SECTION 13 00 23
LABORATORY HVAC DESIGN CRITERIA

1. INTENT AND USE:

A. The intent of this section is to provide general HVAC (heating, ventilation air conditioning) design requirements for laboratories, laboratory support and research spaces. This includes conceptual design requirements pertaining to HVAC system types, overall laboratory ventilation performance requirements, and performance requirements for laboratory ventilation system devices, for both new and retrofit applications. It is not intended to include all HVAC system installation requirements.

B. In addition to best practices, the following applicable guidelines shall be applied:
1. International Mechanical Code
2. Energy Conservation Code
3. NFPA Standards, in particular NFPA 45 Standard on Fire Protection for Laboratories Using Chemicals
4. ANSI Standards, in particular ANSI Z9.5 - Laboratory Ventilation and ANSI Z9.2 - Fundamentals Governing the Design and Operation of Local Exhaust Ventilation Systems

C. Refer to the Brown University Laboratory Design Guidelines and HVAC Design Criteria for additional requirements.

2. GENERAL LABORATORY AND VIVARIA HVAC SYSTEM DESIGN REQUIREMENTS:

A. HVAC systems shall maintain a safe and comfortable working environment and be capable of adapting to new research initiatives. In addition, they shall be easy to maintain, energy efficient, and reliable to minimize impact to research.

B. The need to provide redundant components for major lab HVAC system components (such as chillers, boilers, humidification systems, air handlers, pumps, fume hood exhaust fans,etc.) shall be carefully and fully reviewed during the schematic design phase and included within the project as required to provide reliable and continuous system operation. Designs shall evaluate the impact of single or multiple points of failure, depending on the criticality of the space being designed. The Redundancy and Resiliency decisions shall be incorporated into the Project HVAC Basis of Design documentation.

C. HVAC systems shall be designed for flexibility for airflow, pressurization, heating, cooling and humidification capacities and setpoints. Future capacity allowances shall be considered in new and renovated building designs. New laboratory and Vivaria HVAC systems shall be designed with at least 25% excess capacity for future expansion.

D. HVAC systems shall have adequate ventilation capacity to control fumes, odors, and airborne contaminants, permit safe operation of fume hoods and ventilated devices, and cool the significant heat loads that can be generated in the lab spaces.

E. HVAC systems shall be responsive to rapidly changing research laboratory demands. Temperature and humidity should be carefully controlled. Examples include sudden heat loads from lasers and lab equipment, and consideration of ventilation purge modes for scavenging fumes from leaks and spills.

F. For autoclaves and vivaria, HVAC system design shall consider the heat and high moisture loads produced during autoclave operation and the cleaning of animal rooms and the cage wash process.

G. In laboratories where the heat load exceeds the required ventilation rate, utilize supplemental cooling terminal units (chilled beams, fan-coils, etc.) to provide supplemental cooling.

H. Supply and exhaust air from teaching lab fume hoods shall be routed to air handlers and exhaust fans different from research and vivaria fume hoods and ventilated devices, to allow energy savings for those times when the teaching labs are not being used.

I. Rooms where laser equipment is used shall be properly ventilated to avoid buildup of ozone generated from the laser. A review on specific exhaust requirements based on laser type or use may be warranted. For example, lasers shall be exhausted if they are using heavy metals or may emit harmful gasses.

J. Provisions shall be made for local exhaust of instruments, gas cabinets, vented storage cabinets or special operations not requiring the use of a fume hood (local capture devices).

K. Heat recovery shall be implemented for all fume hood and laboratory exhaust systems. Enthalpy wheels or other technologies which could allow supply/exhaust air cross contamination, are not permitted.

L. Laboratory noise generated by HVAC systems shall be maintained at appropriate levels. Fan location and noise treatment shall provide for sound pressure level (SPL) in conformance with project ambient noise criteria. In the absence of more restrictive criteria, noise generated by the functioning fume hood within 6 inches of the plane of the sash and bypass opening in any position shall not exceed 60 dBA. The noise level in the general laboratory space shall not exceed 55 dBA, to allow for easy verbal communication.

