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F1010 – Laboratory and Research Area Renovation and Construction

Introduction

This section includes requirements when planning, designing and furnishing laboratory and research space at the University of Colorado Boulder (UCB). Laboratory and research space is defined as any research lab, teaching lab, maker space and any research support facilities (shops, chemical and waste storage, preparation areas, etc.) Consult with UCB Environmental Health and Safety (EH&S), UCB Mechanical Engineering, and the UCB Fire Marshal throughout the project on questions regarding health, safety, and laboratory environment especially as it relates to use of hazardous materials.

In general, design principles published by the International Institute for Sustainable Laboratories (I²SL) should be followed, however, consider project specific requirements and confirm design strategies with UCB EH&S and UCB Mechanical Engineering.

Because laboratories are large consumers of campus resources, UCB promotes sustainability and efficient use of energy and water resources when planning laboratory spaces and specifying equipment and fixtures to be used in the laboratory facilities. UCB has outlined laboratory sustainability initiatives with the CU Green Labs Program, which should be referenced during the design and planning of laboratory facilities.

Research laboratories are a crucial component of the success of UCB. It is the overall objective of the University to provide a safe, effective, and resource-efficient environment for laboratory personnel to conduct their work. The design, specification, and construction of the laboratory environment, including laboratory equipment, casework, fixtures, and finishes plays a critical role providing safe, durable, and efficient laboratories which support the University’s reputation as a premier research facility. It is the intent of this standard to outline the University’s requirements for all components included in the design and construction of the laboratory environment.

This standard is not all-inclusive and may not identify all state and local regulatory issues. Additionally, it may not cover all design situations, as each laboratory and science have different needs or

requirements that need specific analysis. Identify and discuss laboratory use and potential health and safety hazards with the appropriate department or UCB representatives during the design process. The design of the laboratory is a result of the analysis of laboratory use and chemicals that will be present. All criteria must be identified and carefully evaluated during the design process and protective measures incorporated into the design.

Although the design consultant may be engaged directly by a UCB Project Manager (PM) or User/Scientist to develop conceptual planning for a potential lab project, it is imperative that the design consultant meet with the UCB PM, UCB Campus Planning, UCB Fire Marshal, UCB Facilities Group, UCB EH&S, UCB Mechanical Engineering and User/Scientist prior to preparing any design documents. This meeting is intended to define project expectations regarding space allocation, existing building systems and equipment, and coordination with any other current renovation work in the particular building.

Coordinate requirements within this section with **Facility Standard F1020** for the complete laboratory design requirements.

UCB Requirements

1. General Design:

- a. Reference Standard: Comply with applicable standards published by the Scientific Equipment & Furniture Association (SEFA) except where more detailed or more stringent requirements are indicated, including the recommendations of equipment manufacturers.
 - 1) Performance ratings, testing requirements, structural performances, chemical resistance of equipment and cabinetry
 - 2) Provide appropriate certification that all selected finishes comply with SEFA 8 standards for chemical and physical resistance.
- b. Comply with other national standards as applicable including but not limited to NFPA, CDC (Center for Disease Control), NIH (National Institute of Health), UL (Underwriter's Laboratory), OSHA (Occupational Safety and Health Administration), and OLAW (Office of Laboratory Animal Welfare).
- c. It is the responsibility of the design team to involve applicable subject matter experts during the design process to determine needs specific to the laboratory or research area (e.g., hazardous exhaust, laboratory fume hoods, biological safety cabinets, radiation shielding, hazardous materials storage and waste areas, etc.).
- d. Obtain a complete list of the proposed processes, equipment, chemicals, biological and radiological materials, nanomaterials and gases to be used and stored in the lab or research area. The hazardous materials list should include the total quantities anticipated to be "in use" for proposed processes, as well as amounts in storage.
 - 1) Provide a chemical inventory list for all labs on the design drawings.
- e. There are extensive requirements for laboratory move-outs, which must be followed prior to commencement of remodeling or renovation of existing spaces. Refer to the UCB "EH&S Guide for Laboratory Moves" and reference the current version of ANSI Z9.11 "Laboratory Decommissioning".
- f. Relocation of laboratory fume hoods and installation of new hoods to existing spaces requires HVAC rebalancing. Fume hoods that are relocated must be recertified and pass a current ASHRAE 110 test (see **Laboratory Commissioning** below).

2. Laboratory Commissioning:

- a. During the design phase, develop a commissioning plan for each new or renovated laboratory/research area. Include the following:
 - 1) Written procedures to verify or validate the proper operation of the entire ventilation system including but not limited to general ventilation and hazardous or specialty exhaust subsystems.
 - 2) Design documents identifying equipment and other building systems integral to the laboratory or research area, including but not limited to autoclaves, cage washers, ventilated cages or racks, humidification or fogging systems, exhaust ducting, wash-down functionality of perchloric acid hoods, toxic gas or oxygen monitoring systems. Include the following in the documentation:
 - i. Final laboratory and system design drawings.
 - ii. Design flow specifications for all components of ventilation system, including designed capture velocity for specialty local exhaust ventilation systems.
 - iii. Copy of the test and balance report for ventilation system.
 - iv. Documentation of current ASHRAE 110 compliance from manufacturer for laboratory fume hoods and vented biosafety cabinets prior to install.
 - v. Tracking system to list deficiencies uncovered and corrective actions
 - 3) Test laboratory fume hoods to confirm compliance with the current ASHRAE 110 test on-site within one year of installation.
 - i. UCB EH&S may temporarily certify that hoods are safe for use until the ASHRAE 110 test can be scheduled (for example during limited lab remodeling projects). Larger projects and new construction are expected to perform the ASHRAE 110 test on all hoods before they can be used.
 - ii. Fume hood flow alarms must be calibrated to alarm at +/-10% of designed capture velocity.
 - 4) Prior to use, certify BSCs by an independent contractor that specializes in the maintenance and certification of BSCs. Cabinets must meet the manufacturer's operating specifications and the NSF 49 standard.
 - i. When specifying Class II Type A2 BSCs that have a thimble connection, provide flow alarms installed on the exhaust and calibrate prior to use.
 - 5) Prior to use, certify functionality of specialty ventilation systems including performance of capture velocity and flow tests per design.
 - 6) Confirm emergency eyewashes and showers are certified meeting ANSI Z358.1.

3. General Architectural Design Criteria:

- a. Coordinate laboratory equipment requirements with other building systems, fixtures, and equipment.
 - 1) Floor Sinks:
 - i. Provide floor sinks instead of floor drains unless existing facility does not allow for floor sink installation.
 - ii. Locate near trapped fixtures, eyewashes, showers and other similar plumbing fixtures, underneath the nearest lab bench.

