Laboratory Guidelines and Standards

Application Note LC-125 Rev C (US)

Introduction

This publication provides excerpts from some of the many guidelines and standards that pertain to the construction and operation of laboratory facilities, primarily concerning ventilation systems that maintain and control fume hoods and room pressurization. The intent of the publication is to provide owners, engineers, architects and laboratory personnel an overview of the standards and guidelines that pertain to the design and operation of today's laboratories. Excerpts have been taken that apply to planning, safety, operation and system design.

This document is arranged by topic. Effort has been made to present the statements that best summarize the documents as they pertain to safety and containment of the ventilation system.

The excerpts in most cases are worded as they appear in the standard or guideline, though in some instances may be out of context. Please review the actual guideline or standard for more detailed information and to make the best interpretation of each statement.

Codes and standards quoted are subject to change. User should verify information is current. Local codes and federal regulatory agencies may impose additional requirements not presented. Those responsible for ensuring compliance with regulatory requirements should determine which codes, standards and guidelines apply to their facility.

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Laboratory Chemical Hoods

Topic	Standard
Usage	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **3.7 Exposure Control Devices** Adequate laboratory chemical hoods, special purpose hoods, or other engineering controls shall be used when there is a possibility of employee overexposure to air contaminants generated by a laboratory activity… **US OSHA, 29 CFR Part 1910.1450 Occupational Exposure to Hazardous Chemicals in Laboratories** Appendix A - National Research Council Recommendations Concerning Chemical Hygiene in Laboratories **A.** General Principles for Work with Laboratory Chemicals 3. *Provide adequate ventilation.* The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by use of hoods and other ventilation devices (32, 198). **C. The Laboratory Facility** **4. Ventilation** **(b) Hoods.** A laboratory hood with 2.5 linear feet of hood space per person should be provided for every 2 workers if they spend most of their time working with chemicals; … If this is not possible, work with substances of unknown toxicity should be avoided or other types of local ventilation devices should be provided. **E. Basic Rules and Procedures for Working with Chemicals** **1. General Rules** **(n) Use of hood:** Use the hood for operations which might result in release of toxic chemical vapors or dust. As a rule of thumb, use a hood or other local ventilation device when working with any appreciably volatile substance with a TLV of less than 50 ppm. Leave the hood "on" when it is not in active use if toxic substances are stored in it or if it is uncertain whether adequate general laboratory ventilation will be maintained when it is 'off'. **National Fire Protection Association, Standard NFPA 45-2000** **6.4 Exhaust Air Discharge** **6.4.8** Canopy hoods shall not be used in lieu of laboratory hoods. **6.4.9** Biological safety cabinets shall not be used in lieu of laboratory hoods. **6.4.10** Laminar flow cabinets shall not be used in lieu of laboratory hoods.

Topic	Standard
Sash-Closers	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **4.1.1.5 Automatic Sash Closers** Automatic sash positioning systems shall have obstruction sensing capable of stopping travel during sash closing operations to avoid injuries, breaking glassware, causing spills, etc. Automatic sash positioning shall allow manual override of the driven system with forces of no more than 10 lbs. (45 N) both when powered and during power failures. With or without automatic closers, users shall understand the importance of the closed sash, and integrate proper sash operation into work procedures.
Location	**Scientific Equipment Furniture Association, Standard SEFA 1.2-2002** **5.1 Location in Laboratory** Laboratory fume hood exhaust systems should be balanced with room exhaust systems and may be used in conjunction with room exhaust to provide the necessary room ventilation. Constant operation of a fume hood will also provide fume control during non-working hours. **ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **6.1.1. Spatial Layout** Laboratory designers shall consider effects of floor plans and spatial layout on contamination control and the function of Exposure Control Devices. Laboratory chemical hoods shall be located so their performance is not adversely affected by cross drafts. Windows in laboratories with hoods shall be fully closed while hoods are in use (emergency conditions excepted). **National Fire Protection Association, Standard NFPA 45-2000** **6.9** Laboratory Hood Location **6.9.1** Laboratory hoods shall be located in areas of minimum air turbulence. **6.9.2** For new installations, laboratory hoods shall not be located adjacent to a single means of access to an exit or to high-traffic areas. **6.9.3** Workstations where personnel will spend much of their working day, such as desks or microscope benches, shall not be located directly in front of laboratory hood openings. **National Fire Protection Association, Standard NFPA 45-2000** **A6.9.1** A person walking past the hood can create sufficient turbulence to disrupt a face velocity of 0.5 m/sec (100 ft/min). In addition, open windows or air impingement from an air diffuser can completely negate or dramatically reduce the face velocity and can also affect negative differential air pressure.

Topic	Standard
Location *(cont.)*	**Scientific Equipment Furniture Association, Standard SEFA 1.2-2002** **5.1 Location in Laboratory** Laboratory fume hoods should be so located within the laboratory to avoid crosscurrents at the fume hood face due to heating, cooling or ventilation inlets. Sufficient makeup air must be available within the laboratory to permit fume hoods to operate at their specified face velocities. Other location factors to be considered are as follows: • Number and types of fume hood in laboratory space; • Location and number of ingress/egress aisles and/or laboratory space exterior doorways; • Frequency and/or volume of expected fume hood users; • Location of laboratory safety equipment **5.2 Safety Considerations** Laboratory fume hoods are potential locations for fires and explosions due to the types of experiments conducted in these units. As such, fume hoods should be located within the laboratory so that in the event of a fire or explosion within the fume hood, exit from the laboratory would not be impeded. Laboratory fume hoods should be located away from high traffic lanes within the laboratory because personnel walking past the sash opening may disrupt the flow of air into the unit and cause turbulence, drawing hazardous fumes into the laboratory. Sufficient aisle space should be provided in front of the fume hood to avoid disruption of the work or interference with the operating technician by passing personnel. **ASHRAE, 1995 HVAC Applications Handbook** **Chapter 13 Laboratory Systems** **Laboratory Exhaust and Containment Devices** **Fume Hood Performance** Air currents external to the fume hood can jeopardize fume hood's effectiveness ... Detrimental air currents can be produced by the following: • Air supply distribution patterns • Movement of the researcher • People walking past the fume hood • Thermal convection • Opening of doors and windows

