Section 1.0: LAB VENTILATION

TABLE OF CONTENTS

A. Regulations, Standards and References

Regulations:

Biosafety in Microbiological and Biomedical Laboratories (BMBL)

National Sanitation Foundation (NSF) Standard 49

OSHA 29 CFR §1910.1450, Occupational Exposure to Hazardous Chemicals in Laboratories

International Fire Code (IFC)

International Mechanical Code (IMC)

National Fire Protection Association (NFPA) 2, Hydrogen Technologies Code

National Fire Protection Association (NFPA) 45, Standard on Fire Protection for Laboratories Using Chemicals

National Fire Protection Association (NFPA) 55, Compressed Gases and Cryogenic Fluids Code

National Fire Protection Association (NFPA) 56, Standard for Fire and Explosion Prevention during Cleaning and Purging of Flammable Gas Piping Systems

National Fire Protection Association (NFPA) 69, Standard on Explosion Prevention Systems

National Fire Protection Association (NFPA) 91, Standard for Exhaust Systems for Conveying of Vapors, Gases, Mist, and Particulate Solids

National Fire Protection Association (NFPA) 720, Standard for the Installation of Carbon Monoxide (CO) Detection and Warning Equipment

National Fire Protection Association (NFPA) 99, Health Care Facilities Code

Consensus Standards and References:

ANSI/AIHA Z9.5 Laboratory Ventilation

ANSI/ASHRAE 62, Ventilation for Acceptable Indoor Air Quality

ANSI/ASHRAE 110, Method of Testing Performance of Laboratory Fume Hoods

ANSI/ASHRAE 111, Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems

ANSI/ASHRAE 41.2, Standard Method for Laboratory Air-Flow Measurement

ANSI/ASHRAE 41.3, Standard Method for Pressure Measurement

Prudent Practices in the Laboratory, Committee on Prudent Practices for Handling, Storage, and Disposal of Chemicals in Laboratories

National Institutes of Health Design Requirements Manual for Biomedical Laboratories and Animal Research Facilities

National Research Council "Safe Handling of Radionuclides", International Atomic Energy Agency, Safety Series No. 1

ACGIH Industrial Ventilation manual

B. Scope

1. The requirements of this Guide applies to all ASU laboratory buildings, laboratory units, and laboratory work areas in which hazardous materials are used, handled, or stored.

2. Deviations from the Design Guideline must be reviewed and approved by EHS.

3. This document does not relinquish the owner or contractor from adhering to any and all applicable codes and standards for this project, requirements presented by the ASU Environmental Health and Safety (EHS), and including the requirements set forth in the ASU Design Guidelines.

C. General Ventilation

1. The room shall have mechanically generated supply air and exhaust air. All lab rooms shall use 100% outside air and exhaust to outside the building. There shall be no return of fume hood and laboratory exhaust back into the building.

2. Mechanical climate control should be provided to the room.

   a. Refer to the ASU Project Guidelines Engineering Design Guidelines for room temperature requirements.

   b. Electrical appliances often exhaust heat into a room (e.g., REVCO freezer, incubator, and autoclave). Failure to take this effect into consideration may result in an artificially warm working environment. Windows shall not be opened for a cooling effect since the room air balance will be altered. A cool room shall not be heated with a portable heater that may be a fire hazard.

3. Cabinetry or other structures or equipment shall not block or reduce effectiveness of supply or exhaust air.

4. Demand Controlled Ventilation

Labs equipped with demand-controlled ventilation (DCV) and air monitoring systems may be installed in ASU EHS Risk Level rated 1 and 2 labs. The system shall provide a required minimum ACH outlined in this section and automatically increase to the maximum designed ACH capacity of the lab ventilation system when the monitoring system detects any condition or event requiring the demand for the increase. DCV shall not be installed in ASU Risk Level 3 labs or Biosafety level 3 or 4 rated labs. A definition of ASU Risk Level rated labs is available in the ASU Chemical Hygiene Plan through the EH&S Department.