- iii. Do not slope floors to drain, as sloped floors present a tripping hazard due to installation of improper slopes.
 - iv. Locate outside of circulation paths.
- b. Flooring:
- 1) Floors should be monolithic and slip-resistant. Consideration should be given to the use of coved floor coverings to facilitate cleanup of spills.
 - 2) Rubber flooring is prohibited in areas where radioactive materials will be used due to known difficulty in decontamination of radioactive material spills. Linoleum tile is recommended for these areas.
 - 3) Penetrations in floors, walls, and ceiling surfaces should be sealed. If feasible, countertops should incorporate a lip to prevent run-off onto the floor.
 - 4) Refer to **Facility Standard C2020** for additional flooring requirements.
- c. Doors and Windows:
- 1) Coordinate door sizes with the equipment being placed in the laboratory and consider future potential equipment as well.
 - 2) Because scientists are often carrying items or samples between labs or to other laboratory areas while wearing gloves, doors for laboratory areas should be fitted with automated opening systems or be furnished with push bars or door hardware that has been designed to be easily operated without use of hands. These considerations will help avoid possible contamination of the door handle with chemicals or biohazards that may be on their gloves and reduce the future purchase and disposal of gloves.
 - 3) Operable windows are prohibited in buildings containing laboratory and research areas to ensure correct balancing of the building ventilation system(s) and to guarantee maintenance of pressure cascades and capture of contaminants.
 - 4) If existing operable windows are present in the laboratory, they should be welded shut.
 - 5) If laboratories are located near vestibules, verify and maintain appropriate design pressure values within and around the vestibule.
- d. Partitions:
- 1) To maintain pressure cascades, extend and seal walls to structural deck above.
 - 2) Occasionally a need for integrated radiation shielding exists (lead drywall) for areas where unique needs arise (i.e. x-ray systems and other high radiation producing processes). UCB EH&S must be consulted for design of integrated shielding methods.
- e. Ceilings:
- 1) Ceiling height must accommodate a 14-inch clearance for biological safety cabinet(s).
 - 2) If the laboratory has a sprinkler system, local fire codes may require a clearance of 18 inches or more.
 - 3) In BSL- 2 laboratories, specify smooth, cleanable ceiling tiles (Mylar face with a smooth surface or equivalent).
- f. Specialty Finishes:
- 1) In chemical use, biosafety areas, and radioactive material use areas: walls, ceilings, floors, furniture, and work surfaces (e.g., benchtops, counters, etc.) should be

smooth, impermeable to liquids, and resistant to the chemicals and disinfectants normally used in the laboratory.

4. Laboratory and Research Space Utilization and Special Needs:

- a. For resiliency, organize and co-localize critical laboratory equipment resources to benefit back-up power for those resources, renewable energy resources to power those critical items in a disaster situation, etc.
- b. Consolidating heat-producing equipment is strongly encouraged including freezer farms, hood alcoves, incubators, floor centrifuges, shakers, drying ovens, autoclaves and other similar equipment.
- c. Design spaces to be flexible and easy to change use since science research directions change over time, as do the needs of scientists.
- d. To increase scientist access to equipment resources and to improve the efficiency of space utilization, the design of renovated or new laboratory spaces should aim (where possible and where compatible with the type of science) to create shared laboratory equipment areas that can be accessed by scientists from multiple labs.
- e. Spatial considerations to address UCB lab sustainability efforts include:
 - 1) Space in labs for three containers to address lab-specific waste diversion efforts (the type of material leaving labs depends on the type of science occurring).
 - 2) Space in common area for Green Labs mobile freezer(s) and Green Labs Shared ultra-low temperature (ULT) freezer(s).
- f. Avoid moving lab items to the new/renovated space that are obsolete or no-longer needed.
 - 1) Work with UCB to identify these items to allow proper disposing of items with Property Services or listing of useful items on Buff Surplus.
- g. Provide separate office spaces and/or break rooms to allow adequate space for workstations and for the consumption of food and drink in compliance with the UCB Food and Drink Policy.
- h. Provide access to the separate office areas or break rooms through public corridors.
- i. Ensure adequate means for emergency egress from areas that can be entered, but are not continually occupied (e.g., cage washes, climate-controlled rooms/chambers, etc.).
- j. Provide layouts following standard laboratory design practices with 5'-0" aisle ways, 2'-6" deep wall benches, and 5'-0" island or peninsula benches.
 - 1) These dimensions allow for a module designation during planning for new construction.
 - 2) Renovation projects shall follow these dimensions as closely as possible.
 - 3) Space furniture and casework considering ease of cleaning and maintenance around and under benches, cabinets, and equipment.
- k. Confirm layouts with the specific UCB Department or Representative for compliance with the research being conducted.
- l. Where biological wastes are generated, place an autoclave near the point of waste generation (i.e., in the same building and, if possible, on the same floor).
- m. Lab buildings constructed away from the Main Campus may require a 90-day waste holding area. Confirm with UCB EH&S.

5. General Mechanical and HVAC Design Criteria:

- a. Refer to **Facility Standard F1020** for additional laboratory mechanical requirements.
 - b. Ensure contaminants from laboratory or research areas do not migrate to other laboratory or research areas. For example, chemical or radioactive use areas require negative pressure whereas animal research areas or vivariums require a more detailed pressure cascade design (see "Air Pressure" section in **Facility Standard F1020**). Review proposed cascade design strategies with UCB EH&S, UCB Mechanical Engineering and Campus Veterinarian.
 - c. For dilution/dispersion of hazardous exhausts, wind tunnel testing is required for all projects which:
 - 1) Add new or modify existing roof-mounted exhaust fans.
 - 2) Significantly alter or add to existing rooftop geometries.
 - d. Coordinate locations of supply air diffusers, heavy traffic areas and doorways/exits so as not to negatively affect the function of exhaust systems and fire suppression systems.
 - e. Where hazardous, biohazardous, or radioactive materials are used, provide a sink in each laboratory or research unit for hand washing (hands-free sinks preferred). Provide a path of travel to the sink from hazardous areas which is free of obstructions, including doors.
 - f. Specify sinks constructed of impervious material with chemical-resistant traps, a coved backsplash, and hot-cold water pre-mixing faucet. Locate a paper towel dispenser and a soap dispenser (hands-free operation preferred) within easy reach of sink.
 - g. Clearly label main shutoffs (valves/switches for utilities, gas and vacuum lines) and locate outside the laboratory or research areas.
 - h. Label HVAC ducting, as well as process and waste piping, for contents and direction of flow (e.g., supply, return, specified hazardous exhaust system, etc.). Insulate piping with potential for hot or cold surfaces to prevent injuries or strategically locate to prevent inadvertent bodily contact.
 - i. Confirm location of the different types of storage cabinets and contents with UCB. Some types of cabinets may require certain proximities fume hood locations.
 - j. Locate fume hoods away from laboratory entrances, paths of egress, or high-traffic areas.
6. General Electrical Design Criteria:
- a. Provide a means to initiate a building evacuation near the laboratory or research unit area.
 - 1) Locate sub-panels adjacent to and immediately outside of labs.
 - b. Provide Ground Fault Circuit Interrupter (GFCI) protection for convenience receptacles located within 6' of sinks, emergency eyewash/showers, or other wet locations including chemical dispensing and consolidation areas such as chemical and waste storage rooms.
 - c. Do not specify GFCI receptacles for critical equipment such as refrigeration, sump pumps, or gas detectors. Use dedicated single receptacle outlets for such equipment.
 - d. Wire all labs for emergency power; uninterruptible power supply is required. Discuss strategies for emergency power with UCB Mechanical and Electrical Engineering.
7. General Security Design Criteria:
- a. Provide security appropriate for the department and research being conducted.
 - b. Laboratory areas shall be accessible to authorized personnel. Refer to **Facility Standards B3010** and **B3011** and confirm requirements with UCB Access Services.

- c. Provide enhanced security for areas for radioactive material use and storage (including waste materials). Areas designated for use of radioactive materials need ability to be isolated and secured separately from the main lab areas (i.e. a locked room within the lab).
8. General Laboratory Furniture, Cabinetry and Casework:
- a. Reference Standard: Comply with current SEFA-8 guidelines as published by the Scientific Equipment & Furniture Association (SEFA) except where more detailed or more stringent requirements are indicated, including the recommendations of equipment manufacturers.
 - b. Modular, mobile casework is recommended for future flexibility.
 - c. Design Criteria:
 - 1) No vibration, movement, or loading limitations.
 - 2) Not seismic sensitive.
 - 3) Interacts with laboratory equipment.
 - 4) Ergonomically designed.
 - 5) Complies with ADA accessibility requirements.
 - 6) Sturdy and capable of supporting anticipated loading and uses.
 - 7) Furniture and casework should be smooth, non-porous, and resistant to hazardous materials and chemicals, including biological and radioactive materials.
9. Metal Laboratory Cabinets:
- a. Provide the specified cabinet types from a single manufacturer wherever possible.
 - b. Reference Products:
 - 1) Hamilton Laboratory Solutions
 - 2) Kewaunee Scientific Corporation
 - 3) Mott
 - 4) LBI (Confirm State purchasing agreement)
10. Wood Laboratory Cabinets:
- a. Cabinet Construction:
 - 1) Finish: Match other wood species and finishes to aesthetically align with adjacent interior finishes.
 - 2) Provide smooth flush interior.
 - 3) Do not offset cabinet bottom with front face frame.
 - 4) Assemble units in the shop in as large components as practicable to minimize field cutting and jointing.
 - 5) Provide scribes and fillers as required.
 - b. Exposed Wood:
 - 1) Provide finish free from defects, mill marks, dirt and foreign matter, of superior quality, highly chemical resistant, evenly applied under proper room temperatures.
 - 2) Provide required stain finish and multiple coats of highly chemical resistant acrylic urethane finish, force dried, sanded and wiped clean between coats. Finish will be completely dried under controlled conditions before applying subsequent coats.
 - i. Finish shall be resistant to acids, alkalis, salts, and solvents in accordance with the performance requirements listed in this section.