Topic	Standard
Face Velocity	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **4.3.1 Face Velocity** The average face velocity of the hood shall be sufficient to capture and contain the hazardous chemical emissions generated within the hood, which the hood was selected by following guidance in Section 3.4 and as generated under as-used conditions. An adequate face velocity is necessary but is not the only criterion to achieve acceptable performance and shall not be used as the only performance indicator. **4.3.1 (notes): Face Velocity** Design face velocities for laboratory chemical hoods in the range of 80–100 fpm (0.41–0.51m/s) will provide adequate face velocity for a majority of *fume hood applications.* Hoods with excellent containment characteristics may operate adequately below 80 fpm (0.41 m/s) while others may require higher face velocities. It is, therefore, inappropriate to prescribe a range of acceptable face velocities for all *hood styles.* Room and operator dynamics can have significant effect on hood performance at low face velocities. Therefore, it is important to understand the effects of dynamic challenges on hood performance so that standard operating procedures and user restrictions can be established. Operating a hood below 60 fpm (0.30 m/s) is not recommended since containment cannot be reliably quantified at low velocities and significant risk of exposure may be present. **National Fire Protection Association, Standard NFPA 45-2000** **6.4 Exhaust Air Discharge** **6.4.6** Laboratory hood face velocities and exhaust volumes shall be sufficient to contain contaminants generated within the hood and exhaust them outside of the laboratory building. The hood shall provide containment of the possible hazards and protection for personnel at all times when chemicals are present in the hood. **A6.4.6** Laboratory fume hood containment can be evaluated using the procedures contained in ASHRAE 110, *Method of Testing Performance of Laboratory Fume Hoods.* Face velocities of 0.4 m/sec to 0.6 m/sec (80 ft/min to 120 ft/min) generally provide containment if the hood location requirements and laboratory ventilation criteria of this standard are met. **Scientific Equipment Furniture Association, Standard SEFA 1.2-2002** **4.3.1 Face Velocity** Face Velocity shall be adequate to provide containment. Face velocity is not a measure of safety. Face Velocity Guide – Face velocities of laboratory fume hoods may be established on the basis of the toxicity or hazard of the materials used or the operations conducted within the fume hood. The most widely requested target average face velocity is 100 FPM. The measured deviation across the face may vary ±20 FPM.

Topic	Standard
Face Velocity *(cont.)*	**US OSHA, 29 CFR Part 1910.1450 Occupational Exposure to Hazardous Chemicals in Laboratories** Appendix A - National Research Council Recommendations Concerning Chemical Hygiene in Laboratories **C. The Laboratory Facility** **(g) Quality** General airflow should not be turbulent and should be relatively uniform through the laboratory, with no high velocity or static areas; airflow into and within the hood should not be excessively turbulent; hood face velocity should be adequate (typically 60-100 lfm, *linear feet per minute*).
Face Velocity Monitors	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **4.3.3. Flow-Monitoring Device for Laboratory Fume Hoods** All hoods shall be equipped with a flow indicator, flow alarm, or face velocity alarm indicator to alert users to improper exhaust flow. The flow-measuring device shall be capable of indicating that the air flow is in the desired range, and capable of indicating improper flow when the flow is high or low by 20%. The device shall be calibrated at least annually and whenever it is damaged, potentially damaged, or otherwise observed to be providing questionable information. **4.3.3. (notes) Flow-Monitoring Device for Laboratory Fume Hoods** The means of alarm or warning chosen should be provided in a manner both visible and audible to the hood user. The alarm should warn when the flow is 20% low, that is, 80% of the set point value. When feasible the output should be connected to the building management or alarm system. Tissue paper and strings do not qualify as the sole means of warning. **National Fire Protection Association, Standard NFPA 45-2000** **6.8.7 Measuring Device for Hood Airflow** **6.8.7.1** A measuring device for hood airflow shall be provided on each laboratory hood. **6.8.7.2** The measuring device for hood airflow shall be a permanently installed device and shall provide constant indication to the hood user of adequate or inadequate hood airflow. **Scientific Equipment Furniture Association, Standard SEFA 1.2-2002** **4.1.10** All hoods shall have some type of monitor for indicating face velocity or exhaust flow verification… Regardless of the monitor installed, it should provide clear indication to the hood user whether exhaust flow or face velocity is within design parameters. A ribbon taped to the bottom of the sash is not acceptable.

Topic	**Standard**
Face Velocity Monitors *(cont.)*	**US OSHA, 29 CFR Part 1910.1450 Occupational Exposure to Hazardous Chemicals in Laboratories** Appendix A - National Research Council Recommendations Concerning Chemical Hygiene in Laboratories **C. The Laboratory Facility** **4. Ventilation** **(b) Hoods.** …each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use.
Sash Alarms	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **4.1.1.1. (notes) Vertical Sashes** Training, mechanical sash stops, alarms, and other means are important for ensuring that the fume hoods and exhaust systems can provide the protection for which they were designed.
Flow Visualization Testing	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **7.2.3.4.6. *Airflow Visualization Tests*** Airflow visualization tests shall be conducted as described in the ANSI/ASHRAE 110-2016, *Method of Testing Performance of Laboratory Fume Hoods.* (Refer to ANSI/ASHRAE 110-2016 for testing methods) Visible escape beyond the plane of the sash when generated 6 in. (15.2 cm) into the hood shall constitute a failure during the Airflow Visualization Tests. **ANSI/ASHRAE 110-1995** **ASHRAE Guideline: Method of Testing Performance of Laboratory Fume Hoods** **6. Flow Visualization and Velocity Procedures** **6.1 Flow Visualization** This test is a visualization of a hood's ability to contain vapors. ... The intent of this test is to render an observation of the hood performance. **6.1.1 Local Visualization Challenge** **6.1.1.1** The operation of the bottom air bypass airfoil shall be tested by running the smoke bottle under the airfoil. **6.1.1.2** A stream of smoke shall be discharged ... along both walls and the floor of the hood in a line parallel to the hood face **6.1.1.3** A stream of smoke shall be discharged ... on the back of the hood. **6.1.1.4** If there is visible smoke flow out of the front of the hood, the hood fails the test.