M. Laboratory Exhaust Air Discharge and Wind Engineering:

1. Laboratory exhaust air discharges shall be located and designed in accordance with ASHRAE and good design practices.
2. Fume hood and other contaminated lab exhaust shall not be recirculated into the building air supply.
3. Interactions with adjacent buildings and their supply air intake requirements shall be carefully evaluated to assure that reentrainment of exhaust air will not occur, that potentially hazardous exhaust will not impact nearby buildings, and to protect maintenance workers in the course of performing routine maintenance work on building roofs.
4. Fume hood exhausts should have vertical stacks that terminate at least 10 feet above the roof deck or two feet above the top of any parapet wall, whichever is greater. Higher stacks may be found to be necessary, based on wind-wake studies. The selection of stack height is dependent on the building geometry and airflow pattern around the building and is as variable as meteorological conditions.

N. Provide standby electrical power for critical laboratory system equipment, including fume hood controls, lab ventilation control panels, lab safety monitoring equipment (oxygen deprivation / chemical leak detection systems, and lab equipment alarm monitoring systems, etc.). Sufficient standby power shall be provided to maintain the lab supply air handlers and exhaust fans serving chemical fume hoods at normal operating conditions. Standby power shall also be provided to maintain normal operation of critical lab and vivaria heating, cooling and humidification systems, as well as supplemental heating/cooling terminal units in labs that cannot tolerate power interruptions.

O. The project engineer shall develop, in the design phase, a formal startup and commissioning plan and procedures that addresses the lab indoor air quality and all HVAC control requirements.

3. SUPPLY AND EXHAUST AIR CRITERIA:

A. For all new lab facilities, the ventilation control scheme shall be variable air volume (VAV). For new or renovated labs in existing facilities that meet the requirements of this design standard, match systems with other labs in the facility. For non-compliant buildings (e.g. constant volume AHUs and exhaust systems), install systems that can operate with existing systems, but which can later be converted to VAV without hardware changes.

1. Constant air-volume (CAV) lab ventilation systems shall be limited to low hood density labs where full hood exhaust flow is required to maintain the minimum laboratory air change rate.

2. Use of a constant-volume system shall be permissible only with an approved waiver.

B. Air supplied to laboratory spaces shall maintain temperature gradients and keep air turbulence to a minimum, especially near the face of the laboratory fume hoods and biological safety cabinets. Air outlets shall not discharge into the face of fume hoods. Large quantities of supply air may best be introduced through perforated plate air outlets or diffusers designed for large air volumes.

C. Local exhaust ventilation (e.g., “snorkels” or “elephant trunks”), other than fume hoods, shall be designed to adequately control exposures to dust and noxious nontoxic vapors. An exhaust manifold or manifolds with connections to local exhaust may be provided as needed to collect exhausts from gas chromatographs, vacuum pumps, excimer lasers, small-scale soldering or other equipment which can produce potentially hazardous air contaminants. Snorkel exhausts shall be tied into the main exhaust using a control valve and be fitted with on/off actuation.

1. A risk assessment by EH&S can determine if a snorkel is appropriate for the proposed equipment or process. Manufacturer guidelines shall be reviewed to ensure all potential controls are implemented to contain air contaminants including enclosures, consistent with operational needs.

4. VENTILATION RATES:

A. Ventilation rates for laboratory HVAC systems are driven by three factors: fume hood / ventilated device demand, cooling loads, and removal of fumes and odors from laboratory work areas.

B. Laboratory ventilation systems shall be designed to meet the following performance requirements.

1. Occupied air changes shall be designed for a minimum ventilation rate of 4 air changes per hour (ACH) and a maximum ventilation rate of no greater than 12 ACH (excludes CARE).

2. Unoccupied air changes shall be designed for a minimum ventilation rate of 4 ACH, but installed systems shall be capable of reducing to 2 ACH (for future use).

3. The designer shall include provisions for room “purge mode” in rooms where the use and/or storage of high hazard chemicals, or storage of oxygen-depleting gasses, is anticipated. Purge modes may be manually initiated or automatically initiated via gas detection / oxygen depletion monitoring systems.