- 3) Do not use two adjacent faces which are noticeably dissimilar in color, grain, figure, and natural character markings.
 - 4) Match semi-exposed wood to species, color and grain of exposed solid wood.
- a. Reference Products:
- 1) Hamilton Laboratory Solutions
 - 2) Kewaunee Scientific Corporation
 - 3) Institutional Casework, Inc.; "Campbell Rhea"
 - 4) Manufacturer must have a minimum of 10 years' experience and at least 10 successful installations of equal or greater complexity.

11. Laboratory Tops:

- a. General:
- 1) Plastic laminate is not acceptable for tops containing sinks or areas where standing water may occur.
 - 2) When selecting countertop materials, consider long-term operations and maintenance requirements including the ease of repairing damaged countertops or ease of modification to countertops.
 - 3) Provide smooth, clean, exposed tops and edges, in uniform plane free of defects. Make exposed edges and corners uniformly rounded.
 - 4) Provide 1" minimum thickness tops in maximum practicable lengths. Phenolics may be 3/4" or even 1/2" to minimize weight for mobile tables.
 - 5) Provide front and end overhang of 1" over base cabinets, formed with continuous drip groove under surface 1/2" from edge.
 - 6) Provide a minimum 3/8" raised edge around cup sink cut outs.
- b. Epoxy:
- 1) Factory molded tops of modified epoxy resin formulation, uniform texture throughout full thickness.
 - i. Color: Black, with minimal glare.
 - ii. Provide smooth surfaces with factory cut-outs for sinks and drip grooves.
 - 2) Provide 4" integral backsplash with intersection covered.
- c. Plastic Laminate:
- 1) Provide 0.051" thick plastic laminate sheet, Formica 840, lab grade, Wilson Art "Chem-Surf" or Pioneer Plastics "Chem-Guard H48" complying with NEMA LD-3.
 - i. Color: Provide black for chemical resistant tops to distinguish from non-chemical-resistant tops.
 - 2) Provide 3 mm hot melt applied PVC to exposed edges of tops and splashes to match color of top.
 - 3) Provide self-edging with same plastic laminate used for tops at all other openings.
 - 4) Provide one-piece 4" back splash with intersection not covered.
- d. Stainless Steel:
- 1) Provide raised marine edge around the entire perimeter of tops and counters containing sinks.
 - 2) Provide 14-gage stainless steel sheet, AISI Type 302/304 with No. 4 satin finish.
 - 3) Weld all shop joints, grind smooth and polish to become practically invisible.

- 4) Keep field jointing to a minimum. Provide hair-line butt jointed field joint mechanically bolted through continuous channels welded to underside at edges.
 - 5) Apply steel reinforcing channels to the underside of top where necessary to minimize deflection.
 - 6) Extend top down to provide a 1.25" thickness and 0.5" return flange under frame.
 - 7) Provide heavy build mastic coating under-surface for sound deadening.
 - 8) Provided integral coved backsplash.
 - 9) Pitch top surface two-ways to bowl to provide adequate drainage without channeling or grooving.
 - 10) Where stainless steel sinks occur in stainless steel tops, factory assemble sinks and tops into one integral unit with all welds ground and polished.
- e. Joints and Fasteners:
- 1) Where practicable, use factory jointing techniques recommended by manufacturer.
 - i. Identify field joints on shop drawings to be factory prepared so that there is no job site processing of top and edge surfaces.
 - 2) Plastic Laminate and Stainless-Steel Field Joints:
 - i. Use concealed clamping devices located within 6" of front, at back edges, and at intervals not exceeding 24".
 - ii. Tighten in accordance with manufacturer's instructions to exert a constant, heavy clamping pressure at joints.
 - iii. Secure tops to cabinets with "Z"-type fasteners or equivalent, using 2 or more fasteners at each front, end, and back.
 - 3) Epoxy Resin:
 - i. Provide plain butt-type joints assembled with epoxy adhesive and pre-fitted, concealed metal spline.
 - ii. Secure to cabinets with epoxy cement applied at each corner and along perimeter edges at not more than 48" o.c.
- f. Reference Products:
- 1) Thermo Fisher Scientific, Inc.
 - 2) Hamilton Laboratory Solutions
 - 3) Campbell Rhea
 - 4) Durcon Co. or Trespa (epoxy resin only)
 - 5) Kewaunee Scientific Corp.
 - 6) Just Manufacturing (stainless steel only)

12. Hazardous Materials Storage:

- a. General Requirements:
- 1) Consult with UCB EH&S for additional requirements and restrictions in areas where flammable liquid dispensing occurs.
 - 2) Secure hazardous materials storage areas against unauthorized entry.
 - 3) Provide proper storage for hazardous chemicals used or kept in inventory, as well as any waste generated.
 - 4) Provide separate storage cabinets to segregate chemicals by hazard class (i.e. acids, bases, oxidizer, flammables, and organics).

- 5) Provide flammable-proof refrigerators or freezers for cold storage of any Class I flammable liquids (i.e. ethyl alcohol, methanol, acetone and hexane).
- 6) Properly ground all cabinets storing hazardous materials.
- b. Hazardous Materials Storage Cabinet Construction:
 - 1) Provide cabinets meeting the IFC definition of “Approved Storage Cabinet”.
 - 2) Do NOT locate near sources of ignition, exit doorways, stairways, or in a location that would impede leaving the area.
 - 3) If corrosive materials are stored, line the entire interior of the cabinet with a corrosion-resistant liner.
 - 4) Provide a 2” deep liquid tight pan covering on the entire bottom of the cabinet to contain leaks and spills.
 - 5) Provide removable shelves constructed of the same material as the cabinet, lined as required for corrosive storage, and perforated to allow vapors to reach the vent and spills to reach the bottom spill containment pan.
 - 6) Each approved storage cabinet may not exceed a capacity of 120 gallons, limited to 25 gallons of Class 1 flammable liquids.
- c. Hazardous Materials Cabinet Venting:
 - 1) Hazardous materials storage cabinets do not have to be vented in most cases. However, venting is required for all corrosives, and if odiferous chemicals or hazardous vapors may be emitted, ventilation is recommended. Provide ventilation in accordance with the requirements of NFPA 30 and as approved by UCB EH&S and UCB Facilities Management; installed by an authorized contractor only.
 - 2) Consider vapor density when determining vent location.
 - 3) Route exhaust into the hazardous exhaust system as far away from any laboratory fume hood as possible to prevent flashback. Provide rigid exhaust vent materials, compatible with contents of the cabinets and have flame spread index of 25 or less (e.g., stainless steel, hard-soldered copper, and carbon steel are appropriate in most cases). Metal duct should be PVC coated or resistant to corrosive or reactive materials. PVC piping may be used to vent corrosive and other non-flammable storage cabinets.
 - 4) Vent each cabinet separately and with sufficient mixing distance so as not to create chemical incompatibility.
 - 5) Any solvent cabinet vent opening which has not been vented with vent pipe shall have manufacturer’s bungs secured in place.
- d. Compressed Gases:
 - 1) Provisions must be made to properly secure all gas cylinders, whether they are stored in a gas cabinet, fume hood, or open laboratory space. Compressed gas cylinders shall not be stored in an unventilated cabinet, near elevators, walkways, platform edges, or in locations where they may sustain damage.
 - 2) Gas cabinet storage is required for cylinders larger than lecture bottle size of pyrophoric gases and NFPA Health Hazard 3 and 4 gases. For pyrophoric gases, a sprinklered cabinet is also required. Examples of NFPA Health Hazard Rating 4 include arsine, chlorine, hydrogen fluoride, and phosgene. Ammonia and carbon monoxide are examples of NFPA Health Hazard Rating 3.