Topic	Standard
Flow Visualization Testing *(cont.)*	**ANSI/ASHRAE 110-1995** **ASHRAE Guideline: Method of Testing Performance of Laboratory Fume Hoods** **6.1.2 Large-Volume Visualization Challenge** A suitable source of smoke or other visual challenge shall be used to release a large volume in the center of the sash opening on the work surface 6 in. (150 mm) inside the rear edge of the sash.
Face Velocity Testing	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **7.2.3.4.3. Fume Hood Face Velocity Tests** Fume hood face velocity shall be determined by the methods described in the current version of ANSI/ASHRAE 110 Method of Testing Performance of Laboratory Fume Hoods. The average face velocity, the maximum and minimum traverse grid velocities, and the calculated flow shall be reported and compared to design specifications for the design opening sash configuration(s). For auxiliary air hoods or fume hoods with air supplied at or near the perimeter of the sash opening, the total flow of the auxiliary air or the supplied air shall be determined along with the average, maximum and minimum velocity from the opening. The auxiliary air or supplied air shall meet the design specifications and not be sufficient to disrupt the measurement of average face velocity from the exhaust flow alone. The flow and velocity of the auxiliary air shall not be sufficient to adversely affect hood containment performance. **ANSI/ASHRAE 110-1995** **ASHRAE Guideline: Method of Testing Performance of Laboratory Fume Hoods** **6.2 Face Velocity Measurement** A 1.0 ft^2 imaginary grid pattern shall be formed by equally dividing the design hood opening into vertical and horizontal openings. Velocity readings shall be taken with a calibrated anemometer. For VAV hoods measurements should be made at 25, 50, and 100% sash openings. **Scientific Equipment Furniture Association, Standard SEFA 1.2-2002** **4.3.1 Face Velocity** Refer to ASHRAE 110 – 1995 (or latest edition) for velocity measurement procedures.

Topic	Standard
Competing Air Flow Testing	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **7.2.3.4.4. Cross-Draft Velocity Tests** Cross-draft velocity measurements shall be made with the sashes open and the velocity probe positioned at several locations near the hood opening to detect potentially interfering room air currents (cross drafts). Record measurement locations. Cross-draft velocities shall be measured at the approximate left, center and right sides of the design opening at approximately 1.5 ft (46 cm) in front of the sash opening and at the approximate midpoint height of the sash opening. Measurements shall be taken over a period of 10 to 30 seconds using a hot-wire thermal anemometer having an accuracy of +5% at 30 fpm (0.15 m/s) or better. The average and maximum cross-draft velocities at each location shall be recorded and compared to design specifications for the design opening sash configuration(s). Cross draft velocities shall not be of such magnitude and direction as to negatively affect containment.
VAV Response Time Testing	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **7.2.3.4.5. Variable Air Volume (VAV) Flow Control Tests** …VAV Response shall increase or decrease flow to within 90% of target flow or face velocity within 5 seconds or as specified in the design documents. VAV Stability shall be sufficient to prevent flow variations in excess of 10% from design at each sash configuration or operating mode. **7.2.3.4.5. (notes) Variable Air Volume (VAV) Flow Control Tests** In the majority of VAV hood systems, the purpose of the VAV control system is to adjust airflows to compensate for changes in sash configurations or system operating mode (occupied/unoccupied, night setback, etc.). The VAV control system must be capable of quick and precise adjustment of flows without experiencing major overshoot or undershoot (10% of steady-state value). A response time of less than 5 seconds after initiation of sash movement or a change in operating mode is considered acceptable for most operations. Faster response times may improve hood containment following the sash movement. **ANSI/ASHRAE 110-1995** **ASHRAE Guideline: Method of Testing Performance of Laboratory Fume Hoods** **6.4 VAV Response Test** **6.4.2** The hood sash shall be closed to 25% of the design hood opening. **6.4.3** The sash shall be fully opened in a smooth motion at a velocity between 1.0 ft/s and 1.5 ft/s. ... The time it takes from the start of the sash movement until the sash reaches the top and the time it takes from the start of the sash movement until the face velocity reaches and maintains, within 10%, the design face velocity shall be recorded.

Topic	Standard
Containment Testing	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **7.2.3.4.7 Tracer Gas Containment Tests** Tracer gas containment tests shall be conducted on all fume hoods during “as installed” commissioning tests. The tracer gas containment tests shall be conducted as described in the ANSI/ASHRAE 110-1995, *Method of Testing Performance of Laboratory Fume Hoods* or by a test recognized to be equivalent or approved by the owner. The performance rating for any 5-minute tracer gas test conducted during “as installed” commissioning tests conducted according to the ANSI/ASHRAE 110-2016 standard shall be no greater than 0.10 ppm for “as installed” commissioning tests (4 AI 0.10 ppm) or a value determined appropriate to satisfy the owners program requirements and the Hazard Evaluation and Risk Assessment Section 3.4. Escape more than the control levels stated above shall be acceptable at the discretion of the design professional in agreement with the responsible person (Section 3.2). The control levels shall be based on the Hazard Evaluation and Risk Assessment described in Section 3.4. **ANSI/ASHRAE 110-1995** **ASHRAE Guideline: Method of Testing Performance of Laboratory Fume Hoods** **7. Tracer Gas Test Procedure** *Tracer gas test measures containment by measuring the amount of sulfur hexafluoride that is released from the fume hood and sensed by a gas detector mounted in the breathing zone of a mannequin positioned in front of the hood. Measurements are made with the mannequin in different positions, by traversing the opening with the gas sensor, and while the sash is being moved.* **Scientific Equipment Furniture Association, Standard SEFA 1.2-2002** **4.3.2 Containment Testing – As Manufactured** The manufacturer shall provide standard (AM) test data for all standard hoods. This should be done in accordance with the most current ASHRAE 110 standard. The AM testing demonstrates what the hood is capable of doing under controlled conditions. The report shall verify that all laboratory fume hood types specified have been tested to ASHRAE 110-1995 (or most current edition) procedures and have achieved AM 0.05. AM 0.05 can be achieved with a properly designed laboratory fume hood. **It shall not be implied that this exposure level is safe. Safe exposure levels are application specific and should be evaluated by properly trained personnel.**

Topic	Standard
Frequency of Testing	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **7.3.5. Routine Fume Hood and other ECD Tests** Lab Environment Tests and Maintenance tasks shall precede Routine Fume Hood and ECD Tests. The routine performance tests shall be conducted whenever a significant change has been made to the operational characteristics of the hood system in accordance with the LVMP Management of Change procedures (Section 3.4). Fume Hood and ECD performance shall be tested periodically to confirm operation equivalent to the most recent series of fume hood and ECD commissioning test results. The routine tests shall be conducted at least annually or as necessary to provide proper operation of the systems and validate the information reported to the BAS and other monitoring and alarm systems. Preventative maintenance activities shall be coordinated with routine tests to help improve reliability of system performance. At a minimum routine tests and maintenance activities shall be conducted at the design openings configurations and operating modes corresponding to maximum and minimum flow and include: • survey and inspection of the fume hood and other ECD measurement of velocity, • measurement of cross draft velocities • measurement of VAV response and stability (if applicable), • verification of proper operation of occupancy sensor and/or other controls (if applicable), • verification of monitor and alarm response • airflow visualization tests Problems achieving proper performance and variations greater than 10% from the most recent commissioning test results shall be noted, further investigated and subject to repair maintenance. The Responsible Person shall be notified upon identification of operational issues and performance problems. A fume hood that is found to be operating with an average face velocity greater than 10% below the designated average face velocity shall be labeled as out of service or restricted use and corrective actions shall be taken to increase flow. Routine tests or maintenance that reveal the inability achieve performance equivalent to the most recent commissioning tests shall be subject to further review and management of change procedures.

