby Power Generation Systems:
    a. Section Includes:
        1) Packaged engine generator system
        2) Remote radiator
        3) Exhaust silencer
        4) Fuel system and day tank

5) Remote status/control panel
6) Battery and Charger
7) Weatherproof enclosure

b. Submit all standby power generation systems for review by project EOR as well as by UCB. Provide the following information:
   1) Plan and elevation views with all dimensions shown including points of connection, clearance required for equipment and tanks, and equipment pads for generator system.
   2) Fuel consumption rates, ventilation, and combustion air requirements
   3) Electrical diagrams, including schematic and inter-connection
   4) Weights of system components
   5) Product data for control panel, battery, battery charger, exhaust silencer, vibration isolators, day tank and/or sub-base fuel tank, remote or attached radiator, remote annunciator, main alternator, engine jacket heater, custom or standard enclosure (including acoustic characteristics), and circuit breaker enclosure.
   6) Product data for governor
c. Engineered design of generator and fuel system shall comply with NEC and local codes as well as provide a thorough code review of NFPA 110, NFPA 37, and NFPA 30 for compliance.
d. Standby Power Generation Systems Design Requirements:
   1) Provide standby generators for all research laboratory facilities and facilities with data centers, regardless if generator is not required by code.
   2) Engine exhaust, fuel storage, fuel pumping, combustion air intake and relief, and fuel piping shall be designed and specified by a qualified mechanical engineer and coordinated with the electrical drawings.

2. <u>Standby Power Generation Systems Manufacturers and Performance Requirements:</u>
   a. Require company specializing in package engine generator systems with minimum five years of experience.
   b. Require compliance with UL 2200 for certifying the entire generator set package.
   c. Require that supplier have a local service facility within 50 miles of project with factory authorized service technicians.
   d. Packaged Generator Systems:
      1) Onan Corp./Cummins Power Generation
      2) Caterpillar Engine Division
      3) MTU Onsite Energy
   e. Engine:
      1) Provide water cooler diesel, sized to operate at site elevation and ambient conditions.
      2) Fuel:
         i. No. 2 fuel oil
         ii. Natural Gas
      3) Governor:
         i. Isochronous type to maintain engine speed within 0.5% steady state and 5%, no load to full load, with recovery to steady state within two seconds following sudden load changes.

4) Safety Devices:
    i. Engine shutdown on high water temperature, low oil pressure, overspeed, engine over-crank, and a means of emergency shutdown.
5) Engine Starting:
    i. DC starting system with positive engagement
    ii. Dual starters required for critical facilities including but not limited to research laboratories, vivarium, and data centers.
6) Engine Jacket Heater:
    i. Thermal circulation type water heater with integral thermostatic control. Maintain water jacket temperature at 80°F. Coordinate operating voltage.
7) Radiator:
    i. Glycol coolant type remote or engine mounted. Sized to maintain safe engine temperature in ambient of 110°F. For engine mounted radiator, duct flow restriction limited to 0.5" column of water. Provide lockable cap.
8) Engine Accessories:
    i. Fuel filter, lube oil filter, intake air filter, lube oil cooler, fuel transfer pump, fuel priming pump, gear driven water pump. Provide lockable fuel cap.
9) Mounting:
    i. Provide unit with suitable spring-type vibration isolators. Mount on structural steel base with concrete housekeeping pad.

f. Generator:
1) Provide three-phase, six pole reconnectable brushless synchronous generator with brushless exciter.
2) Specify required kW, kVA at 0.8 power factor, voltage, phase, 60 Hz at rpm of motor.
3) Class F Insulation
4) 125°C Temperature Rise (standby)
5) Open drip proof enclosure.
6) Generator mounted voltage regulation for volts per Hz exciter-regulator to match engine and generator characteristics, with voltage regulation plus or minus 1% from no load to full load. Include manual controls to adjust voltage drop plus or minus 5% voltage level and voltage gain.

g. Accessories:
1) Fuel Tanks:
    i. Fuel tanks shall be in compliance with UL 142.
    ii. Provide a base mounted fuel tank with capacity for 4 hours of operation and with dual integral pumps and level control. Require flexible fuel line connections, fuel gage, check valve, high fuel level alarm contact, and indicating light. Coordinate pump motor voltage. Tank shall provide required fuel containment in case of primary tank rupture, minimum 110% tank volume.
    iii. Provide a day tank only if needed for proper operation.
        - Provide all day tank and all fuel delivery pipes with secondary containment (double wall construction) providing 100% volume of day tank and 4" of free board.