- i. Gas cabinets shall have self-closing doors, and limited access ports/ windows, with an average face velocity of 200 fpm.
 - ii. Store halogen gas mixtures used for excimer lasers in ventilated gas storage cabinets.
 - 3) Adequate space shall be made available for segregation of gases by hazard class. Flammable and oxidizing gas storage must be at least 20 feet from storage of highly combustible materials.
- e. Silane:
 - 1) Reference Standard: In the use, storage, and dispensing of 0.5 scf (14L) and greater of silane, comply with the current requirements of ANSI/CGA G-13: Storage & Handling of Silane and Silane Mixtures to reduce the chance of a deflagration or fire and to minimize damage and injuries that could occur from such incidents.
 - 2) For indoor storage, provide a gas cabinet, dedicated to the storage of silane, equipped with gas detection, optical flame detection, and quick response sprinklers. If flames or gas are detected, automatic shutdown of the system is required. Sequential inert gas evacuation/purge must be provided. Provide manual shutdown outside of the gas cabinet.
 - 3) For outdoor storage, provide for bulk cylinder storage, dedicated to the storage of silane, in a nest or bunker separate from the building meeting ANSI/CGA requirements. Locate outdoor storage a safe distance from public assembly areas. Provide mechanical or natural ventilation greater than 1 cfm per square foot of storage area.
 - i. Cylinders with a capacity greater than 450L are prohibited due to large separation distances necessary.
 - ii. Outdoor storage locations require a means of optical flame detection.
 - 4) Dispensing Stations Design Criteria:
 - i. Separate from buildings and fences.
 - ii. Provide ventilation meeting hazardous exhaust requirements (e.g., maintain atmosphere <25% LEL).
 - iii. Provide remote manual shut-off minimum 15' away.
 - iv. Provide a dedicated purge gas system.
 - v. Provide deluge water spray protection activated by optical flame detection.
 - vi. Provide sequential inert gas evacuation/purge.
 - 5) Hazardous atmosphere monitoring requirements are applicable.
- f. Cryogenic Liquids:
 - 1) Locate liquid nitrogen dispensing areas out of hallways and areas frequented by the public. A separate liquid nitrogen dispensing area/room is recommended.
 - 2) Storage or dispensing areas should be highly ventilated (4-6 ACH).
 - 3) Storage closets, enclosed spaces, or areas with high volumes of cryogenic liquids may necessitate the addition of an oxygen monitoring system and alarm.
 - 4) Critical vent areas should be covered, or pointed down (i.e., Dewar necks, and pressure relief valves).
 - 5) Protect all portions of lines that could contain liquid cryogen by pressure relief devices. Install a pressure relief device on any portion of a line that could be isolated by shutoff valves.

13. Vacuum Pump Cabinets:

- a. Vacuum pumps serving hazardous processes should be vented to the hazardous exhaust system. Consult UCB Mechanical Engineering.
- b. Consider using scroll pumps in place of rotary vane pumps, and turbomolecular pumps in place of diffusion pumps. These are usually preferred by the scientists, are more energy efficient, and potentially reduce ventilation requirements because of a reduction of heat or oil vapor.
- c. If a vacuum pump uses oil, provide an oil mist trap or filter to prevent building up vacuum pump oil exhaust lines or ducting.
- d. A larger exhaust fan may be required for greater heat loads. Attach the exhaust fan assembly to the exterior of the cabinet for maximum pump storage and airflow.
- e. Cabinet Construction:
 - 1) Provide bottomless cabinet.
 - 2) Attach toe-kick to the doors and allow total access to the front of the cabinet.
 - 3) Provide 1" neoprene foam interior lining for sound deadening and easy cleaning.
 - 4) 120 VAC, 20 amp duplex mounted on the inside of the cabinet back and toggle switch mounted in the top panel.
 - 5) 1-1/2" PVC vent pipe in the back for venting or access to the fume hood above.

14. Biological Safety Cabinets (BSCs):

- a. Reference Standards:
 - 1) Comply with applicable standards published by of National Sanitation Foundation International/American National Standard International (NSF/ANSI) Standard No. 49 (latest edition) for each type and size of safety cabinet required.
 - 2) Biosafety cabinet installations and proposals for biological or biomedical research must be reviewed and approved by UCB to evaluate conformance with requirements of the Center for Disease Control (CDC) and the National Institute of Health (NIH). Such requirements can be found in CDC/NIH publication: "Biosafety in Microbiological and Biomedical Laboratories."
 - 3) If NIH funding is used to facilitate project, follow the NIH Building and Construction requirements.
- b. Confirm selection of Biological Safety Cabinets with the UCB Department group for which the laboratory is being designed. These cabinets may be provided by the owner, but the design consultants are expected to coordinate all appropriate building systems to ensure efficient operations and occupant safety.
 - 1) Recirculated hoods are desired. Confirm selection with UCB Mechanical Engineering.
 - 2) In general, externally vented BSCs should be avoided. If proposed, obtain approval from UCB EH&S, UCB Mechanical Engineering, and CU Green Labs.
- c. Provide for emergency power to BSCs.
- d. Based on campus experience and research, UV lights are discouraged in BSCs.
- e. Exhaust Systems:
 - 1) Do not directly connect Class II Type A1 BSCs to the exhaust system.

- 2) Connect Class II Type A2 BSCs to the exhaust system via an air gap (canopy or thimble), or exhaust directly into the laboratory with access provided to the exhaust filter for testing of the HEPA filter.
 - i. If connected via canopy/thimble to the exhaust system, the connection must have a ribbon streamer or like device attached to the edge to indicate the direction of flow and an alarm must be installed to indicate proper flow. Provide the canopy/thimble connection by the BSC manufacturer or as approved by the Biosafety Officer and exhaust airflow must equal (or exceed up to 125%) the BSC manufacturer's exhaust specifications.
 - 3) Class II B2 are generally prohibited. Obtain approval from UCB EH&S for specific uses.
- f. Locate BSCs near where biological materials are stored, and a minimum of 10' from any door or doorway or where interfering air currents and cross drafts from windows, high traffic areas, HVAC systems, or other apparatus, could adversely affect the proper function of the cabinet enclosure. NIH guidelines for BSC placement recommend the following:
- 1) 12" from adjacent walls.
 - 2) 80" from opposing walls.
 - 3) 60" from an opposing active lab bench area or areas with occasional foot traffic.
 - 4) 120" between opposing biosafety cabinets.
 - 5) 40" between biosafety cabinets along the same wall.
 - 6) 48" between the cabinets positioned on perpendicular wall.
 - 7) 40" maintained around the cabinet (avoid high foot traffic locations in the lab).
- g. Systems Spatial Requirements:
- 1) Clearly identify required vertical clearances above cabinet in the construction documents.
 - 2) Where space permits, provide 12" clearance behind and on each side of the cabinet. If not feasible, provide a minimum of 3" clearance on each side and minimum 1-1/2" in back.
 - 3) Locate the electrical outlet for the cabinet to be easily accessible for service and electrical safety testing without moving the cabinet.
 - 4) Provide a hand washing sink in the same room as the cabinet for immediate access. Locate out the path of travel and free of obstructions that may inhibit immediate use, including doors.

