Laboratory Ventilation

A. Scope

The purpose of laboratory ventilation is to help provide a safe and comfortable environment that facilitates scientific research and teaching. The expectation is that the design team will provide a combination of general laboratory ventilation, fume hoods, and other local exhaust ventilation (LEV), to contain emissions within the laboratory, depending on the specific needs of the laboratory. This guide provides minimum requirements; more stringent requirements may be necessary depending on the specific laboratory function or contaminants generated.

B. General Laboratory Ventilation

1. All laboratories shall have mechanical ventilation.
2. All laboratory rooms shall use 100% outside air for supply and exhaust to the outside.
3. Design the air change rate for each laboratory room to provide the following:
    a) Adequate make-up air for LEV including fume hoods and bio-safety cabinets.
    b) Adequate tempering for personal comfort and laboratory requirements
    c) As a general guideline, wet labs should be designed for a minimum of 6 air changes per hour (ACH) and dry labs for a minimum of 3 ACH. Air change rates must be determined based on specific room hazards and reviewed on a case-by-case basis. All laboratory air change rates shall be reviewed and approved by EH&S.
4. Document designed air change rate (ACH) for each laboratory space.
5. Document how the design, including location of supply diffusers, exhaust grilles, and LEV optimizes ventilation effectiveness, including the capture and removal of emissions and mixing of air. Refer to "Determination of Laboratory Airflow Rates" **-** to better understand the University's expectations.
6. Combined general and fume hood exhaust systems are preferred where their application can provide reduced cost and energy use without compromising safety or system integrity. The following should be included unless alternate design strategies are approved:*
    a) Use 316 stainless steel duct material except for general exhaust branch upstream of the combined duct.
    b) Use pressure independent air terminal units for balancing as needed.

    *For clarification, refer to "Combined General and Fume Hood Exhaust and Duct Velocities"
7. Fume hoods should not be the sole means of room air exhaust.

8. Provide excess capacity for equipment aging and future expansion.
9. Design for noise levels of 55 dBA or less.
10. Do not provide operable windows.
11. Direction of airflow should be from low hazard to high hazard areas.
12. Design to maintain negative pressure relative to adjacent non-lab areas. Provide an offset of 10% or 100 cfm per door to the corridor – whichever is greater.
13. Provide adequate makeup air (90% of the exhaust).
14. Locate casework and equipment so as not to interfere with ventilation airflow.
15. Choose location, type, and number of supply air diffusers so as not to compromise performance of fume hoods or other LEV. For further information refer to "Laboratory Airflow Distribution."
16. Avoid duct lining wherever possible.
17. Ventilate and alarm cold rooms meant for human occupancy.

C. Fume Hood Exhaust System Design Criteria (FHES)

1. Design to incorporate user needs, room configuration and general ventilation.
2. The FHES shall contain and remove fumes generated within the hood.
3. Design with adequate space for hood service and utility connections.
4. Constant volume and variable volume systems are acceptable.
5. Design VAV diversity, typically 80%, around needs and practices of facility.
6. Locate hoods per guidelines provided in the "Laboratory Airflow Distribution" paper which includes the following:
    a. At the back of labs or in alcoves
    b. At least 3 feet from obstructions such as large equipment or columns
    c. At least 4 feet from adjacent doorways and main traffic aisles
    d. At least 5 feet between fume hoods that face each other.
    e. At an adequate distance from diffusers to prevent significant cross-drafts
7. For perchloric FHES, provide dedicated fan, duct, and wash-down system.
8. Locate perchloric hood on building's top floor to minimize duct length.
9. For radioisotope FEHS, provide a dedicated fan and duct.
10. For acid digestion, FEHS must be made of fiberglass reinforced plastic or material with similar acid resistance.
11. FHES for research shall not have local on/off or high/low control.

12. Under hood storage units shall comply with EH&S Hazardous Materials Storage Cabinets standards.
13. Ductless hoods are not permitted. Exceptions may be granted for single-process applications if approved by EH&S.
14. Design face velocities for a target sash height of 18 inches
15. For standard FHES, provide a face velocity of 100 fpm +/- 10%.
16. For low velocity FHES, provide a face velocity of 70 fpm +/- 10%
17. Design for noise levels of 65 dBA or less measured per ANSI SI.4-1971 at a point three feet in front of the sash at a height of five feet from the floor.
18. Provide constant volume (CV) hoods with an air bypass that limits the maximum face velocity to 300 lfm at a sash height of 6 inches.
19. Provide variable air volume (VAV) hoods with an exhaust minimum of 25 cfm/ft^2 of work surface area through air bypass.
20. Locate controls for hood utilities outside the hood.
21. Hood lighting and other fixed electrical equipment within the hood shall be designed in accordance with Article 500 Hazardous (Classified) Locations of NFPA 70 National Electric Code.
22. Light fixture lamps shall be accessible from outside the hood.
23. For cup sinks, choose model with lip at least ¼ inch above the work surface.
24. Provide each fume hood with an audible and visible alarm that activates whenever the face velocity drops below 80 lfm for standard hoods and 56 fpm for low velocity hoods.
25. Equip water faucets with a vacuum breaker located outside the hood.
26. If this is not a University owned facility, see Appendix A: Additional Fume Hood Exhaust Criteria for Facilities not Owned by the University of Washington for further design details of the FHES.