Topic	Standard
Frequency of Testing *(cont.)*	**7.3.6. Annual Performance Report** The results of routine test and maintenance efforts shall be documented and stored at least annually. **7.5. Posting and Signage** Each fume hood and other ECD shall be posted with a notice giving the date of the last test. If the fume hood or other ECD failed the performance test, it shall be taken out of service until repaired, or posted with a restricted use notice. The notice shall state the partially closed sash position necessary for safe/normal operation and any other precaution concerning the type of work and materials permitted or prohibited. *NOTE: The intent is to ensure that those using the hood know its current status and where to get help or further information.* *Other information that should be posted may include flowrates, fan numbers, an indication that the system is VAV or less than 100% diversity and an emergency phone number.* Each fume hood or ECD shall be posted with a notice giving the date of the routine performance test, the measured average face velocity, and any other parameter (such as sash height) that describes the prevailing test conditions. If the fume hood or other ECD device is taken out of service, it shall be posted with a restricted use or out-of-service notice. The restricted use notice shall state the requisite precautions concerning the type of materials permitted or prohibited for use in the device. **National Fire Protection Association, Standard NFPA 45-2000** **6.13** Inspection, Testing, and Maintenance **6.13.1** When installed or modified and at least annually thereafter, laboratory hoods, laboratory hood exhaust systems, and laboratory special exhaust systems shall be inspected and tested. The following inspections and tests, as applicable, shall be made: 1. Visual inspection of the physical condition of the hood interior, sash, and ductwork 2. Measuring device for hood airflow 3. Low airflow and loss-of-airflow alarms at each alarm location 4. Face velocity 5. Verification of inward airflow over the entire hood face 6. Changes in work area conditions that might affect hood performance **6.13.2** Deficiencies in hood performance shall be corrected or one of the following shall apply: 1. The activity within the hood shall be restricted to the capability of the hood. 2. The hood shall not be used. **6.13.3** Laboratory hood face velocity profile or hood exhaust air quantity shall be checked after any adjustment to the ventilation system balance.

Topic	Standard
Frequency of Testing *(cont.)*	**6.13.4 Detectors and Alarms.** Air system flow detectors, if installed, shall be inspected and tested annually. Where potentially corrosive or obstructive conditions exist, the inspection and test frequency shall be increased. **US OSHA, 29 CFR Part 1910.1450 Occupational Exposure to Hazardous Chemicals in Laboratories** Appendix A - National Research Council Recommendations Concerning Chemical Hygiene in Laboratories **C. The Laboratory Facility** **4. Ventilation** **(h) Evaluation** Quality and quantity of ventilation should be evaluated on installation, regularly monitored (at least every 3 months) and reevaluated whenever a change in local ventilation devices is made. **ASHRAE, 1995 HVAC Applications Handbook** **Chapter 13 Laboratory Systems** **Laboratory Exhaust and Containment Devices** All fume hoods should be tested annually and their performance certified.
Minimum Exhaust (VAV)	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **4.3.2. Laboratory Hood Minimum Flow Rate** … the minimum flow rate of Variable Air Volume hoods shall be sufficient to prevent hazardous concentrations of contaminants within the laboratory fume hood at the maximum credible hazard emission scenario of use. In addition to maintaining the selected hood face velocity, laboratory hoods shall maintain a minimum exhaust volume to ensure that contaminants are properly diluted and exhausted from a hood. **National Fire Protection Association, Standard NFPA 45-2000** **A6.4.6** In addition to maintaining proper fume hood face velocity, fume hoods that reduce the exhaust volume as the sash opening is reduced should maintain a minimum exhaust volume to ensure that contaminants are diluted and exhausted from a hood. The hood exhaust airflow should not be reduced to less than 1 L/sec/m^2 (25 ft^3/min/ft^2) of internal hood work surface even when the sash is fully closed.
Emergency Modes	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **4.2.1. notes: Variable Air Volume (VAV) Hoods** …It is recommended that VAV systems be equipped with emergency overrides that permit full design flow even when the sash is closed. **National Fire Protection Association, Standard NFPA 45-2000** Laboratory hoods equipped with control systems that vary the hood exhaust airflow as the sash opening varies and/or in conjunction with whether the laboratory room is in use (occupied/unoccupied) shall be equipped with a user accessible means to attain maximum exhaust hood airflow regardless of sash position when necessary or desirable to ensure containment and removal of a potential hazard within the hood.

Topic	Standard
Fire Suppression	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **6.4.3.6. Fire Dampers** Fire dampers shall not be installed in exhaust system ductwork (NFPA 45). **6.4.3.7. Fire Suppression** Fire sprinklers shall not be installed in laboratory chemical hood exhaust manifolds. **National Fire Protection Association, Standard NFPA 45-2000** **6.10 Laboratory Hood Fire Protection** **6.10.1** Automatic fire protection systems shall not be required in laboratory hoods or exhaust systems. *Exception No. 1: Automatic fire protection shall be required for existing hoods having interiors with a flame spread index greater than 25 in which flammable liquids are handled.* *Exception No. 2: If a hazard assessment shows that an automatic extinguishing system is required for the laboratory hood, then the applicable automatic fire protection system standard shall be followed.* **National Fire Protection Association, Standard NFPA 45-2000** **6.10.2** Automatic fire protections systems, where provided, shall comply with the following standards, as applicable: (List of NFPA standards) **6.10.3** Automatic fire dampers shall not be used in laboratory hood exhaust systems. Fire detection and alarm systems shall not be interlocked to automatically shut down laboratory hood exhaust fans… **Scientific Equipment Furniture Association, Standard SEFA 1.2-2002** **4.1.9 Hood Services** **…Fire Suppression Systems:** • Any fire suppression system used in a chemical fume hood should be compliant with local codes and regulations, and NFPA 17. • Any fire suppression system should be rated for all fire classes (A, B, and C). • The recommended fire suppression for chemical fume hoods is a dry powder, rated A, B, or C with manual and thermal activation triggers. Other water or liquid based systems may be acceptable if appropriate testing and certification are available. • No fire dampers of any kind should ever be installed in a chemical fume hood exhaust system. • Flammable materials should never be stored directly below a chemical fume hood in anything but an NFPA specified, UL listed or FM approved solvent storage cabinet.