15. Hazardous Atmosphere Monitoring:

- a. Hazardous atmosphere monitoring ensures safe concentrations of vapors and gases and an oxygen-deficient atmosphere does not exist.
- b. Consult with UCB EH&S to determine if monitoring for a hazardous atmosphere detecting and monitoring system is required based on the hazard assessment (i.e., hazardous materials, volumes, concentrations, toxicity, physiological warning properties, etc.) performed during the design phase.
- c. Provide hazardous atmosphere detection systems in the area of the hazard that initiate local audible and visual alarms installed inside the area of the hazard to alert occupants, as well as immediately outside of the hazard area.

- d. Depending on the hazard, UCB EH&S may require a hazardous atmosphere detection system to connect with the building fire alarm control panel to evacuate the building and summon the fire department during an emergency. Alarm signals shall indicate the type of alarm and the zone of origin, in accordance with NFPA 72.
- e. A gas leak detecting system is required when a cylinder larger than lecture bottle size containing a gas with a NFPA Health Hazard Rating of 4 will be used or stored in the laboratory (gas cabinet also required).
- f. A gas leak detecting system may also be required if a cylinder larger than lecture bottle size containing a gas with a NFPA Health Hazard Rating of 3 has been approved by UCB EH&S to be stored outside of a gas cabinet.
- g. Activation of the monitoring system shall automatically close the shutoff valve on toxic, highly toxic, and radioactive gas supply lines to the system being monitored.
- h. All areas where silane is stored or used requires a silane leak detection system. If applicable, silane systems must be installed per the latest ANSI/CGA standard for storage and handling of silane and silane mixtures.
- i. O₂ sensors are generally required in areas in which oxygen-deficient environments are foreseeable under normal or emergency situations (e.g., closets storing oxygen-displacing compressed gases, large volumes of cryogenic liquids, etc.).

16. Specialty Lab Equipment:

- a. Whenever possible, energy or water efficient equipment should be used.
- b. Pressurized Lab Equipment:
 - 1) Normal and emergency relief venting and vent piping for pressure vessels should be adequate and in accordance with the design of the vessel. Specify vessels in accordance with the ASME Boiler and Pressure Vessel Code for Unfired Pressure Vessels.
- c. Autoclaves:
 - 1) Provide water miser to minimize water consumption when autoclaves use water to pull vacuum.
 - i. For additional water conservation, pre-program with a 5-minute standard dry time.
 - 2) Where possible, use house-steam for chamber and jacket for energy efficiency.
 - 3) Consider autoclaves with the following energy saving features:
 - i. Programmable to automatically turn off steam to jacket when not in use.
 - ii. Capable of returning jacket steam to the house system.
 - iii. Programmable to turn off jacket steam during exhaust.
 - iv. Contain an online internet system for users to maximize autoclave use and minimize the need to purchase additional autoclaves.
 - 4) Locate a canopy hood above the autoclave to exhaust escaping steam and heat.
 - 5) Provide a floor drain in autoclave area.
 - 6) Provide an area for storage of autoclaved wastes in the immediate vicinity of each autoclave. Include floor space for a 96-gallon, plastic wheeled trash can with lid (roughly 36" x 36") with no obstructions above.
- d. Ultra-Low Temperature (ULT) Freezers:
 - 1) Consult UCB Mechanical for remote monitoring requirements.

- 2) If ULT freezer is purchased as part of the project, provide energy efficient ULT. Confirm selection with UCB Green Labs representative.
- e. Coolers and freezers for research should have temperature sensors wired to BAS for alarming.
- f. Anaerobic Chambers and Other Unique Pieces of Biological Containment Equipment:
 - 1) Anaerobic chambers and other pieces of biological containment equipment can have special space requirements. Contact the UCB EH&S Biosafety group prior to installation.
- g. Lasers:
 - 1) Provisions shall be made to shield and enclose lasers.
 - i. Laser enclosure is required for Class 4 lasers.
 - 2) Design areas containing laser hazards in accordance with the requirements of ANSI Z136.1, including provision for access control to open beam Class 4 lasers and avoidance of flammable/combustible construction materials. Provide lighted laser warning signs for areas containing Class 3b and Class 4 lasers.
 - 3) Locate partitions, dogleg entrances, or other building elements to allow persons to don laser protective eyewear and other required PPE before entering spaces where beam hazards exist or could exist. Preferably, these provisions should be made before they enter the lab.
 - 4) If windows are present, specify glazing systems to prevent escape or reflection of beams.
 - 5) For areas using Class 4 lasers, install red, mushroom-type, room/area emergency power shutoffs in conspicuous locations that are easily accessible from the laboratory entrances.
 - 6) Hazardous exhaust systems may be required. Consult with UCB EH&S.

17. Maker Spaces:

- a. Consult with UCB EH&S for all Maker Spaces. Specialty exhaust, containment systems, or other controls may be necessary depending on the planned processes, equipment, and material use.
- b. Confirm ventilation requirements with UCB Mechanical.
- c. Exhaust laser cutter directly to the exterior (see Hazardous Exhaust Requirements).
- d. Provide laboratory fume hoods for processing activities utilizing hazardous materials.

18. Nanomaterials:

- a. Consult with UCB EH&S to design for appropriate controls for proposed use of nanomaterials.
- b. In general, a laminar flow control system is desirable to control release of nanoparticles. Fume hoods and other local exhaust systems create a turbulent airflow pattern that increases release of contaminants.

F1020 – Laboratory and Research Mechanical Systems

Introduction

The following section provides requirements in the design and construction of laboratory mechanical systems at the University of Colorado-Boulder (UCB). Discuss types of proposed systems with UCB EH&S and UCB Mechanical Engineering.

In general, a VAV system is preferred. Obtain UCB EH&S approval for designs of specialty local exhaust systems (slot exhaust, backdraft/downdraft tables, canopy hoods, point exhaust, etc.).

Coordinate requirements below with **Facility Standard F1010** for full laboratory and research area design requirements.

UCB Requirements

1. General Ventilation:

a. Pre-Design Considerations:

- 1) Safety cabinets and enclosures for highly-reactive or toxic gases, and other specialized operations (shop areas, maker spaces, dark rooms, ceramics areas, spray painting, vivariums, glove boxes, food preparation areas, chemical/gas/cylinder storage rooms, liquid nitrogen dispensing areas, gas generation or recycling areas, etc.) may have different or additional requirements than those listed below. Consult with UCB EH&S before planning these types of installations.
- 2) Early in design, coordinate the collection and analysis of information needed to determine mechanical requirements and hazard control techniques for each laboratory process with applicable subject matter experts (i.e., the lab user(s)/department, UCB Facilities Engineering, UCB EH&S, etc.). Examples of such information includes, but may not be limited to the equipment list, standard operating procedures, and the proposed inventory of hazardous materials (i.e., chemicals, gases, biological and radiological materials).
- 3) Compile a complete list of the chemicals, biological and radiological materials, nanomaterials, and gases to be used and stored in the lab and submit to UCB. The hazardous materials list should list the total quantities anticipated to be "in use" for proposed processes, as well as amount needed for storage. Use the list to analyze the need for exhaust based on flammability, toxicity, corrosiveness, and explosion hazards. Work closely with UCB when selecting and analyzing fume hazard control techniques.

b. General Requirements:

- 1) Ventilate laboratories per ASHRAE Standard 62, NFPA 45, NFPA 91, and ANSI/AIHA Z9.5.
- 2) Provide sufficient exhaust air to assure the removal of hazardous airborne materials. In general, enclose hazardous operations in fume hoods or other exhausted enclosures. UCB Mechanical and UCB EH&S employ performance-based Air Changes per Hour (ACH) for laboratories. The ACH is driven by the worst case, based on the following three variables:
 - i. Hazard Classification
 - ii. Fume Hood or Ventilation Needs
 - iii. Potential loads if there are not decoupled from the air handling unit system.
- 3) Provide a fully-integrated Variable Air Volume (VAV) airflow/pressure control system to control room temperature, ventilation rate and room pressurization. The

control system should constantly monitor the amount of supply and exhaust air for the laboratory rooms, regulate the flow to maintain a net designed pressurization, and have ability for remote adjustment and local override.