- Underground fuel piping is not permitted.

iv. Containment area to be supplied with a drain valve for periodic draining of precipitation as needed.

2) Exhaust Silencer:
   i. Critical type silencer with muffler connection flanges and flexible stainless-steel exhaust fittings.
   ii. Design of exhaust outlet location must consider supply air intake locations. Where installation may provide contamination via particulate or odor to supply air or other critical areas, a detailed analysis is recommended to be reviewed with the University.
3) Heavy duty diesel starting type lead acid storage batteries, 170 ampere-hour (Ah) minimum capacity. Provide corrosion resistant tray.
4) Current limiting type designed to float at 2.17V per cell and equalize at 2.33V per cell. Provide with wall mounted enclosure, DC voltmeter, and ammeter.
5) Molded case line circuit breaker on generator output with integral thermal and instantaneous magnetic trip in each pole. Quantity of breakers may be more than one under certain conditions.
6) Engine-Generator Control Panel Criteria:
   i. Control panel enclosure with engine and generator controls and indicators.
   ii. Frequency Meter
   iii. AC output voltmeter with seven position phase selector-switch
   iv. AC output ammeter with four position phase selector-switch
   v. Output voltage adjustment
   vi. Push-to-test indicator lamps for low oil pressure, high water temperature, overspeed, and over-crank
   vii. Engine start/stop selector switch
   viii. Engine running time meter
   ix. Oil pressure gauge
   x. Water temperature gauge
   xi. Auxiliary relay, 3 PDT operates when engine runs. Wire to terminal strip
   xii. Remote Alarm contacts for remote status panel
   xiii. Fuel gauge
   xiv. High fuel level alarm and low fuel level alarm
   xv. Utility loss of power
   xvi. Engine-generator control panel points shall be integrated/communicated to the BMS system.
7) Remote Status Panel Criteria:
   i. Wall mounted
   ii. Push-to-test indicator lamps for low oil pressure, high water temperature, overspeed, and over-crank. Provide panel mounted audible alarm
   iii. Engine start/stop selector switch and push-to-test engine run indicator light
   iv. Fuel gauge
8) Weather-Protective Housing:
   i. When a package generator unit is installed outdoors, provide reinforced steel housing allowing access to control panel and service points. Include

fixed louvers, day tank (if necessary for proper operation of generator), battery rack, silencer, jacket water heater, and a battery heating pad. Provide all necessary screens (heavy metal) to prevent small rodent access (rodent-proof).

ii. Paint all exterior equipment including aluminum and factory finished items with color approved by UCB.

iii. Weather-protective housings shall have minimum sound attenuation of 75 dB at 25' from the unit.

h. Field Quality Control and Testing:

1) Fuel tanks with a volume of 660 gallons and greater must be registered with and installed according to the Colorado Division of Oil and Public Safety.
2) Fuel tank foundation and supports must be installed in such a manner to allow water to drain away from tank(s).
3) Contractor shall provide all fuel for testing and then, after successful test, fill the fuel tank.
4) Provide for a full factory test **and** on-site test utilizing portable test load bank for minimum of four hours. Simulate power failure including operation for transfer switch, automatic starting, automatic shutdown, and return to normal.
5) During test record the following at twenty-minute intervals:
   i. Kilowatts
   ii. Amperes
   iii. Voltage
   iv. Coolant temperature
   v. Room temperature
   vi. Frequency
   vii. Oil Pressure
6) Test alarm and shutdown circuits by simulating conditions.
7) Set generator output and engine speed
8) Turn over to CU factory test results **before** shipment of generator.
9) Turn over to CU written site test results of generator.