Topic	Standard
Perchloric Acid Hoods	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **5.5. Perchloric Acid Hoods** Perchloric acid hoods are specially designed to safely handle certain types of perchloric acid work, because when heated can lead to the formation of perchlorate salts in the exhaust system that create potential explosive conditions. Perchloric acid hoods are part of a system that combine exhaust ventilation with water flushing features for the exhaust system. These specifically designed systems shall be installed if a hazard assessment has reviewed options to control hot or concentrated perchloric acid vapors and determined they are required. Where possible local exhaust and air scrubbing systems shall be employed to capture the vapor at the source. All hazard assessments and procedures conducted in a perchloric acid hood shall be reviewed by the responsible safety person and immediate supervisor. All procedures using a perchloric acid hood shall be performed by trained personnel, knowledgeable and informed about the hazards and properties of these substances, provided with appropriate protective equipment after suitable emergency contingency plans are in place. Perchloric acid hoods and exhaust system shall be washed down daily while in use. The design of a perchloric acid hood and exhaust system shall follow NFPA 45. **6.4.3.1. Manifold Requirements** …Perchloric acid hoods shall not be manifolded with nonperchloric acid hoods unless a scrubber is installed between the hood and the manifold… **ASHRAE, 1995 HVAC Applications Handbook** **Chapter 13 Laboratory Systems** **Laboratory Exhaust and Containment Devices** **Perchloric Acid** A standard hood with special integral work surfaces, coved corners, and nonorganic lining materials. Perchloric acid is an extremely active oxidizing agent. Its vapors can form unstable deposits in the ductwork that present a potential explosion hazard. To alleviate this hazard, the exhaust system must be equipped with an internal water wash down and drainage system, and the ductwork must be constructed of smooth, impervious, cleanable materials that are resistant to acid attack. The internal wash down system must completely flush the ductwork, exhaust fan, discharge stack, and fume hood inner surfaces. … Perchloric acid exhaust systems with longer ductwork runs may need the wash down system zoned to avoid water flow rates in excess of the ability to drain the water… Because perchloric acid is an extremely active oxidizing agent, organic materials should not be used in the exhaust system in places such as joints and gaskets. Ductwork should be constructed of a … material … not less than 316 stainless steel, or of a suitable nonmetallic material. Joints should be welded and ground smooth. A perchloric acid exhaust system should only be used for work involving perchloric acid.

Topic	Standard
Perchloric Acid Hoods *(cont.)*	**National Fire Protection Association, Standard NFPA 45-2000** **6.11 Perchloric Acid Hoods** Perchloric acid heated above ambient temperatures shall only be used in a laboratory hood specifically designed for its use… *Exception: Hoods not specifically designed for use with perchloric acid shall be permitted to be used where the vapors are trapped and scrubbed before they are released into the hood.* **6.11.2** Perchloric acid hoods and exhaust ductwork shall be constructed of materials that are acid resistant, nonreactive, and impervious to perchloric acid. **6.11.3** The exhaust fan shall be acid resistant and spark resistant. The exhaust fan motor shall not be located within the ductwork. Drive belts shall be conductive and shall not be located within the ductwork. **6.11.4** 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… **6.11.5** Sealants, gaskets, and lubricants used with perchloric acid hoods, ductwork, and exhaust systems shall be acid resistant and nonreactive with perchloric acid. **6.11.6** A water spray system shall be provided for washing down the hood interior … and the entire exhaust system… The hood baffle shall be removable for inspection and cleaning. **National Fire Protection Association, Standard NFPA 45-2000** **6.11.8** If a laboratory hood or exhaust system was used for perchloric acid heated above ambient temperature, tests shall be conducted for explosive perchlorates before any inspection, cleaning, maintenance, or any other work is done on any part of the exhaust system or hood interior. **6.11.9** Prior to using a perchloric acid hood for any purpose, the hood shall be water-washed and shall be tested … to ensure residual perchlorates are not present. **A6.11.1** If perchloric acid is heated above ambient temperature, it will give off vapors that can condense and form explosive perchlorates. Limited quantities of perchloric acid vapor can be kept from condensing in laboratory exhaust systems by trapping or scrubbing the vapors at the point of origin… **A6.11.6** Perchloric acid hoods should be washed down after each use.

Topic	Standard
Perchloric Acid Hoods *(cont.)*	**Scientific Equipment Furniture Association, Standard SEFA 1.2-2002** **4.2.3 Perchloric Acid Fume Hood** A perchloric acid hood has the general characteristics of a bench-top hood; however, the interior lining must be coved and welded seamless stainless steel (other non-reactive material such as CPVC or polypropylene have been used when heat is not a concern). Nonreactive and corrosion resistant material should extend all the way through the exhaust system. In addition, the hood, duct, and fan must have a water wash down system to remove perchlorates and prevent the build-up of potentially explosive perchlorate salts. Drain outlet shall be designed to handle a minimum of 15 gallons (56.8 liters) per minute. The work surface on perchloric acid hoods typically has a water trough at the back of the hood interior under the baffle. The fume hood liner in a perchloric acid fume hood shall have no access holes such as those which may be used for plumbing access. Access panels should be considered in the lab layout for access through the hood exterior. In nearly all other respects, however, the design of perchloric acid hood is the same as conventional or bypass fume hoods. A perchloric acid hood shall never be tied to a manifold system.
Radioisotope Hoods	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **6.4.3.1. Manifold Requirements** …Where there is a potential contamination from hood operations as determined from the Hazard Assessment of Section 3.4, radioisotope hoods shall not be manifolded with non-radioisotope hoods unless in-line HEPA filtration and/or another necessary air-cleaning system is provided between the hood and the manifold: HEPA filter and/or carbon bed filters for gases. **ASHRAE, 1995 HVAC Applications Handbook** **Chapter 13 Laboratory Systems** **Laboratory Exhaust and Containment Devices** A standard hood with special integral work surface, linings impermeable to radioactive materials, and structure strong enough to support lead shielding bricks. The interior must be constructed to prevent radioactive material buildup and allow complete cleaning. The ductwork system should have flanged neoprene gasketed joints with quick disconnect fasteners that can be readily dismantled for decontamination. Provisions may need to be made for HEPA and or charcoal filters in the exhaust duct. **National Fire Protection Association, Standard NFPA 45-2000** **A6.12.1** Laboratory hoods in which radioactive materials are handled should be identified with the radiation hazard symbol…