- 4) Provide a means to activate the laboratory's emergency ventilation system (for spills, chemical releases, etc.). Provide emergency purge buttons where applicable.
 - 5) Exhaust from laboratory or research units utilizing hazardous materials should not be recirculated to other areas of the building. Design airflow to allow flow from low-hazard areas to high-hazard areas.
 - 6) In BSL-2 areas, recirculation of air is prohibited outside of the laboratory unit.
- c. Air Pressure:
- 1) Laboratory modules in which hazardous chemicals/gases, biohazards, and/or radioactive materials are planned for use shall be maintained at an air pressure of at least 0.03" wg* that is negative to the corridors or adjacent non-laboratory areas.
 - i. An exception to this requirement is where operations, such as those requiring clean rooms, require a positive pressure relative to surrounding areas. In these cases, special precautions shall be taken (e.g., The HEPA units are laminar flow and will be located as far from the hood as possible to avoid air currents near the hood. In an emergency, a ventilation "off" switch will be located in the room near the door that will, when activated, shut off the air coming into the room (via a control damper) and shut off the air handler and fan. The main exhaust fan will continue to run, and the room will be negative.).
 - 2) Some biological and animal research areas, including vivariums have specific pressurization requirements:
 - i. Non-hazardous cell culture areas should be positively-pressurized.
 - ii. Hazardous cell culture areas should be negatively-pressurized.
 - iii. Animal holding rooms should be negatively-pressurized, unless animals are immunocompromised. If animals are immunocompromised, the area should be positively-pressurized in relation to immediately-adjacent areas, but the entire area should be negatively-pressurized in relation to other functional areas of the building to contain contaminants and prevent exposures to others. A common solution is to provide an ante-room immediately adjacent to a positively-pressurized animal holding room. The anteroom would then be negatively pressurized in relation to the adjacent corridor (or other area, as appropriate).
 - 3) If laboratory pressurization becomes critical to prevent undesirable airflow from one area to another in high-hazardous applications, an airlock may be necessary. Consult UCB EH&S and UCB Mechanical Engineering for guidance.
 - 4) In BSL-2 areas, it is recommended that a visual monitoring device that indicates and confirms directional inward airflow be provided at the laboratory entry. Consideration should be given to the installation of a HVAC control system to prevent sustained positive pressurization of the laboratory. Audible alarms should be considered to notify personnel of HVAC system failures.

2. Hazardous Exhaust Systems:

- a. Reference Standard: Consult current versions of the American Conference of Governmental Industrial Hygienists (ACGIH) Industrial Ventilation: A Manual of Recommended Practice for Design, NFPA 91: Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids, and the ASHRAE Handbook of Fundamentals as the basis of design for hazardous exhaust systems and ductwork, including enclosing hoods (e.g. laboratory fume hoods, glove boxes, gas cabinets) and other local exhaust hoods (e.g., fume/vapor extraction arms, backdraft/downdraft tables, canopy hoods, 3D printer emissions, laser cutter exhaust, etc.).
 - 1) Testing procedures:
 - i. Latest version of ANSI/ASHRAE 110: “Method of Testing Performance of Laboratory Fume Hoods”.
 - ii. Calibrated air velocity measuring devices as specified in Chapter 9 of the ACGIH – “Industrial Ventilation, a Manual of Recommended Practice”.
 - iii. Testing, inspecting, and certifying hazardous exhaust systems, fume hoods, and chemical storage cabinets will be performed by UCB Facilities Management and UCB EH&S.
- b. Discharge any air containing hazardous chemicals and gases directly to the exterior through hood/duct systems maintained at a negative pressure relative to the pressure of normally occupied areas of the building.
- c. In general, use laboratory fume hoods to capture and contain contaminants generated in laboratory and research areas. When a laboratory fume hood is not feasible for the process, specialty local exhaust ventilation systems may be necessary. Use of specialty local exhaust ventilation systems requires the approval of UCB EH&S and UCB Mechanical Engineering.
- d. Hoods need to be low-flow, high-performance hoods. For fume hood specification, work with UCB EH&S and UCB Mechanical Engineering to obtain list of acceptable hood manufacturers. Coordinate hood accessory requirements with User Groups.
 - 1) All piping and fittings need to comply with **Facility Standards –Section D**.
 - 2) All utilities serving the hood need to comply with **Facility Standards – Section D**.
- e. Hood Accessibility Concerns:
 - 1) Coordinate with UCB Accessibility Officer to provide accessible hoods as necessary on a per project basis.
- f. Provide sufficient capture velocities per manufacturer specifications and/or ACGIH “Industrial Ventilation, a manual of Recommended Practice”. UCB EH&S will verify designed capture velocity prior to use (see **Facility Standard F1010; Laboratory Commissioning**).
- g. Discharge all chemical exhaust through unobstructed, uncapped vertical stacks. Locate exhaust discharge with clearances as required by the latest version of ASHRAE 62.1 “Separation of Exhaust Outlets and Outdoor Air Intakes” or as indicated following wind tunnel testing of discharge locations; terminate stacks at required distances above roof level, away from eddy currents, air intakes, and openings. Discharge velocities and locations shall follow the ASHRAE 62.1 standard depending on the hazard class of the exhaust system. Specify fans, stack heights, and discharge velocities to prevent the reentry of contaminants into any facility. UCB may consider a discharge height exception if it is deemed that adequate velocity and dilution will be achieved by the specified fan and confirmed by a wind study.

- 1) Wind studies are required for all hazardous exhaust systems to ensure that re-entrainment of hazardous exhaust does not occur. Emergency generator exhaust should also be considered in the wind study.
- h. If a new hood is connecting to an existing central or manifolded hazardous exhaust system serving multiple locations, the air system shall be evaluated to see if it has sufficient capacity for additional exhausted equipment.
 - 1) Consult with UCB EH&S to arrange for performance of a hazard assessment to ensure incompatible or reactive chemicals will not present a hazard in manifolded exhaust ductwork.
 - 2) Label individual exhaust drops on a central or manifold exhaust system for the specific room(s) it services.
- i. Snorkel exhausts are not allowed on campus, unless under specific approval by UCB. Spot exhaust is a good alternative but only considered based on application and approval from UCB Mechanical Engineering.
- j. Hazardous exhaust systems are not typically equipped with filters to capture contaminants. In some cases, however, pre-filters may be installed to protect heat exchange coils or other HVAC equipment from accumulating debris. Consult with UCB Mechanical Engineering regarding filter specifications for hazardous exhaust systems.
- k. Locate local exhaust systems (including chemical fume hoods) near where chemicals/hazardous materials are stored, at the point of contaminant generation, and with a minimum clearance from any door or doorway or where interfering air currents and cross drafts from windows, high traffic areas, HVAC systems, fire detection and extinguishing systems, or other apparatus could adversely affect the proper function of the exhaust system. The location of the discharge shall conform to the latest version of ASHRAE 62.1 "Separation of Exhaust Outlets and Outdoor Air Intakes" requirements.
- l. Provide audible and visual low air flow or duct static pressure indicators for at the point of operation for all local exhaust ventilation systems.
- m. Provide make-up air to compensate for the exhaust air. The location and volume of make-up air is critical to assuring proper fume hood operation and occupant protection.
- n. Local exhaust ventilation systems shall not have a user-controlled on/off switch. Turning these systems on/off can negatively affect general ventilation system balance.
- o. Emergency backup power to exhaust fans and control system is necessary. Design hazardous exhaust systems to maintain proper flow and static within all hazardous exhaust ducts during power failures (on emergency generator power). Provide emergency backup power that does not shut down upon activation of any alarm, however, dedicated switches may be provided in the building fire alarm panel to allow capability for manual fan shut-down by emergency responders.
 - 1) In general, all mechanical equipment will be required to be wired on emergency generator and via UPS. Confirm emergency power requirements with UCB Mechanical and Electrical. FSD for AHU's are also included in this requirement.
- p. Design for continuous negative pressure in all parts of exhaust ductwork when hazards may be present, including maintenance, shut-down and emergency situations. At no point will it be acceptable for hazardous exhaust systems to back flow or dump contents of the ducts.