3. Automatic Transfer Switches:

a. Preferred Manufacturers:

1) Caterpillar Tractor Company
2) Onan Corp.; Sub of McGraw-Edison Co.
3) Russelectic Inc.
4) GE (ABB)/Zenith
5) ASCO

b. Automatic Transfer Switches Performance Requirements:

1) All automatic transfer switches shall be four-pole construction.
2) Transfer switches shall be open transition, standby transfer switches shall be delayed transition.
3) Switches shall be electrically operated, mechanically held, and electrically and mechanically interlocked.

4) Select switches capable of automatically transferring the load from normal to emergency power source.
5) Select transfer switch with limiter which opens starting circuit after 45 seconds when engine fails to start.
6) Equip switch with time delay to prevent excessive transfer and retransfer operation during momentary line voltage dips, load retransfer, and engine shutdown.
7) Provide signal circuit to indicate when load is on emergency source.
8) Provide switch with appropriate engine-starting contact and relays for starting emergency engine-generator unit.
9) For inductive loads, equipment poles with magnetic blowouts and arc barriers; for non-inductive loads, equip switches with barriers between poles.
10) Equip unit with trickle-charger, and with indicator for starting battery, and with test switch for manual simulation of power outages including standby unit operation and load transfer, and with time-clock exerciser circuit for automatic periodic exercise of engine-generator unit.
11) Provide free-standing 14-gage welded steel NEMA Type 1 enclosure with swing out service panel and door locks.
12) Coat enclosure with manufacturer's standard color acrylic enamel finish over a corrosion-resisting primer.

c. Transfer Switch Accessories:
1) A time delay to override momentary normal source outages to delay all transfer switch and engine starting signals. The time delay shall be field adjustable from 0.5 to 6 seconds and factory set at 3 seconds.
2) A time delay on retransfer to normal source. The time delay shall be automatically bypassed if the emergency source fails and normal source is available. The time delay shall be field adjustable from 0 to 30 minutes and be factory set at 30 minutes.
3) An unloaded running time delay for emergency generator cool-down. The time delay shall be field adjustable from 0 to 5 minutes and be factory set at 5 minutes.
4) Independent single-phase voltage and frequency sensing of the emergency source. The pickup voltage shall be adjustable from 85% to 100% of nominal. Transfer to emergency upon normal source failure when emergency source voltage is 90% or more of nominal frequency is 95% or more of nominal.
5) Pilot lights to show switch position.
6) One set of normally open and one set of normally closed auxiliary contacts on each side of the switch.

d. Maintenance Bypass Requirements:
1) All new ATS installations require bypass type ATS, or separate three breaker maintenance bypass cabinet. Exception may be granted for housing or non-critical installations at the discretion of the campus electrical engineer.
2) Non-load break type to allow maintenance, testing, and repair of ATS without disrupting power to load.
3) Dead source interlock to prevent accidental manual bypass to a de-energized source.

4) Capable of providing test bypass and complete isolation of ATS contacts without opening doors of enclosure.
5) Ensure "Transfer Switch Disabled" remote alarm indications communicate to Andover system when ATS is bypassed.
6) Three breaker maintenance bypass cabinets must meet the following requirements:
   i. Verify adequate space is available for installation.
   ii. Kirk key or similar mechanical breaker type interlock capable of preventing improper operation.

e. Field Quality Control and Testing:
1) Test transfer switches by means of simulated power outage; automatic start-up by remote-automatic starting, transfer of load, and automatic shutdown. Prior to these tests, adjust transfer switch timers for proper system coordination.
2) Upon completion of installation and after circuitry has been energized, demonstrate capability and compliance of transfer switches with requirements. Initial testing and retesting, where necessary, at no cost to Owner.
3) Test maintenance bypass and perform test transfer of ATS without interruption of power to building loads.