D. Fume Hood Exhaust System Testing

1. Measure FHES face velocities per ASHRAE 110 part 6.
2. Provide information on instrumentation including calibration dates and results.
3. Measure the velocity of cross drafts.
4. Calibrate monitor, set and test low alarm, verify monitor is tracking correctly.
5. Once the criteria above are met, provide test results to EH&S.
6. After review of test results, EH&S will test the hood to confirm adequate performance, label it appropriately, and approve for use.

7. If this is not a University owned facility, see Appendix A: Additional Fume Hood Exhaust Criteria for Facilities not Owned by the University of Washington for testing details of the FHES ducts.

E. Exhausting Biosafety Cabinets (BSCs)

Design exhaust for Class I A2 BSCs with canopies and Class I B2 BSCs per the Biohazard Design Guide.

F. Local Exhaust Ventilation (LEV)

1. For purposes of this design guide, LEV refers to ventilation systems that are designed to capture and remove emissions at the source.
2. Examples of LEV include fume hoods, B2 BSCs, glove boxes, spray booths, dust collectors, snorkel hoods, canopy hoods, downdraft tables and backdraft tables,
3. Design LEV systems per the most recent edition of the ACGIH Industrial Ventilation Manual – currently the 30th edition - or other professionally recognized design criteria.
4. Provide the basis of design for the LEV system including relevant calculations such as capture velocity, capture distance and exhaust airflow.
5. If purchasing equipment that creates emissions, choose equipment that is designed to be vented if available.
6. If purchasing equipment that creates emissions but does not have a vented option, consider installing the equipment inside of a vented enclosure.

G. Laboratory Renovations General Design and Commissioning

1. For projects involving modifications to existing facilities, systems, and equipment the project engineering lead shall review relevant code history and risk assessments (if applicable) with the client and EH&S. The project team shall ensure that any changes to code compliance requirements identified during the project lifecycle are documented within the project requirements document.
2. 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.
    a. Performance ratings, testing requirements, structural performances, chemical resistance of equipment and cabinetry.
    b. Provide appropriate certification that all selected finishes comply with SEFA 8 standards for chemical and physical resistance.

3. Identify and comply with other national standards as applicable, including but not limited to, International building codes and current editions amended by local authority having jurisdiction (AHJ), NFPA, CDC (Center for Disease Control), NIH (National Institute of Health), UL (Underwriter's Laboratory), WISHA, OSHA (Occupational Safety and Health Administration), and OLAW (Office of Laboratory Animal Welfare) and best management practices and standards, e.g., ANSI Z9.5 Laboratory Ventilation.
4. The Project Manager shall identify the 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.).
5. The Project Manager shall 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.
    a. Provide a chemical inventory list for all labs on the design drawings.
6. Prior to work being performed, the end user must comply with the requirements in the UW lab Safety Manual Section 10 Lab Move-in/Move-out.
7. Relocation of laboratory fume hoods (and ducted BSC's B2) and installation of new hoods to existing spaces **require** HVAC rebalancing. Fume hoods that are relocated must be recertified and pass the current UW fume hood certification process.
    a. For laboratory systems that are constant air volume (CAV), it is impossible to remove these containment devices without influencing the certified airflow through other containment devices on the same mechanical system. All ventilation containment devices should be locked out of service. The segment of the mechanical system that is part of the renovation should be isolated. The mechanical system should be rebalanced, devices back to compliant condition, and EH&S must confirm safe operation of other containment equipment, as well as the integrity of directional airflows both in and out of labs, before these devices can be put back into operation providing user safety.
    b. During the design phase, develop a commissioning plan for each new or renovated laboratory/research area. Include the following:
        i. 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.
        ii. 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, washdown functionality of perchloric acid hoods, toxic gas or oxygen monitoring systems. Local exhaust ventilation and emergency washing devices that do not conform to current standards must be upgraded to meet the current requirements.

iii. Final laboratory and system design drawings.

iv. Design flow specifications for all components of ventilation systems, including designed capture velocity for specialty local exhaust ventilation systems.

v. Copy of the test and balance report for ventilation system.

vi. Documentation of current ASHRAE 110 compliance (AM) from manufacturer for laboratory fume hoods and vented biosafety cabinets prior to install.

vii. Tracking system to list deficiencies uncovered and corrective actions Test laboratory fume hoods to confirm compliance with the current UW certification and testing process.

viii. Fume hood flow alarms must be calibrated to alarm at +/-10% of designed capture velocity.