- q. Provide redundancy for both supply and exhaust systems; each system manifolded together between AHU's and/or exhaust fans. Size fans at 60% each for supply. Exhaust may need to be three fans and should be reviewed with UCB Mechanical based on size and capacity.
 - r. Operations generating flames, sparks, or hot material such as from grinding wheels and welding shall not be manifolded into any exhaust system that air conveys flammable or combustible materials.
3. Chemical Fume Hoods:
- a. Purchased laboratory fume hoods must be low-flow, high performance hoods with VAV and able to meet a minimum of 60 FPM face velocity unless a specific face velocity is needed due to hazard. Provide hoods certified by a Nationally Recognized Testing Laboratory (NRTL) and certified by the manufacturer to pass the current ASHRAE 110 test.
 - b. Specify hoods to pass ASHRAE 110 test at the UCB recommended maximum sash operating height of 14" above the work surface unless a specific sash opening is needed for unique process. Install sash stops at 18" above the work surface with an override release. Combination sashes (with both horizontal and vertically adjustable sashes) are not allowed unless approved by UCB EH&S except for specific applications.
 - c. For labs intended for chemistry or chemical synthesis, strongly consider access to Process Chilled Water (PCW) at the fume hoods. This will enable the incorporation of heat exchangers between the PCW and a small tank of recirculating water to be used with water condensers in chemical synthesis reactions at each hood. Having access to PCW will avoid the need for single pass through water use with water condensers in chemistry reflux reactions and greatly minimize the risk of floods that are common with single pass through water use in water condensers in fume hoods.
 - d. Fume hood and ductwork construction must be compliant with current versions of NFPA 45: Standard on Fire Protection for Laboratories Using Chemicals, and ANSI Z9.5: Laboratory Ventilation, in addition to the publications that shall be referenced for hazardous exhaust (e.g., NFPA 91, ACGIH Industrial Ventilation Manual, ASHRAE Handbook of Fundamentals).
 - e. Supply or auxiliary air hoods are not permitted due to the difficulty of maintaining proper balance.
 - f. Equip fume hoods with audible and visual low air flow alarm, field-calibrated to alarm at +/- 10% of designed face velocity.
 - g. The base of the hood should provide for containment of the maximum anticipated spill quantity of hazardous materials to be used in the hood (i.e. a lip on the benchtop or a spill tray for floor mounted hoods).
 - h. Chemical fume ducts are generally not equipped with fire sprinklers or fire dampers; however, code may require ducts to be in fire-rated or fire-protected shafts. Where fume hood exhaust contains flammable vapor, confirm compliance with the UCB Fire Marshal for automatic fire suppression requirements protecting the fume hood and the exhaust duct. Address this requirement on a case-by-case basis, since it may result in a variety of other potential hazards associated with fume hood operation.
 - i. Class I Division I (explosion-proof) interior lighting and other electrical utilities are required where internal utilities are desired.

- j. Locate electrical receptacles and switches in a manner to minimize potential for contact with spills (e.g., outside of the hood). Equipment and controls located within fume hoods should be provided with a disconnect switch within 15’.
 - k. Plumbing (e.g., vacuum lines) should exit the sides or back of the hood behind the baffles and not the benchtop.
 - l. Equip chemical fume hoods with an exterior mounted single point or remote adjustment baffle system.
 - m. When sinks are provided, specify cup sink type with an elevated lip. If an elevated lip is not possible, install a drain plug. Use backflow preventers or vacuum breakers to protect domestic water supplies, as required by UCB.
 - n. Laboratory fume hoods must pass current ASHRAE 110 after installation to ensure appropriate capture of contaminants (see **Facility Standard F1010 - Laboratory Commissioning**). Notify UCB EH&S on completion of new installation or relocation in order to certify hood flow and capture.
 - o. Reference Products:
 - 1) Labconco
 - 2) Waldnor (without fan assist and without controls)
 - 3) AMS
 - 4) Other manufacturers with UCB approval.
4. Specialty Fume Hoods:
- a. Specialty hoods are required for the use of Hydrofluoric Acid (HF), Perchloric Acid, and Radioactive Iodine.
 - 1) Conventional chemical fume hoods are acceptable for most low-level radioisotope applications.
 - b. Perchloric Acid Fume Hoods:
 - 1) A perchloric hood is required if perchloric acid is being used or stored in concentrations greater than 72.5%, or if it is being heated or evaporated.
 - 2) The hood and ductwork must be used for perchloric acid only (i.e., cannot be manifolded) and be labeled as such.
 - 3) Inside hood surfaces, ductwork, fans, and gaskets shall be compatible with perchloric acid, non-organic, have smooth seams, and be equipped with water wash-down capability. The hood, duct system, fan (if necessary) and stack must be included in wash-down capability per manufacturer specifications.
 - 4) Install perchloric hoods as close to the exhaust fan as possible and connect only by vertical duct runs with as few turns in the duct as possible, and with water spray nozzles provided at each turn.
 - 5) Install all components to manufacturer’s specifications. Absolutely no modifications of the hood/fan/duct system are allowed by the general contractor or sub-contractors during installation. Any proposed modifications must be explicitly approved, in writing, by the manufacturer.
 - 6) If the perchloric hood is designed with a collection trough inside the hood, the trough must be protected against incidental spills within the hood with an elevated lip or berm above the working surface. Additionally, install an acid neutralization

basin for wash down rinse water. Consult with UCB EH&S for connection to the sanitary sewer.

- c. Hydrofluoric (HF) Acid Fume Hoods:
 - 1) The hood must be used for HF acid only and be labeled as such.
 - 2) HF acid hoods are required to be constructed of materials resistant to the effects of HF (PVC, polycarbonate, etc.).
 - 3) The exhaust cannot be manifolded or joined to non-HF acid exhaust systems.
 - 4) High temperature HF work requires an HF gas monitoring system within the lab.
- d. Radioisotope Hoods:
 - 1) Proposed radioisotope hood installations and the use of radioactive materials on campus require review, approval, and licensing by UCB.
 - 2) The use of radioactive iodine requires a specialized radioisotope hood equipped with integral filter components that are within the hood or within the duct.
 - 3) Service contracts must be set up for maintenance, calibration, and filter replacement or disposal. Consult with UCB EH&S when the use of radioactive iodine is required.
- e. Ductless Hoods:
 - 1) Ductless fume hoods are not allowed at UCB due to the hazards of improper use and neglect of proper maintenance. The question of who 'owns' future maintenance for ductless fume hoods is a known issue on campus.