5. Minimum Air Changes per Hour (ACH) for Laboratories

a. Laboratories with hazardous materials shall have continuous air flow with a minimum air changes per hour (ACH) for laboratories. The table in this section provides the required ACH for ASU labs. The minimum ACH depends on the requirements of the specific lab space. The ACH for Animal Labs shall not be reduced below the rates established in this chart unless the ASU Institutional Animal Care and Use Committee (IACUC) has granted an exception.

b. Discharge of contaminated air shall not be allowed to be recirculated into the laboratory building or adjacent buildings. Air exhausted from laboratory fume hoods and other exhaust systems shall not to be recirculated into the building. Laboratory ventilation systems shall be designed to ensure that hazardous materials originating from the laboratory are not recirculated into the building.

c. Non-laboratory air or air from building non-hazardous areas adjacent to the laboratory may be used as part of the supply air to the laboratory if its quality does not create a hazardous condition.

Lab Design	Minimum Air Changes per Hour (ACH)
General Lab Employee Occupied	
Without DCV	6
With DCV (see Requirements)	4
General Lab Employee Unoccupied	
Without DCV	4
With DCV (see Requirements)	2
Animal Labs	
Animal Research Facilities (i.e. Vivarium, ABSL3)	15
Small Animal, Static Cage/Rack	15
Small Animal, Ventilated Cage/Rack	10
Large Animal	15
Aquatics (zebra fish)	10

Note: The minimum ACH are determined by regulatory standards or consensus standards. General Lab applies to ASU Risk Level 1 and 2 lab spaces. The ASU Risk Levels are defined @ http://www.asu.edu/ehs/documents/risk_category_chart.pdf

6. Requirements For Reduced Minimum ACH for Laboratories utilizing DCV

   a. ASU EH&S Department review and approval.

   b. Demand Control Ventilation system shall be installed and monitor hazardous materials contaminants. The system shall monitor indoor air quality and adjust supply and exhaust air delivery based upon indoor contaminant concentrations. The system shall sample and analyze packets of air for containments using sensors to determine air change rates required for each zone. The sensors shall be calibrated per manufacture's requirements and the system monitored via a web interface. The air contaminants to be monitored must be reviewed with the ASU EH&S Department.

   c. Lab bench top risk assessments shall be performed to determine safe work practices with hazardous materials. These assessments shall be coordinated through ASU EH&S Department. Bench top risk assessments will be conducted in laboratory rooms to identify labs with high risk operations. The assessment will evaluate work practices with hazardous materials which are not detected by DCV system sensors (and conducted outside of a fume hood on the lab bench top).

   d. A display panel shall be located on the wall of each lab to allow occupants to check the status of the room's air change rate, as well as ensure that the occupancy sensors are working properly.

e. Presence sensors shall be installed to determine occupied and unoccupied labs.

f. Compressed gases shall be installed in exhaust ventilated gas cabinets in accordance with the written ASU Compressed Gases Safety Program.

g. Hazardous material storage cabinets shall be exhausted to remove potential vapors (i.e. flammable liquid cabinets, corrosive cabinets, and acid cabinets).

7. Bench Top Screening Criteria for Exclusion from Reduced Minimum ACH

If the following conditions are found within a laboratory space, ASU EH&S Department will recommend the space be excluded from a proposed reduced ACH ventilation rate setting:

a. Asphyxiation hazard (i.e. use of large quantities of nitrogen (N2) gas or liquid which may create an oxygen deficiency condition, <19.5% oxygen in the air);

b. Use of protocols outside of a fume hood in which any of the chemicals identified as Highly Acute Toxicity by Inhalation" may be inhaled (potential immediately dangerous to life and health (IDLH) scenario);

c. Autoclave rooms which may produce a strong odor (odor control)

8. Exposure Monitoring Criteria Requiring an Increase of Ventilation Rate

ASU EH&S Department will recommend an increase in ventilation from 4 ACH (occupied) and 2 ACH (unoccupied), to a higher rate if these following conditions exist:

a. Data indicating any detectable exposure to a select carcinogen. A select carcinogen is any substance which meets one of the following criteria:

It is regulated by OSHA as a carcinogen; or

It is listed under the category, "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP); or

It is listed under Group 1 ("carcinogenic to humans") by the International Agency for Research on Cancer Monographs (IARC); or

It is listed in either Group 2A or 2B by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP.

b. Data indicating any detectable exposure to a reproductive toxin via inhalation.

c. Data indicating that a hazardous material occupational exposure limit has been exceeded.