Topic	Standard
Radioisotope Hoods *(cont.)*	**Scientific Equipment Furniture Association, Standard SEFA 1.2-2002** **4.2.2 Radioisotope Fume Hood** A fume hood used for Beta and Gamma radiation shall be referred to as a radioisotope hood. A radioisotope hood has the general characteristics of a bench-top fume hood except the work surface and interior lining must be type 304 stainless steel with coved seamless welded seams for easy cleaning and decontamination. The hood design is identical to other hood types in nearly all other respects. The work surface shall be dished to contain spills and cleaning liquids and shall be properly reinforced to support lead shielding and shielded containers. The load-bearing capacity shall be 200 pounds per square foot (976.5 Kg/m 2) minimum up to a total weight of 1,000 pounds (453.6 Kg) per fume hood or base cabinet section.
Ductless Hoods	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **5.2 Ductless Hoods** Ductless hoods shall meet the general requirements of Sections 4.1 and 4.3 as applicable. A Hazard Evaluation and Analysis shall be conducted as directed in ANSI/ASSP Z9.7 and Section 3.4. Compliance with the general requirements of Sections 3, 4.3, 6.3, and 7.1shall be evaluated by qualified persons. Users shall limit hazardous emission activities in ductless hoods to those safely performed on an open bench, unless the ductless hood meets the requirements specified in Sections 10.3 and 10.4. The owner shall establish the limits of use parameters for ductless hoods. Ductless hoods shall have signage prominently posted on the ductless hood to inform operators and maintenance personnel on the allowable chemicals used in the hood, type and limitations of filters in place, filter change-out schedule, and that the hood recirculates air to the room. Ductless hoods are limited to approved applications only because of the wide variety of chemicals used in most laboratories. The containment collection efficiency and retention for the air-cleaning system used in the ductless hood shall be evaluated for each hazardous chemical… **4.2 (notes): Ductless Hoods** Air-cleaning performance monitoring is typically limited for many hazardous materials. Chemical-specific detectors located downstream of adsorption media or pressure drop indicators for particulate filters are necessary for systems recirculating treated air from the ductless hood back into the laboratory… Where multiple air contaminants may challenge the ductless hood air-cleaning system, the collection efficiency and breakthrough properties of such mixtures are complicated and are dependent on the nature of the specific mixture…Also, the warning properties (i.e. odor, taste) of the chemical being filtered should be adequate to provide an early indication that the filtration media are not operating properly.

Topic	Standard
Ductless Hoods ***(cont.)***	**5.2.1 Airborne Particulates** Ductless hoods that utilize air-cleaning filtration systems for recirculating exhaust air contaminated with toxic particulates shall meet the requirements of Section 10.3.1 **5.2.2 Gases and Vapors** Ductless hoods utilizing adsorption or other filtration media for the collection or retention of gases and vapors shall be specified for a limited use and shall meet the requirements of Section 10.3.2… **5.2.3 Handling Contaminated Filters** Contaminated filters shall be unloaded from the air-cleaning system following safe work practices to avoid exposing personnel to hazardous conditions and to ensure proper containment of the filters for final disposal. Airflow through the filter housing shall be shut down during change-out. **National Fire Protection Association, Standard NFPA 45-2000** **A6.4.1** Ductless laboratory hoods that pass air from the hood interior through an absorption filter and then discharge the air into the laboratory are only applicable for use with nuisance vapors and dusts that do not present a fire or toxicity hazard.

Chemical Laboratories

Topic	Standard
Ventilation Rates	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **6.3.3. Supply Air Quality** Supply systems shall meet the technical requirements of the laboratory work and the requirements of the latest version of ANSI/ASHRAE 62.1. **3.8 Laboratory (Room) Dilution and Minimum Ventilation Rate** The minimum room ventilation rate, sometimes called dilution ventilation, shall provide secondary control and removal of airborne hazards generated from emissions and nonhazardous odors in the laboratory. The dilution rate shall be expressed in terms of exhaust flow in negatively pressurized laboratories and supply flow in positively pressurized laboratories. Both the magnitude of the flow and the resulting airflow patterns in the room shall be considered when evaluating the effectiveness of dilution and contaminant removal. The minimum room ventilation rate for dilution and contaminant removal shall be established or agreed upon by the owner or their designated “responsible person” as defined in Section 2 The minimum ventilation rate shall be based on the demand for ventilation required to meet the needs of the occupants and determined through a hazard evaluation and risk assessment per Section 3.4. Generic assignment of air change rates is not appropriate. The minimum air change rate shall be adequate to minimize exposure dose below levels achieved or equivalent to a theoretically well-mixed space.

Topic	Standard
Ventilation Rates ***(Cont.)***	**3.8 (notes) Laboratory (Room) Dilution and Minimum Ventilation Rate** The quantity of dilution (or displacement) ventilation required is based on the risk of exposure associated with the use and generation of airborne hazards. Typical dilution ventilation rates can range from 4 to 10 air changes per hour depending on the risk of exposure and other factors driving minimum ventilation rates such as heating, cooling, and comfort needs and the number and size of exposure control devices and occupied versus unoccupied operating modes……Excessive airflow with no demonstrable safety benefit other than meeting an arbitrary air change rate can waste considerable energy. **6.3.3 National Fire Protection Association, Standard NFPA 45-2000** Laboratory units in which chemicals are present shall be continuously ventilated. **A6.3.3** A minimum ventilation rate of unoccupied laboratories (e.g., nights and weekends) is four room air changes per hour. Occupied laboratories typically operate at rates of greater than eight room air changes per hour, consistent with the conditions of use for the laboratory. It is not the intent of the standard to require emergency or standby power for laboratory ventilation systems. **Scientific Equipment Furniture Association, Standard SEFA 1.2-2002** **5.4.4 Make-up Air** Make-up air is a ventilation term indicating the supply of outdoor air to a building replacing air removed by exhaust ventilation systems. In general, laboratories require four to twelve total volume changes per hour... Special applications may require more air changes per hour. A sufficient quantity of makeup air must be available to allow fume hoods to develop required face velocities. Consideration must be given to the makeup required for air changes in each specific laboratory involved. This data must be coordinated with fume hoods and ventilation equipment. In order to provide a balanced and functioning system, all factors such as fume hood exhaust volume, air change data, makeup air systems and auxiliary air performance, if applicable, must be considered.