5. Ducts, Fans, and Control Systems

- a. Provide controls and dampers, where required for balancing or control of the exhaust system, of a type that, in event of failure, will fail open to assure continuous draft. If energy conservation devices are used, they shall not recirculate laboratory exhaust air or otherwise compromise the safety of the building occupants.
- b. Clearly label all fans, ducts, and power supplies to indicate areas of service.
- c. Installation of ductwork must be in compliance with NFPA 91 and ANSI Z9.5, including provisions for properly sealing penetrations, grounding, and sealing duct construction materials. Avoid penetration of fire barriers.
 - 1) Install ductwork with a minimum number of elbows, using round ducts and sweep ellipses wherever possible. To further minimize friction loss and turbulence, provide duct interiors which are smooth and free from obstructions, especially at joints.
 - 2) Rectangular elbows are not acceptable, unless there is no other feasible method. If used, turning vanes and inspection doors upstream of the vanes are required.
- d. Hazardous System Ductwork:
 - 1) Specify rigid construction, fire-resistant (i.e., NFPA flame spread of 25 or less), corrosion-resistant ductwork, specified based on the anticipated hazards and materials used. For example, stainless steel is not appropriate for hydrochloric or nitric acid vapors. Provide PVC coated or FRP ductwork for corrosive or reactive material exhaust. PVC piping may be used to vent corrosive and other non-flammable storage cabinets.
 - 2) Ducts for ventilating flammable storage cabinets shall be tied into the hazardous exhaust as far down stream from the fume hood as practical to prevent fire-flashback.

- 3) Equip hazardous exhaust system ductwork with a balancing damper.
 - e. The fan housing and components shall be corrosion resistant and meet the AMCA standard for spark-resistant construction. The motor must be vapor tight (Class I, Division I) if it is located in the air stream.
 - f. Although previous locations on campus may be designed in this manner, fans used for hazardous exhaust are not allowed in enclosed areas, such as attics, penthouses, and mechanical rooms, shall comply with ASHRAE.
 - g. Internal fans or blowers are not permitted on or within fume hoods. Fans or blowers must not be located inside any duct that is used to vent hazardous exhaust.
6. Equipment Cooling:
 - a. "Once through" laboratory equipment cooling is not allowed on campus.
7. Laboratory Plumbing Equipment:
 - a. Clean-outs: Verify Orion cleanout above sink fits within ceiling-to-bench chase.
 - b. Traps:
 - 1) Polypropylene, cast-brass, or Duriron complete with tailpiece and arm.
 - 2) All traps and waste shall conform to materials as required in **Facility Standard D2030**. All supplies, stops and valves nickel plated brass where installed in areas subject to acid fumes. Quarter turn shutoff valves at each piece of laboratory equipment and each piece of laboratory furniture for all services.
 - c. Escutcheons: Nickel plated brass.
 - d. Stops and supplies: Quarter turn, nickel plated brass wheel handle operated stops and nickel-plated copper supplies or braided stainless steel hose.
 - e. Water piping: Chrome or nickel-plated finish where exposed with wrought copper fittings of same finish.
 - f. Low flow fixtures are to be specified as well as aerators.
 - g. Waste and vent piping: Acid-resistant to be of same as balance of building waste system: cast iron with no-hub joints.
 - 1) Acid waste neutralization systems are generally not allowed on campus. Consult with UCB EH&S for needed exceptions. Acid waste is collected and removed from labs without entering the sanitary waste system.
 - h. Specific approval is required from the City of Boulder (through UCB EH&S) for all lab equipment that discharges waste directly to sanitary.
 - i. Provide "ASCO" gas air or water rated (115 psi) 2-way valves with actuation and control as required.
 - j. Vacuum Breakers: If laboratories are fed from the domestic water systems, provide vacuum breakers on faucets and cocks.
 - 1) Industrial system
 - 2) Vacuum breakers at all fixtures and fume hoods

8. Laboratory Service Fixtures:**a. General:**

- 1) Provide units complete with washers, locknuts, unions, nipples and other accessories for positive mounting to supporting laboratory units. Include wall and deck flanges, escutcheons, handle extension rods, remove valves, and similar items required. Fabricate units to withstand test pressure of 100 psig.
- 2) Furnish fixtures all handed in the same direction for each type provided unless specifically required otherwise by the user. In existing spaces, hand fixtures to match exiting like fixtures.
- 3) Provide complete list or schedule of all service fixtures including material and finish.
- 4) Provide colored plastic index discs with embossed identification letters at each service fixture handle or knob. Secure discs to fixture handles to be virtually tamperproof. For remodeling work recode existing fixtures to meet requirements of this section. Color code as follows:
 - i. Air - Orange
 - ii. Gas - Blue
 - iii. Vacuum - Yellow
 - iv. Carbon Dioxide - Pink
 - v. Steam - Black
 - vi. Hot Water - Red
 - vii. Cold Water - Green
 - viii. Distilled or Deionized Water - White

b. Water Valves or Faucets:

- 1) Provide units with renewable barrel locked in valve body. Barrel shall contain all wearing parts, with renewable discs. Equip with vacuum breaker for all units.

c. Aspirators:

- 1) Aspirators are not allowed at laboratory sinks to avoid significant unnecessary water consumption to pull vacuum.

d. Emergency Showers and Eye/Face Washes:

- 1) Reference Standard: ANSI Standard Z358.1, NIH Guidelines for Research Involving Recombinant DNA Molecules, CDC-NIH Biosafety in Microbiological and Biomedical Laboratories, OSHA Bloodborne Pathogen Standard 29 CFR 1910.1030.
- 2) Combined eye wash/safety shower units shall be placed in areas where corrosive or injurious chemicals area used and there is a possibility of exposure during normal operations and/or emergencies (e.g., corrosives, severely irritating to skin/eyes, toxic by skin absorption, air/water-reactives, formaldehyde >1%, etc.).
- 3) If chemicals are used in small quantities and the likelihood of exposure is limited, only an eyewash may be required. EH&S should be consulted in these cases.
- 4) Eyewashes are required in BSL-2 areas.
- 5) The use of self-contained shower and eye/face wash units are discouraged, but may be permitted in special circumstances specifically when approved by UCB EH&S.
- 6) Emergency eyewash/showers shall be located so they are visible and easily accessible.

- i. The area beneath the shower and/or in front of the eye wash to a radius of 30" shall be constructed of a non-slip surface and have a distinctive pattern and color to facilitate a clear path of access.
 - ii. Locate units within 10 seconds of travel time along an unobstructed pathway. Avoid doors if possible; if this is not possible, the door shall swing in the direction of travel and be equipped with a crash bar (preferable) or hands-free hardware.
- 7) Units must meet current ANSI Z358.1 standards for water flow rate, potability, and temperature.
- 8) Connect all eyewash units to a sanitary sewer drain using a hard connection, unless approved otherwise by UCB.
 - i. Floor drains plumbed to sanitary sewer lines are required where emergency showers or eyewash/shower combo units are installed to promote flushing/testing of the system and decrease the potential for wet, unsafe floors or flooding.
- 9) Water flow should be activated by a push-pull or on-off mechanism so that the water remains on without requiring the use of the operator's hands. Automatic shut-off or water volume/timed units are not permitted. Whenever possible, shower units should have a visible, dedicated, labeled shut-off valve. If the valve is concealed, such as above the ceiling, a sign must indicate the location of the valve.
- 10) If showers are located in hallways or other high traffic areas, provide stainless steel fixtures and other non-plastic components to resist damage.
- 11) Position showerheads below ceiling tiles and away from walls to prevent water damage to building materials. Flushed or recessed heads are not permitted without approval from UCB.
- 12) If a shower must be located immediately adjacent to a chemical use/storage area, a method must be incorporated, such as a berm or sloped floor, to prevent releases from hazardous material containers to the sanitary sewer while collecting and directing shower water to the drain. Provide plugs for existing floor drains which are located immediately adjacent to chemical use/storage areas where the floor is not sloped or bermed, to prevent accidental hazardous releases to the sanitary sewer.

F2010 – Housing Interior Standards

Introduction

The Housing and Dining Services (HDS) at the University of Colorado-Boulder (UCB) have their own unique set of standards which are required to be followed when designing and constructing HDS projects.

UCB Requirements

1. Refer to **Appendix F2010.1** for HDS Interior Standards.

F2020 – Housing Integrated Security Standards

Introduction

The Housing and Dining Services (HDS) at the University of Colorado-Boulder (UCB) have their own unique set of standards which are required to be followed when designing and constructing HDS projects.

UCB Requirements

1. Refer to **Appendix F2020.1** for HDS Interior Standards.