9. Where appropriate, general ventilation systems should be designed, such that, in the event of an accident, they can be shut down and isolated to contain hazards such as radioactivity.

10. The air velocity volume in each duct should be sufficient to prevent condensation or liquid or condensable solids on the walls of the ducts.

11. Fume hoods should not be the sole means of room air exhaust. General room exhaust diffusers shall be provided to maintain minimum air change rates, maintain room pressurization, and temperature control.

12. Operable windows should be prohibited in lab buildings and should not be used on modifications to existing buildings.

13. Sufficient local exhaust ventilation (e.g., “snorkels” or “elephant trunks”), other than fume hoods, shall be designed to adequately control exposures to hazardous chemicals. An exhausted manifold or manifolds with connections to local exhaust may be provided as needed to collect potentially hazardous exhausts from equipment which can produce potentially hazardous air pollutants. The contaminant source needs to be enclosed as much as possible, consistent with operational needs, to maximize control effectiveness and minimize air handling difficulties and costs.

14. Hoods should be labeled to indicate the exhaust fan or ventilation system they are connected to.

15. No laboratory ventilation system ductwork shall be internally insulated. Sound baffles or external acoustical insulation at the source should be used for noise control.

16. Air exhausted from laboratory work areas shall not pass unducted through other areas.

D. Pressurization

1. Airflow shall be from low hazard to high hazard areas.

2. An adequate supply of supply (i.e. make-up) air shall be provided to the lab.

3. An air lock or vestibule may be necessary in certain high-hazard laboratories to minimize the volume of supply air required for negative pressurization control. These doors should be provided with interlocks so both doors cannot open at the same time.

4. A corridor should not be used as a plenum.

    a. Laboratory rooms shall maintain air negative to corridors or adjacent spaces. Air exhausted from a laboratory shall exceed the air supplied to the laboratory space. Air exhausted from a non-hazardous room (i.e. office, classroom) shall not exceed the air supplied to the non-hazardous room. Exceptions shall be requested through ASU EH&S Department for review.

    b. Room pressure relationships to adjacent spaces shall be from the cleanest spaces to least clean spaces. Depending on the application of the program, multiple step pressurization may be required. Where this is required, cascading type air locks shall be used for non-containment applications to prevent contamination of the room; sinks, bubbles or dual-compartment air locks shall be used for containment applications to prevent contamination of both the room and adjacent spaces. Clean rooms requiring positive pressure should have entry vestibules provided with door-closing mechanisms so that both doors are not open at the same time. Consult with EH&S Department for design details.

E. Supply Air Arrangements

1. Room air currents shall not compromise the fume hood function andcontaminant containment.

2. Supply air (make-up) air should be introduced at opposite end of the laboratory room from the fume hood(s) and flow paths for room HVAC systems shall be kept away from hood locations, to the extent practical.

   a. Supply air (make-up) air shall be introduced in such a way that negative pressurization is maintained in all laboratory spaces and does not create a disruptive air pattern to exhaust devices.

   b. Cabinetry or other structures or equipment should not block or reduce effectiveness of supply or exhaust air.

3. Humidification of supply air

   a. Humidifiers and Water-Spray Systems. Steam and direct-evaporative humidifiers, air washers, direct-evaporative coolers, and other water-spray systems shall be designed in accordance with this section.

   b. Water quality. Water purity shall meet or exceed potable water standards at the point where it enters the ventilation system, space, or water-vapor generator. Water vapor

   c. generated shall contain no chemical additives other than those chemicals in a potable water system.