8. 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.
    a. When specifying Class II Type A2 BSCs that have a thimble connection, provide flow alarms installed on the exhaust and calibrate prior to use. Prior to use, certify functionality of specialty ventilation systems including performance of capture velocity and flow tests per design.
9. Confirm emergency eyewashes and showers are certified meeting the UW emergency washing device standard and ANSI Z358.1.

H. Appendix A: Additional Fume Hood Exhaust Criteria for Facilities not Owned by the University of Washington

1. Mount the fan with vibration isolators.
2. Locate the fan as the last element of the system to assure that the ductwork throughout the building is under negative pressure.
3. Discuss fire alarm interlocks to fume exhaust fans and standby power requirements with EH&S.
4. Provide ball-type fan bearing (selected for extended life), lubricated with grease fittings extended through fan casing for easy access.

5. Provide FHES fans with the following:
    a. Outboard “split” bearings
    b. Shaft Seal
    c. An access door
    d. Multiple 150 percent rated belts, or direct drive. In designing for explosion and fire control, the fan shall be of non–sparking construction and the V-belt drive shall be non –conductive.
6. Provide a chemical resistant fan system.
7. Weld or permanently seal fan housing to avoid air leakage from the wheel shaft and discharge.
8. Fume exhaust fans to have arrangement 1 or 9, overhung wheel type with bearings outside air stream. Fans to have two bearings; split-case with split inner and outer races and cage.
9. Choose fan type as follows:
    a. Use straight-radial fan for systems handling moderate to heavy quantities of particulate matter in air.
    b. Use backward-curved fans for systems handling relatively clean (low particulate) air.
    c. For perchloric acid hoods, provide an induction type fan.
10. Fume hood ductwork to be round 18-gauge minimum thickness Type 316L stainless steel. A VanStone flange can be used in situations where the quality of the weld will be compromised because of inaccessibility to the work area.
11. Use 16-gauge stainless steel for perchloric acid systems.
12. Use fiberglass reinforced plastic or material with similar acid resistant material for acid digestion systems.
13. Slope all horizontal ductwork down towards the fume hood. Low points or “bellies” in the ductwork run are unacceptable.
14. Provide a flanged removable spool piece (minimum of 12 inches long) at each fume hood connection. Use spool sections for leak tests, inspection, and to facilitate removal of equipment. Install acceptable gaskets at flanged joint connections.
15. Provide adequate space and easy access to facilitate inspection, repair, or replacement of exhaust ducts.
16. Provide perchloric acid FHES with a dedicated fan and duct and wash-down system that meets the following requirements:
    a. Design to provide as complete a wash down as possible with all ducts at 45˚ or less from vertical.

   b. Provide fan casings and hood bottoms with continuous gravity drainage to the sanitary sewer.
   c. Design wash down to be activated by a manual valve located at the fume hood.
   d. Prior to substantial completion, testing of the wash down system must be witnessed and approved by appropriate University representatives.

17. The target design velocity in each duct shall be in the range of 1200 to 1500 fpm to prevent condensed fumes or particulate from adhering to the walls of the ducts or settling out onto horizontal surfaces and to address acoustical issues. The actual value needs to consider noise and prevention of product deposition in the ducts.
18. Terminate fume hood stacks at whichever is the greatest of the following: At least 10 feet above the roof for workers safety or stack height as determined by the air flow study.
19. Design the discharge velocity from the stack to be at least 3000 feet per minute.
20. Do not provide exhaust stacks with weather caps or louvers, which require the air to change direction or cause turbulence upon discharge. Provide means to drain rainwater from exhaust stacks.
21. Fume Hood Duct Testing
    a. Connect a blower to the duct specimen through a shutoff valve. Provide a magnehelic gauge or inclined manometer with 0 to 10 inch W.G. range on the duct side of the shutoff valve.
    b. Provide temporary seals at all open ends of the duct.
    c. Average test pressure shall be 6 inches W.G. Initial pressure shall be 7 inches W.G.
    d. Test all fume duct joints from the fume hood collar to the fan inlet flex connection, not inclusive.
    e. To prevent over-pressurizing the ducts, start the blower with the variable inlet damper closed. Controlling pressure carefully, pressurize the duct section to the required level. When the pressure of the duct reaches 7 inches W.G., close the shutoff valve.
    f. Using a stopwatch, measure the time elapsed from when the duct is at 7 inches W.G. to 5 inches W.G. Use the formula t=6.23D to determine if the duct passes the test. (“D” is the nominal duct diameter, measured in inches; “t” is the MINIMUM allowable elapsed time, measured in seconds.