4. Battery Power Systems:
a. Although these are viable systems, they are usually more expensive than other systems. Accordingly, these will be used only with University approval.
b. Specify a forward transfer type emergency power supply consisting of rectifier/charger unit, storage battery, and mechanical transfer switch. NOTE: If HID luminaires are to be supplied from this system, specify a static transfer switch.
1) Require submittals on all battery power systems
c. Require a ten-year warranty on batteries. Prorate warranty after first year on straight line basis.
d. Battery Power Supply Manufacturers:
   i. Exide
   ii. Chloride
   iii. Siltron
e. Equipment Performance Requirements:
1) Input Voltage: 120V or 277V, 1Ø, 60 Hz
2) Output Power: kVA as required, 0.8 power factor
3) Battery Operating Time: 90 minutes
4) Output Voltage: 120V or 277V, 1Ø, 60 Hz, plus or minus 5%
5) Efficiency: 90% minimum
6) Maximum Recharge Time: Twelve (12) hours following 1.5-hour discharge
7) Total Harmonic Distortion: Less than 10% at full resistive load
8) Transfer Time: 50 milliseconds (continuous output power if serving HID luminaires)
9) Batteries: Lead calcium
10) Exercising Clock: Simulate power interruption for fifteen-minute periods every thirty days.
11) Accessories:
   i. Remote battery alarm

f. Remote Trouble Monitor:
    1) Common audible signal for system disarray.
g. Locate unit in area not subject to unusual temperature extremes.
h. Require factory authorized technician to test and start up system.

D5040 – Fire Alarm

Introduction

This section of the Facility Standards provides requirements and guidelines for the design and construction of fire alarm systems at the University of Colorado-Boulder (UCB). The University is the Authority having Jurisdiction (AHJ) for Fire Alarm Systems on campus. Any interaction or coordination with the City of Boulder Fire Department will be performed or approved by UCB.

The University has a sole source agreement with JCI/Simplex Supervising Station Fire Alarm Systems for campus fire alarm systems. It is the intent to upgrade or replace existing fire alarm systems to a Simplex system where current system is not a Simplex system.

Fire alarm systems are often a "delegated" design relying upon deferred submittals. For UCB projects, the consultant shall remain responsible for the final design of the fire alarm system. The role of the technician is to understand the engineer's design intent and help implement that design. The design team develops design documents which establish the objectives and design criteria of the system, including but not limited to:

a. Identification of the scope of work.
b. Selection of type of system and components.
c. Identification of interface(s) required between fire safety and other building systems including input on sequence of operations matrix.

UCB Requirements:

1. <u>UCB Review:</u>
    a. Meet with the UCB Fire Marshal prior to the commencement of the design phase to determine scope of fire alarm systems expected for the project.
    b. All equipment and wiring configurations shall be reviewed and approved by UCB.
    c. For major renovations and new construction, a Fire Alarm Test Plan is required prior to any acceptance testing can take place. Submit a record of completion after the fire alarm test has passed.
    d. Follow UCB Facilities Management outage requirements for any proposed interruption or modification of any existing fire alarm system.
    e. Make all connections to the control equipment under UCB or manufacturer's supervision.
    f. Coordinate the sequence of operation between the mechanical air handling systems and fire alarm to properly sequence the shutdown of supply and exhaust air in buildings based on the building usage and hazard class. Not all buildings can simply have the HVAC systems shut down when a fire alarm event occurs.

1) Provide a project specific sequence of operations matrix to UCB Engineering and FLS for approval.

g. Prior to inspection of completed work, installer will provide pre-test sign-off as required by UCB.

2. General Design:
   a. Provide Simplex equipment only which is compatible with the campus fire alarm systems and networks.
   b. Meet with UCB personnel and Simplex representative prior to start of system design.
   c. All new and modified fire alarm systems on campus must integrate seamlessly with the existing infrastructure while maintaining the UL listing.
   d. If there is overlap in or conflicts between the requirements of the codes, laws and ordinances and this standard, then the requirement which provides the highest level of safety as determined by the Consultant, shall take precedence unless directed in writing to the contrary by AHJ.
   e. The design team shall work with EH&S and UCB Fire Marshall prior to connecting any non-fire systems to the fire alarm system.
   f. Unrelated systems or conduit, including fire alarm systems, are not allowed to pass through IT rooms.