4. Purge Button / Mode

   A purge button is an optional feature. The purpose of the purge button is to increase air flow to reduce concentration of hazardous materials during a major spill or release (i.e. reduce flammable or toxic atmosphere) and return the lab back to occupied mode more quickly. This button can be an additional feature for labs operating at reduced air change rates for achieving energy savings. There is not a specified standard ventilation rate for purge mode, but when the purge button is pushed, exhaust ventilation is increased to its maximum potential. This button will override the ventilation set point in the lab and increase exhaust. The purge mode is not designed to be activated during a fire. This purge mode should not be activated automatically when a fire alarm pull station is pulled or the fire alarm is activated in the building. However, the purge mode should activate a local alarm to warn occupants of the event in the immediate area. Ideal button location is near exits in laboratories.

F. Fume Hood Location

1. Fume hoods should be located away from activities or other equipment, which produce air currents or turbulence. Locate away from high traffic areas, air supply diffusers, doors, and operable windows.

2. Fume hoods should not be located adjacent to a single means of access to an exit. Recommend hoods should be located more than 10 feet from any door or doorway.

3. Fume hood openings should not be located opposite workstations where personnel will spend much of their working day, such as desks or microscope benches.

G. Approved Equipment

1. Equipment shall meet the requirements within the ASU Project Guidelines and section Regulations, Standards and References

H. Fume hood and Local Exhaust Ventilation Selection/Types

1. General: Factors to consider when selecting a fume hood:

   a. Room size (length x width x height)
   b. Number of room air changes
   c. Lab heat load
   d. Types of hazardous materials to be used in the fume hood
   e. Linear feet of hood needed based on:
      Number of users/hood
      The size of apparatus to be used in hood, etc.

2. Face Velocity

   Traditional style laboratory fume hoods shall provide a minimum average effective face velocity between 80- 120 feet per minute (fpm). High performance hoods designed to operate at lower velocity rates must meet the manufacturer minimum face velocity rates, typically 65 fpm. The minimum air flow in the interior of the fume hood shall meet 250 air changes per hour (ACH) as the minimum exhaust rate during non-use time periods with the sash closed. Where the required velocity can only be obtained by partially closing the sash, the sash and/or hood jamb shall be marked to show the maximum opening at which the hood face velocity will meet these requirements.

3. Constant Volume Hoods

   These hoods permit a stable air balance between the ventilation systems and exhaust by incorporating a bypass feature. The bypass allows a constant volume of air to be exhausted through the hood regardless of sash position.

4. Variable Air Volume (VAV) Hoods

   These hoods maintain constant face velocities by varying exhaust volumes in response to changes in sash position. Since only the amount of air needed to maintain the specified face velocity is pulled from the room, significant energy savings are possible when the sash is closed.

5. Supply or Auxiliary Air Hoods

These hoods are not permitted, unless a reviewed and approved by ASU EH&S Department.

6. Walk-In Hoods

A performance test must be performed and a ventilation profile sticker sash height settings must be installed for proper working sash height. Shall provide a minimum average effective face velocity between 80- 120 feet per minute (fpm). These hoods are designed so lab personnel can walk into the hood to set up large and bulky equipment. It is not intended for personnel to stay in the hood when equipment is operating.

7. Ductless Fume Hoods

a. Ductless, non-ducted, and portable fume hoods are not permitted unless reviewed and approved by ASU EH&S Department. These types of fume hoods shall not be used for carcinogens or particularly hazardous substances. Ductless fume hoods are typically not feasible for use since they require continuous monitoring, filters replaced frequently (each 6 to 15 months), and hazardous waste disposal costs for the filters. Highly recommend use of high performance ducted fume hoods with a proximity sensor for hibernation mode.

b. According to ANSI, ductless fume hoods have limited application in research laboratories due to the wide variety of chemicals used in most labs, and should only be used with chemicals of low hazard and where the access to the hoods and the chemicals used are

c. carefully monitored. According to NFPA, air from laboratory hoods should not be recirculated and ductless fume hoods in laboratories are only applicable for use with nuisance vapors and dusts that do not present a fire or toxicity hazard. According to NIH, these devices are not appropriate for a research environment.