C. The project design drawings shall clearly indicate the design supply and exhaust (minimum and maximum) airflows throughout the lab spaces, terminal devices, air handlers and major ducts.

5. RELATIVE PRESSURIZATION:

A. Overall Facilities: Brown preference for the design minimum outdoor air intake to be greater than design maximum exhaust airflow to provide slightly positive overall building pressurization to the outdoors, to prevent infiltration of outside air.

B. Room or zone pressurization shall be designed to prevent movement of air from more contaminated to less contaminated areas.

C. Laboratories shall remain at a negative air pressure in relation to the corridors and other non-laboratory spaces. Laboratory air shall flow from low-hazard to high-hazard use areas. Administrative areas in laboratory buildings shall be under positive pressure with respect to corridors and laboratories. Laboratories containing harmful substances shall be designed and field balanced so that air flows into the laboratory from adjacent spaces, offices, and corridors. Air supplied to the corridor and adjacent spaces shall be exhausted through the laboratory to achieve effective negative pressurization.

D. Clean rooms and certain vivaria spaces require higher pressurization in relation to adjacent spaces and corridors to reduce contaminated air from entering the space.

E. The project design drawings shall clearly indicate, via flow arrows or equivalent, the intended air pressure differentials and airflow paths throughout the lab spaces.

6. LABORATORY HVAC SYSTEM CONTROL REQUIREMENTS:

A. Where permitted, laboratory spaces shall be designed for occupied/unoccupied ventilation control modes. Single mode infrared sensors, covering the full lab footprint, shall be used to establish occupancy/unoccupancy intervals along with BAS occupancy schedules and fume hood sash positions as required.

1. Occupancy systems shall integrate controls for both lighting and lab ventilation control to avoid duplicate control systems in the lab.

2. For spaces having an unoccupied ventilation mode, some form of local indication of mode shall be provided (e.g. general lighting on or indicator stack lights).

3. An unoccupied laboratory is defined as having no people present in the room for a specified period of time, and all hood sashes are at working height or lower. Adjustment of fume hood ventilation rates for unoccupied mode is discouraged. If fume hood ventilation rates must be adjusted for occupancy status, the fume hoods shall be tested for containment with the sashes positioned at 3" from the bottom. If all fume hoods pass, the lab will only be allowed to go to unoccupied mode if all fume hood sashes are within 3" of closed. There may be other considerations for occupancy including building automation system (BAS) occupancy schedules and the need for transfer air from other spaces to meet ventilation requirements.

B. The control system for all laboratories and research space shall include a space differential pressure sensor for each adjacent space fitted with a door or other access to the laboratory space. Sensors shall provide local indication and also be integrated into the campus BAS for alarm and trending.

C. Renovations to existing labs that presently utilize pneumatic or standalone temperature, airflow and fume hood exhaust controls shall be renovated to DDC controls that are integrated with the campus BAS.

D. The project design drawings shall clearly indicate the desired HVAC operational sequences for occupied/unoccupied airflows, temperature and humidification/dehumidification setpoints as well as the various failure modes of system operation (power failure, fire alarm, purge mode, gas detection, etc.) throughout all of the lab spaces.

7. AIR VALVE AND CHEMICAL FUME HOOD REQUIREMENTS:

A. Lab air controls, fume hoods and ventilated device controls shall be designed to operate continuously. Minimum device exhaust air volumes, per ANSI standards, shall be maintained.

B. Pressure-independent air control valves shall be provided for laboratory supply, general exhaust and fume hood / ventilated device exhaust air. For CAV systems, the supply air valve may be a standard VAV box with flow feedback to the BAS. All exhaust valves shall be provided with airflow feedback potentiometers connected to the campus BAS.

C. All fume hood and lab HVAC controls shall have setpoints, alarms, graphics and trend information integrated into the campus BAS system as detailed in the relevant Brown Design Standard.

D. Air valve controllers shall be fitted with differential pressure (DP) switch. Supply and general exhaust air valves shall have an integral airflow ring or measuring device in compliance with manufacturer's requirements.