3. Fire Alarm Control Panel (FACP):
   a. Provide a FACP having following functions:
      1) Pre-action system bypass
      2) Other suppression systems bypass
      3) Elevator bypass
      4) Door holder bypass
      5) Fan/Damper bypass
      6) Voice capability
   b. Where applicable, locate the main fire alarm panel as close to the main entry to the building as possible. UCB will review and approve final location. When the fire alarm panel is not readily available, a remote annunciator panel with voice capabilities should be provided at the entrance most likely to be used by first responders.

4. Fire Alarm Control Panel Labeling Guidelines:

Table D5040.1 – Fire Alarm Control Panel Labeling Guidelines

ABBREVIATION	**FULL WORD**
DIRECTIONS	
N, S, E, W	NORTH, SOUTH, EAST WEST

FLOOR DESIGNATION	
FLR	FLOOR
2B	SUB-BASEMENT
1B	BASEMENT
MEZZ	MEZZANINE
FLR1, ETC.	FLOOR ONE, ETC.

SPRINKLER SYSTEMS	
TS	TAMPER SWITCH
WFS	WATER FLOW SWITCH
APS	ALARM PRESSURE SWITCH
LOW AIR	LOW AIR PRESSURE SWITCH
PA	PREACTION SPRINKLER SYSTEM
DRY	DRY PIPE SPRINKLER SYSTEM
SOLENOID	NO ABBREVIATION
WATER FLOW BELL	NO ABBREVIATION

GENERAL	
CORR	CORRIDOR

ELEV	ELEVATOR
RM	ROOM
STAIR	STAIRWAY
MACH	MACHINE
MECH	MECHANICAL
HIGHVOLT	HIGH VOLTAGE ROOM

5. Fire System Devices:
    a. Provide an outside bell and strobe appliance above the fire department connection to track the main water flow device only.
    b. Provide non-supervised door holders that release upon AC power loss after a maximum 30-second delay.
    c. Install all remote power supplies, transponders and riser boxes in either mechanical or electrical rooms where feasible.
    d. Manual Pull Stations:
        1) At a minimum, provide manual pull stations at each building exit, adjacent to the FACP, and any stage manager consoles.
        2) In dormitories, and other areas susceptible to nuisance alarms, provide a clear shielded enclosure with a battery-operated sounder.
    e. Heat Sensors:
        1) Provide addressable-type heat sensors unless environmental conditions prohibit their use. If non-restorable detectors are used, locate an addressable module in an area not subject to the adverse environment.
    f. Provide an additional horn/strobe notification appliance at the closest fire department access point to the fire alarm control panel. This device is used as a guide for the fire department to know which building is in alarm since physical addresses are not displayed on many campus buildings.
    g. Smoke Detectors:
        1) Provide analog smoke detectors capable of alarm verification.
        2) Arrange smoke detector/control unit so that the detector causes a signal at the control unit when its sensitivity is outside its listed range.
        3) Provide duct detectors having duct sampling tubes, a remote indicator and test switch. Units shall be able to reset at the FACP.

6. Identification and Device Labeling:
    a. Paint all new and reused junction boxes red and label “Fire Alarm”.
    b. Number all conductors corresponding to the terminal block numbering of which they are connected.
    c. Label all initiating and notification devices with the appropriate circuit numbers.
    d. Provide labels with 3/8” high black lettering on a clear background.

7. Installation of Basic Wiring Systems:
    a. All cable and wiring shall be installed in conduit by a State of Colorado licensed electrician.
    b. Do not pull wire through existing raceways with live circuits without UCB approval.
    c. Provide wire color and size per table below. If these standards are inconsistent with the existing fire alarm wiring, match the existing wire colors and note it on the as-built drawings.