8. Perchloric/Hot Acid Hoods:

a. Heated perchloric acid shall only be used in a laboratory hood specifically designed for its use and identified as "For Perchloric Acid Operations."

b. Perchloric acid hoods and exhaust duct work shall be constructed of materials that are acid resistant, nonreactive, and impervious to perchloric acid.

c. The exhaust fan should be acid resistant and spark-resistant. The exhaust fan motor should not be located within the duct work. Drive belts should not be located within the duct work.

d. Ductwork for perchloric acid hoods and exhaust systems shall take the shortest and straightest path to the outside of the building and shall not be manifolded with other exhaust systems. Horizontal runs shall be as short as possible, with no sharp turns or bends. The duct work shall provide a positive drainage slope back into the hood. Duct shall consist of sealed sections. Flexible connectors shall not be used.

e. Sealants, gaskets, and lubricants used with perchloric acid hoods, duct work, and exhaust systems shall be acid resistant and nonreactive with perchloric acid.

f. A water spray system shall be provided for washing down the hood interior behind the baffle and the entire exhaust system. The hood work surface shall be watertight with a minimum depression of 13 mm (½ inch) at the front and sides.

g. An integral trough shall be provided at the rear of the hood to collect wash-down water.

h. Spray wash-down nozzles shall be installed in the ducts no more than 5 ft. apart. The ductwork shall provide a positive drainage slope back into the hood. Ductwork shall consist of sealed sections, and no flexible connectors shall be used.

i. The hood baffle shall be removable for inspection and cleaning.

j. Each perchloric acid hood shall have an individually designated duct and exhaust system.

9. Biological Safety Cabinets and Other Vented Biological Containment Devices

a. All cabinets must be NSF listed, UL approved, and installed in accordance with the manufacturer's requirements. Cabinets, which when used and installed properly, will provide both product and personnel protection. However, if the cabinet is not installed properly (e.g., not ducting a Class II, B2 cabinet), then it will not be serviceable. Installation of a cabinet which deviates from the listed NSF requirements will void the NSF Standard 49 approved listing.

b. For Biosafety Level 2 and 3 (BSL-2 and BSL-3) applications, fume hoods are not appropriate. A fume hood is not designed for the usage of biological materials. An appropriate biological safety cabinet must be used. The exact type of BSC shall be specified early in the design process.

c. Biological safety cabinets must be located away from doors and other high traffic areas. People walking parallel to a biological safety cabinet can disrupt the air curtain. Currents of air can disrupt and degrade the protective capability of the cabinet. All attempts shall be made to neutralize any interference.

d. A biological safety cabinet should not be installed directly opposite of another biosafety cabinet if spatial considerations allow otherwise. Laminar airflow is greatly hindered by the operation of a biological safety cabinet located directly opposite of another biological safety cabinet. At least six feet between cabinets is required.

e. A biological safety cabinet shall not be installed directly under air supply inlets. External air currents degrade the effectiveness of biological safety cabinets. Locate cabinets where air supply inlets will not interfere with performance.

f. A biological safety cabinet shall not be installed within 10’ of an autoclave. Exhaust from an autoclave may contain heat and moisture that will blow into the face of the cabinet. This will cause air turbulence in the cabinet and adversely affect performance of the unit. There is also an increase of potential contamination within the cabinet if the autoclave is not functioning properly since the steam may contain spores or aerosols.

g. The air curtain created at the front of the biological safety cabinet is quite fragile, amounting to a nominal inward and downward velocity of 1 mile per hour. Therefore, a biological safety cabinet shall not be installed within 10 feet of a chemical fume hood, open windows, portable fans, or laboratory equipment that creates air movement (e.g., centrifuges, vacuum pumps).

h. A reasonable clearance shall be provided behind and on each side of the cabinet to allow easy access for maintenance, and to ensure that the air return to the laboratory is not hindered. When the biological safety cabinet is hard-ducted or connected by thimble unit to the ventilation system adequate space must be provided so as not to interfere with air flow. These placement considerations are required to ensure maximum effectiveness of the primary barrier (e.g., biological safety cabinet).