Topic	Standard
Fume Hood Diversity	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **3.2.2. Diversity** A designer, applying the concept of ventilation load diversity, shall consider the following issues: • Capacity of any existing equipment • Expansion considerations • Maintenance department's ability to perform periodic maintenance • Minimum and maximum ventilation rates for each laboratory • Quantity of hoods and researchers • Requirements to maintain a minimum exhaust volume for each hood on the system • Sash management (sash habits of users) • Thermal loads • Type, size, and operating times of facility • Type of laboratory chemical hood controls • Type of ventilation system • Use patterns of variable volume hoods • Chance of change regarding these issues, and the process to manage it (Section 3.6) The following conditions shall be met in order to design a system diversity: Acceptance of all hood-use restrictions by the user groups. Designers must take into account the common work practices of the site users. A training plan must be in place for all laboratory users to make them aware of any limitations imposed on their freedom to use the hoods at any time. An airflow alarm system must be installed to warn users when the system is operating beyond capabilities allowed by diversity. Restrictions on future expansions or flexibility must be identified **ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **5.2.2** Supply Air Distribution Supply air distribution shall be designed to keep air jet velocities less than half, preferably less than one-third of the capture velocity or the face velocity of the laboratory chemical hoods at their face opening. **National Fire Protection Association, Standard NFPA 45-2000** **6.3 Supply Systems** **6.3.5** The location of air supply diffusion devices shall be chosen so as to avoid air currents that would adversely affect the performance of laboratory hoods, exhaust systems, and fire direction or extinguishing systems. **A6.3.5** Room air current velocities in the vicinity of fume hoods should be as low as possible, ideally less than 30 percent of the face velocity of the fume hood. Air supply diffusion devices should be as far away from fume hoods as possible and have low exit velocities.

Topic	Standard
Recirculation	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **5.2.1 (notes): Supply Air Volume** In general, return air is not used in laboratories with hazardous chemicals or biological hazards… **6.4.7. Recirculation of Room Exhaust Air** Non-laboratory air or air from building areas adjacent to the laboratory may be used as part of the supply air to the laboratory if its quality is adequate. **6.4.7.1. Recirculation of General Laboratory Room Exhaust** Air exhausted from the general laboratory space (as distinguished from laboratory chemical hoods) shall not be recirculated to other areas unless one of the following sets of criteria is met and after a thorough hazard assessment or similar procedure is performed as described in Section 3.4, along with consideration of management of change as described in Section 3.6. Criteria A: Contaminant concentrations remain below exposure limits • The hazardous materials in use are known, their associated established airborne exposure limits are known, their anticipated airborne concentrations generated under both routine use (long term) and maximum credible accidents (short term) are below their relevant exposure limits, and the materials and processes are not considered subject to meaningful change as described in Section 3.6. Criteria B: Switch to full exhaust when monitored concentration is high • The hazardous materials in use are known, their associated established airborne exposure limits are known. Provision for room air to be 100% exhausted, whenever continuous monitoring of relevant contaminant concentrations indicates an alarm condition; and the system reverts to 100% exhaust in the event of a failure in the monitoring system. Monitoring devices are required to be tested and/or calibrated on a periodic basis to ensure effective sensors are operational. Criteria C: Air is treated before recirculation • The hazardous materials in use are known, their associated established airborne exposure limits are known, their anticipated airborne concentrations generated under both routine use (long term) and maximum credible accidents (short term) are known. • Contaminants are compatible with a treatment device and treated to reduce contaminant concentrations to below established limits and is monitored for contaminant concentrations. Refer to Section 10 for information regarding recirculation within the work area.

Topic	Standard
Recirculation *(cont.)*	**6.4.7.1 (notes): Recirculation of General Laboratory Room Exhaust** NOTE: This restriction on recirculation does not apply devices that heat, cool, or treat air by circulating it within one laboratory space (i.e., fan coil units). **6.4.7.2. Recirculation of Laboratory Hood Exhaust** Exhaust air from laboratory hoods shall not be recirculated to other areas. Hood exhaust air meeting the same criteria as noted in Section 6.4.7.1 shall only be recirculated to the same work area where the hood operators have control of the hood work practices and can monitor the status of air cleaning. **6.4.7.2 (notes): Exhaust Hood Air** …Laboratory chemical hood air usually contains significant amounts of materials with differing requirements for removal. Providing air-cleaning equipment to permit safe recirculation represents a high capital and operating cost, especially when redundancy and monitoring requirements are considered… **National Fire Protection Association, Standard NFPA 45-2000** **6.3.1** Laboratory ventilation systems shall be designed to ensure that chemicals originating from the laboratory shall not be recirculated. The release of chemicals into the laboratory shall be controlled by enclosure(s) or captured to prevent any flammable and/or combustible concentrations of vapors from reaching any source of ignition. **6.4.1** Air exhausted from laboratory hoods and other special local exhaust systems shall not be recirculated. *(See also 6.3.1.)* **6.4.2** If energy conservation devices are used, they shall be designed in accordance with 6.3.1. Devices that could result in recirculation of exhaust air or exhausted contaminants shall not be used unless designed in accordance with Section 4.10.1, “Nonlaboratory Air,” and Section 4.10.2, “General Room Exhaust,” of ANSI Z9.5, *Laboratory Ventilation.*
Emergency Modes	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **6.2.3. Laboratory Ventilation—Emergency Modes** A hazard assessment (see Section 3.4) shall be performed to identify the credible emergency conditions that may occur. FIRE – If the ventilation system responds to manual or automatic fire detection, the fire emergency mode shall operate all supply and exhaust equipment in a manner that promotes egress, retards the spread of fire and smoke, and complies with applicable fire safety codes and standards. LOSS OF HVAC AIR FLOW - There are other failures and abnormal events (e.g. drop out of supply fans due to freeze stat alarms) that can cause excessive space pressure differences. The design of the supply air, exhaust air, and smoke management system shall address each of these scenarios so that safe laboratory and building egress is maintained under all conditions.