Table D5040.2 – Wire Installation

CIRCUIT TYPE	COLORS	SIZE
Fire Alarm Zones	Red + \ Black -	14 THHN
Mapnet	Red + \ Black -	18 Twisted Shielded
Communication Line (Miniplex Or Lcd)	Red + \ Black -	18 Twisted Shielded
Audio Riser (Vertical Runs)	Red + \ Black -	12 Twisted Shielded
Horns	Red + \ Black -	#14 THN Jacketed Cable (2 Conductor)
Strobes (Visuals)	Yellow + \ Brown -	14 THHN
Speakers (Horizontal Runs)	Red + \ Black -	14 Twisted Shielded
24 Volt Dc Power	White + \ Black -	14 THHN
Door Holders (24 Volts Dc)	Blue + \ White -	14 THHN
Remote Test Switches	White \ White	16 THHN
Remote Lights	Red + \ Black -	16 THHN
Fan Controls	Gray (N/C) \ Pink (N/O) Orange (Common)	14 THHN
Damper Controls	Gray (N/C) \ Pink (N/O) Orange (Common)	14 THHN
Remote Fire Fighters Reset	Blue \ Blue	#18
Remote Fire Fighters Signal Silence	White \ White	#18
Remote Fire Fighters Trouble Light	Yellow	#18

Remote Fire Fighters Alarm Light	Red	#18
Remote Fire Fighter Lamp Common	Black	#18
Fire Alarm Network Connections (2 Cables Required)	Red And Black	16 Twisted Shielded
Elevator Recall Primary	Purple \ Purple	16 THHN
Elevator Recal Alternate	Silver \ Silver	16 THHN
Shunt Trip (#12 Conductors For 120 Vac)	White \ Black	14 THHN

d. For all junction boxes 8”x8” or larger, provide numbered terminal strips with all wires numbered and landed on corresponding terminals. Only one conductor per terminal is allowed.
e. Provide a 1” conduit from the FACP to the building main telephone room for the campus fire alarm network connection. Run 4 multimode or single mode fiber strands or 4 copper conductors as appropriate for the fire alarm system between the FACP and the fire alarm network. Verify the connection type with campus OIT personnel prior to installation.
f. All riser conduits shall be a minimum 1” to 8”x8” minimum junction boxes.

8. Installation of Fire Alarm Systems:
   a. Install all outside bells, horns, and strobes minimum 10’-0” above finished grade and visible from the roadway.
   b. All conduit and boxes within 6’-0” of tamper and water flow switches shall be watertight.
   c. Locate all remote test switches in common areas at a height of 7’-0” above finished floor.

9. Fire Alarm Network:
   a. Update all additions and/or changes to the fire alarm system at the True Site Command Center and all appropriate (as determined by the UCB Facilities Operations Fire Systems Group) graphic command centers which include graphic screens.
   b. Use fiber optics to tie all new or updated FACP’s into the campus fire alarm network.
   c. Include initiating devices, room numbers, indication of North and the current building footprint in all graphics.

10. Elevators:
    a. Design consultant is expected to determine relation of heat detection and actions performed for elevator recall and shunt trips.
    b. Refer to **Campus Standard D1010** for additional information pertaining to elevators.

D6010 – General BAS Controls

Introduction

The University of Colorado has a proprietary network and controls system the project will need to comply with. The project shall use the standard BAS spec and edit for their project based on scope. These will need to be reviewed by the BAS team for security, functionality and reliability for the campus. The controls contractor shall also submit a one-line diagram of the proposed architecture with UCB Mechanical Engineer. The following section provide requirements and guidelines for use in the design and construction of BAS Control systems at the University of Colorado-Boulder. Coordinate with UCB Mechanical Engineering to obtain latest requirements and current sole-source agreements. Currently Andover and Integrated logic are the only two BAS systems permitted on campus. See appendix for a copy of standard one line diagrams and sequence of operation used on campus.

UCB Requirements

1. The control system must first and foremost provide effective and reliable control, commensurate with the systems it is controlling. The types, complexities and the criticalities of the systems being controlled will dictate the quality of the control system that should be applied to them.