E. Air valve controllers and fume hood controller communication pathways shall reside on the MS-TP trunk of the campus BAS. The use of interface servers or network converters is not acceptable.

F. Fume Hood Controls and Alarms:

1. All new fume hood controls shall be equipped with the following minimum control and alarm points:
    a. Visible and audible alarms for high and low face velocity.
    b. Local alarm reset.
    c. Display of face velocity.
    d. Sash sensors (position), flow monitor with audible alarm which is tied into the BAS.
    e. Output to BAS shall be via native Bacnet or hard-wired. No “gateway” server between the lab control system components and BAS is allowed.
    f. Output signals to the BAS shall include face velocity, airflow, sash position and general alarm.
    g. All hood exhaust valves shall include a differential pressure (DP) switch.
    h. Avoid the use of individual fume hood occupancy sensors.

G. Acceptable Air control valve and fume hood control manufacturers .
    a. Price/ Amtek
    b. Phoenix
    c. Confirm with FM-Ops the standard to be used within existing buildings.

8. EQUIPMENT LOCATION AND MAINTAINABILITY:

A. HVAC systems design and configuration shall be designed to accommodate ready service isolation and system maintenance while minimizing disruption to laboratory functions.

B. Facility utilities and terminal equipment that support critical Research areas shall be located outside of the spaces, within service corridors or dedicated mechanical spaces. Isolation valves and dampers for lab and research space HVAC equipment shall be located outside the labs.

C. Hydronic heating and cooling equipment, such as fan-coil units, and other HVAC equipment that may require preventive maintenance, where installed in labs, shall not be located above active research equipment and spaces within the lab; this equipment is also not allowed in vivaria housing areas.

D. For mechanical piping systems (chilled water, hot water, steam, etc.) emergency isolation valves shall be conveniently located on branch lines so that segments can be taken offline quickly in the advent of line failures to maintain overall building operation.

9. DUCTING DETAILS:

A. Duct materials shall be compatible with vapors to be exhausted. Stainless steel (Type 316, 26 gauge minimum) should be used with most solvents and potentially flammable vapors. PVC ducting (Type 1, Grade 1, Schedule 10 minimum) should be used for corrosive vapors and perchloric acid.

B. All duct seams and joints shall be sealed. Stainless steel ductwork shall be welded. Solvent welding is acceptable for PVC and FRP ductwork.

C. Fume hood exhaust ducts shall not contain fire dampers per NFPA 45.

10. LABORATORY AND VIVARIA EXHAUST FANS:

A. Fans shall be of the “high-plume dilution” design with variable-speed drives, isolation and bypass dampers.

   1. Manufacturers: Greenheck or Strobic Air

B. Standard Features:

   1. Epoxy coating, interior and exterior.
   2. NEMA 4X external electrical devices and wiring methods.
   3. Fan isolation dampers so maintenance can be performed without system shutdown. Dampers shall be located so they can be easily replaced without removal of major equipment.
   4. Motor removal hoist mounting bracket.
   5. Variable-speed drives shall conform to Brown Design Standards.
   6. Jib crane and hoist to allow for ready motor removal/replacements.

C. The exhaust design shall carefully consider acoustics, both inside and outside of the building. Proper acoustic design should be accomplished by providing appropriate fan size and type. Sound attenuators or silencers are acceptable, though not preferred.

D. Size fans to provide a minimum stack discharge air exit velocity of 3,000 FPM unless it can be demonstrated that the design meets the dilution criteria necessary to reduce the concentration of hazardous materials to safe levels at all potential receptors.

E. For exhaust systems serving multiple hoods, provide a redundant fan of equal capacity.

F. The fume hood exhaust fans shall not shut down automatically when the supply air system is shut down by the fire alarm system per NFPA 45. However, a reduced-flow exhaust operating mode shall be designed to prevent excessive negative pressure in the building.

G. Accessibility and fall protection concerns shall be reviewed in the fume hood exhaust fan location and design. All roof-top equipment and equipment access pathways shall be confirmed with the University Architect. The architectural and engineering teams shall work in tandem to provide accurate elevations and renderings for University review and approval.