i. The biological safety cabinet shall be vented from the building if toxic or malodorous chemicals are used. A thimble connection to the exhaust is one way to exhaust a Class IIA cabinet.

j. Venting to external ducts shall be monitored. Where cabinets are connected to external ducts, a flow monitoring system with audible and visual annunciations shall be used to alert the cabinet users of loss of external ventilation. Alternatively, thimble connections or canopy mini-enclosures in cabinets shall be fitted with a ribbon streamer or equivalent attached at an edge through which air enters the device to indicate the airflow direction.

10. Flammable and Corrosive Storage Cabinets

a. All new construction and all renovations to any space that will be used as a laboratory shall have at a minimum one flammable and one corrosive vented storage cabinet installed and exhausted through the room's air exhaust system. The size of a cabinet is dependent on the volume of materials and allowable quantities in the area based on fire codes. All new fume hood systems shall be equipped with a vented storage area under the fume hood workbench to store chemicals and materials.

b. Under the fume hood storage units intended for hazardous materials (i.e. chemical, flammable liquids, gas, etc.) storage shall contain recessed flooring for spill retention, appropriate internal lining, and exhaust ventilated in order to maintain containment of materials. Units must be constructed to comply with the requirements of the International Fire Codes and the Authority Having Jurisdiction.

11. Radioactive Material Use

a. Laboratory hoods in which radioactive materials are handled shall be identified with the radiation hazard trefoil symbol.

b. In general, glove boxes with HEPA filtered exhausts shall be provided for operations involving unsealed radioactive material that emit alpha particles. Consult with the ASU Office of Radiation Safety for specific requirements.

12. Special Purpose Hoods

These hoods include enclosures for operations for which other types of hoods are not suitable (i.e. enclosures for analytical balances, histology processing machines, special mixing stations, evaporation racks). These hoods shall be designed per section A. Regulations, Standards and References of this document.

13. Nanomaterials
    a. Use of glove bags, glove boxes, fume hoods, or other containment or exhausted enclosures when there is a potential for aerosolization, such as: handling powders; creating nanoparticles in gas phase; pouring or mixing liquid media which involves a high degree of agitation. (DO NOT use horizontal laminar flow hoods (clean benches), as these devices direct the air flow towards the worker.) Consult with ASU EH&S if engineering controls are not feasible.
    b. Use fume hoods or other local exhaust devices to exhaust tube furnaces and or chemical reaction vessels.
    c. Perform any maintenance activities, such as repair to equipment used to create nanomaterials or cleaning/replacement of dust collection systems, in fume hoods or under appropriate local exhaust.

I. Fume Hood and Biological Safety Cabinet Labeling

1. These devices and special local exhaust ventilation systems shall be labeled to indicate intended use (i.e. “Perchloric Acid Hood”, “Radiation Use Hood”).

2. A label shall be affixed to each device containing the minimum following information from the current performance test and inspection:

    a. performance test date
    b. average face velocity
    c. inspector's initials

3. An ASU Green Labs safety/sustainability performance sticker shall be affixed to each fume hood. The sticker is available from ASU EH&S.

J. Specialty, Controlled Climate and Cold Rooms

1. The issue of ventilation in cold rooms during periods of occupancy or for storage of hazardous materials shall be addressed. Cold room ventilation is typically a re-circulated air without a forced supply fresh air source. Volatile hazardous material shall not be used or stored in the cold room. ASU EH&S Department shall be consulted to review arrangements for providing fresh and exhaust air during periods of occupancy and for storage of hazardous materials or compressed gases.

2. Specialty rooms, designed for human occupancy shall have latches that can be operated from the inside to allow for escape.

3. Latches and frames shall be designed to allow actuation under all design conditions, such as freezing. Magnetic latches are recommended.

4. Doors of walk-in specialty rooms shall have viewing windows and external light switches.