2. The new building automation system (BAS) shall utilize electronic sensing, microprocessor-based digital control, and electronic actuation of dampers and valves to perform control sequences and functions specified. Design documents should include control drawings, sequences of operation, and point lists at the DD phase of the project. The distributed digital control (DDC) and BAS defined in this specification shall interface with the University private VLAN, and shall utilize open communications. Certain mechanical systems such as chillers, boilers, cooling towers, and energy recovery units are equipped with manufacturer furnished controls. All system architecture is to be approved by UCB.

3. The manufacturer and installer must be highly qualified with extensive experience and must be committed and bound to thorough Commissioning (Cx) as agreed upon per project basis and performed per the Commissioning Facility Standards. 5 year warranty is required on all controls systems with a min of 1 hour response time to reception of service call and 24 hours for repair.

4. Where these specifications are flexible in the selection of equipment and devices within the bounds of these documents, cost should not always be the primary decision maker. UCB is striving to provide more energy conscious or highly efficient solutions through their building automation systems. Decisions will be based on LCC. All new projects shall be DDC with system architecture prior approved by UCB.

5. BAS Failure modes shall be considered and accounted for in design, including critical power for BAS control panels.

D7000 – Information Technology - General

Introduction
The Office of Information Technology (OIT) at the University of Colorado-Boulder (UCB) have their own unique set of standards which are required to be followed when designing and constructing all projects on the CU Boulder campuses.

UCB Requirements

1. Refer to **Appendix D7000** for OIT's General Standards.

D7010 – IT Pathways

Introduction
This section includes minimum requirements and installation methods for the following: EMT conduit systems, cable tray systems, surface metal raceway systems, Wireless Access Point (AP) mounts and enclosures, and audiovisual equipment (AV)

UCB Requirements

1. Refer to **Appendix D7010** for OIT's Pathway Standards.

D7020 – IT Cabling

Introduction
This section outlines IT cabling requirements for Information Technology systems in all campus projects

UCB Requirements

1. Refer to **Appendix D7020** for OIT's Cabling Standards.

D7030 – IT Equipment Rooms

Introduction
This section outlines standards and requirements for IT Equipment Rooms in all campus projects.

UCB Requirements

1. Refer to **Appendix D7030** for OIT's Equipment Room Standards.

D7040 – IT Contractor Requirements

Introduction
This section outlines standards and requirements for IT Contractors in all campus projects.

UCB Requirements

1. Refer to **Appendix D7040** for OIT's Contractor Standards.

D7050 – IT System Testing & Labeling

Introduction
This section outlines standards and requirements for IT system testing & labeling in all campus projects.

UCB Requirements

1. Refer to **Appendix D7050** for OIT's Standards for System Testing and Labeling.

D7060 – IT CAD Requirements

Introduction
The purpose of this document is to serve as a tight specification for producing and delivering CAD drawings for facility documentation projects and construction projects. The guidelines are intended to ensure the successful use and control of CAD systems and data throughout the UCB OIT Telecom CAD Dept.

UCB Requirements

1. Refer to **Appendix D7060** for OIT's General Standards.

D7070 – Audiovisual System Standards

Introduction
This section outlines standards and requirements for audiovisual (AV) systems projects.

UCB Requirements

1. Refer to **Appendix D7070** for OIT's Audiovisual System Standards.

D7080 – Distributed Communications & Monitoring

Introduction

This section applies to low-voltage cabling and related infrastructure for distributed communications and monitoring systems (C*Cure, Paging, BAS, DAS, etc.) as directed by UCB Access Services and other UCB departments. This section does not apply to cabling and infrastructure for voice and data cabling, as identified in other sections of these specifications, which are intended support UCB OIT services.

UCB Requirements

1. Refer to **Appendix D7080** for OIT's Distributed Communications Standards.

D7090 – Wireless Communications

Introduction

Wireless communications are becoming crucial in supporting students, faculty and staff at the University. Different wireless technologies are implemented for different use cases on the campus. Several types of wireless technologies may be designed and deployed during major or minor construction projects on campus.

UCB Requirements

1. Refer to **Appendix D7090** for OIT's Wireless Communication Standards.