11. MISCELLANEOUS CONSIDERATIONS:

A. If vacuum service (i.e., central or local) is provided, each service connection should be fitted with liquid disinfectant traps and an in-line HEPA filter placed as near as practicable to each use point or service cock. Filters shall be installed to permit in-place decontamination and replacement.

12. LABELING AND IDENTIFICATION:

A. Ventilated Devices:

1. All fume hoods, Biosafety cabinets, flammable storage cabinets, etc. shall be clearly identified and labeled to indicate which exhaust fan or ventilation system they are connected to (e.g. "(e.g. "Hood 121-1 connected to EF-1/2 via EV 121-1").
2. Ventilated device labels shall include room and fume hood number.
3. Ventilated devices and special local exhaust ventilation systems shall be labeled to indicate the intended use (e.g., “Perchloric Acid Hood”).

13. OXYGEN DEPLETION MONITORING SYSTEMS:

A. Provide oxygen depletion monitoring in all occupied spaces and support rooms per ASHRAE requirements, and where required due to the quantities of compressed or liquified gasses. Locate monitors outside the monitored space where practical; where monitors are located in the room, provide a remote monitor outside the room at the main room entrance.

1. Include an alarm horn and yellow alarm light both inside the monitored space as well as outside the space, at each entrance to the space. Audio horn shall be distinct tone separate from Carbon Monoxide and fire alarm systems.
2. Provide signage at each alarm horn and light as noted below: “Warning - Stay out when depletion alarm is sounding. Call Public Safety at 401-863-4111”.

B. In locations where multiple gas types are used, such as liquid Helium and liquid Nitrogen, ensure that the sensor is suitable for all the gasses being utilized in the space. Helium has been known to shorten the life and accuracy of certain systems.

C. Preferred manufacturers: Mine Safety Appliances (MSA) or Toxalert International.

D. The Oxygen depletion system shall initiate a local alarm and transmit both alarm and trouble conditions to the Building Automation System (BAS), and other secondary monitoring systems where required.

E. Activation of the monitoring system shall automatically activate the space exhaust system (where so designed).

14. GAS DETECTION SYSTEMS:

A. Provide toxic and hazardous gas detection systems in all occupied spaces and support rooms per ASHRAE requirements, and where required due to the quantities of gas being stored or used. Gas detection system shall be of the continuous monitoring type, designed to detect the presence of gas at or below the permissible exposure limit or ceiling limit. Locate monitors outside the monitored space where practical; where monitors are located in the room, provide a remote monitor outside the room at each main room entrance.

1. Include an alarm horn and yellow alarm light both inside the monitored space as well as outside the space, at each entrance to the space. Audio horn shall be distinct tone separate from Carbon Monoxide and fire alarm systems.
2. Provide signage at each alarm horn and light as noted below: “Warning - Stay out when depletion alarm is sounding. Call Public Safety at 401-863-4111”.

B. Confirm make and model is appropriate for the gasses used in the spaces. Helium has been known to shorten the life and accuracy of certain systems.

C. Preferred manufacturers: Mine Safety Appliances (MSA) or Toxalert International.

D. The detection system shall initiate a local alarm and transmit both alarm and trouble conditions to the Building Automation System (BAS), and other secondary monitoring systems where required.

E. Activation of the monitoring system shall automatically close the shutoff valve on the gas supply lines to the system being monitored and activate the space exhaust system (where so designed).

15. LABORATORY, FUME HOOD AND VENTILATED DEVICE ACCEPTANCE TESTING:

A. Laboratory HVAC control sequences shall be fully commissioned for all operational and failure modes to confirm proper airflow and pressurization. Test and Balance reports for inclusion into the LVMP shall be completed and verified.

B. For buildings that have a building specific Lab Ventilation Management Plan (LVMP), the building LVMP shall be modified as needed for new lab equipment etc. New construction buildings shall have a LVMP developed

C. All labs shall be commissioned per ASHRAE Standard 202 or agreed upon commissioning standard or guideline.

End of Section