Topic	Standard
Room Pressure Differential	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **6.2.1. Differential Pressure and Airflow Between Rooms** As a general rule, airflow shall be from areas of low hazard to higher hazard unless the laboratory is used as a Clean Room, or an isolation or sterile laboratory, or other special-type laboratories. When flow from one area to another is critical to emission exposure control, airflow monitoring devices shall be installed to signal or alarm that there is a malfunction. Air shall be allowed to flow from laboratory spaces to adjoining spaces only if There are no extremely dangerous and life-threatening materials used in the laboratory; The concentrations of air contaminants generated by the maximum credible accident will be lower than the exposure limits required by Section 3.7. The desired directional airflow between rooms shall be identified in the design and operating specifications. **ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **5.1.1 (notes): Differential Pressure and Airflow Between Rooms** NOTE: 'Space pressurization' or 'directional airflow' between spaces is one of many tools available to limit exposure to laboratory hazards. Effectively applied, it opposes migration of air contaminants; it does not eliminate it. Air moves between spaces in response to many phenomena, including thermal effects, movement of people and direct drafts from the ventilation system. Effective pressurization overcomes many of those drivers, most of the time. In a laboratory with ordinary construction, and a properly functioning ventilation system, air can move briefly the wrong direction. (Very special techniques for construction and operation can eliminate migration. Such facilities are outside the scope of this standard.) Safety professionals and users should understand pressurization as an imperfect secondary barrier and consider it in the context of other exposure control measures. This includes consideration of ordinary work practices, distribution and storage of materials, limits on inventory of hazardous material, and operation of the primary barriers. It also includes consideration of emergencies, and accidents. When a door to the laboratory is open, the differential pressure and the desired containment are lost. Net airflow may continue in the intended direction as a result of the airflow offset, but the average velocity is very low. It is impractical to maintain a differential pressure across an open door. Air is likely to move both directions through the large opening, which is one reason contaminants may migrate, despite proper ventilation. The quantity of Transfer Air is also generally equivalent to the "airflow offset" which is defined as the volumetric difference between Supply Air (SA) to the space and Exhaust (or Return) Air (RA) flows driven by the mechanical ventilation systems.

Topic	Standard
Room Pressure Differential ***(cont.)***	For a building with laboratories or other critical spaces it is recommended that an “airflow map” of the building be produced. This floor plan indicates the Transfer Air Volume through each boundary, or the required relative pressure relationship across it. It should also show the Supply Air Volume, the Exhaust (or Return) Air Volume for each space. The flow rates must balance for each room (TA=SA-EA) and for large common areas such as corridors. These air volumes are summed to size fans and other mechanical equipment. Ventilation system designers use several approaches to control laboratory pressurization. Methods include flow offset control, direct pressure control and combinations of those two. ASHRAE (ASHRAE Handbook – Applications, Laboratories chapter) describes each method in detail and compares them, indicating the circumstances that favor each one. Flow offset control is the most commonly applied approach and is illustrated in the following example. A lab designer chooses a value for the offset between supply and exhaust. For example, the lab Exhaust Air volume is 1000 L/s (2000 CFM) and the Supply Air Volume is 900 L/s (1800 CFM). This is defined as a “-100 L/s (-200 CFM) offset.” This -100 L/s offset draws 100 L/s of Transfer Air into the room. If the flows were reversed (Supply greater than Exhaust) the offset would be+100 L/s (+200 CFM). Flow control accuracy is crucial to the performance of a pressurization system based on the airflow offset. Designers explicitly specify the accuracy needed for the mechanical flows in and out of the room after quantifying the effect of inaccuracy on the flow offset and resulting pressurization. The leakage of the room envelope is just as important. The quantity of offset air to maintain a desired room pressure depends on the effective leakage area of the room, through the doors and envelope. In some projects, delivering an effective pressurization system includes specifying and testing the tightness of the room envelope. The construction process may explicitly include steps to adjust the observed leakage area. Rooms that leak too much are far more common than rooms that are too tight. Sometimes it is necessary to seal the envelope more carefully before the room can be effectively pressurized. Typically, the leakage area is not known. Designers rely on their experience and published design resources, (ASHRAE Handbook Fundamentals, Chapter: Ventilation and Infiltration) to estimate it. Then during the construction, TAB and Commissioning Phase, air flow and pressure measurements confirm the design. If necessary, the Transfer Air Volume can be adjusted and the sealing of critical rooms can be corrected to produce the desired Room Pressure Differential. When rooms are constructed very tightly, the low room leakage means that small changes in the room offset air volume cause significant changes in the differential pressure to the adjacent spaces. If the room envelope is too tight for volumetric offset, direct pressure control is a practical alternative

Topic	Standard
Room Pressure Differential *(cont.)*	**ASHRAE, 1995 HVAC Applications Handbook** **Chapter 13 Laboratory Systems** In order for the laboratory to act as a secondary confinement barrier … it must be maintained at a slightly negative pressure with respect to adjoining areas to contain odors and fumes. Exceptions are sterile facilities or clean spaces that may need to be maintained at a positive pressure with respect to adjoining spaces. **National Fire Protection Association, Standard NFPA 45-2000** **6.3 Supply Systems** **6.3.4 The air pressure in the laboratory work areas shall be negative with respect to corridors and nonlaboratory areas.** Exception No. 1: Where operations such as those requiring clean rooms preclude a negative pressure relative to surrounding areas, alternate means shall be provided to prevent escape of the atmosphere in the laboratory work area or unit to the surrounding spaces. *Exception No. 2: The desired static pressure level with respect to corridors and nonlaboratory areas shall be permitted to undergo momentary variations as the ventilation system components respond to door openings, changes in laboratory hood sash positions, and other activities that can for a short term affect the static pressure level and its negative relationship.* **Scientific Equipment Furniture Association, Standard SEFA 1.2-2002** **5.4.4 Make-up Air** Laboratories using chemicals should operate at a slight negative pressure as compared to the remainder of the building. **US OSHA, 29 CFR Part 1910.1450 Occupational Exposure to Hazardous Chemicals in Laboratories** Appendix A - National Research Council Recommendations Concerning Chemical Hygiene in Laboratories **C. The Laboratory Facility** 4. *Ventilation* — (a) *General laboratory ventilation.* This system should: … direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building …

Topic	Standard
Use of Airlocks	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **5.1.1.1 Airlocks** Airlocks shall be utilized to prevent undesirable airflow from one area to another in high hazardous applications, or to minimize volume of supply air required by Section 5.1.1. An airlock shall consist of a vestibule or small enclosed area that is immediately adjacent to the laboratory room and having a door at each end for passage. Airlocks shall be applied in such a way that one door provides access into or out of the laboratory room, and the other door of the airlock provides passage to or from a corridor (or other nonlaboratory area). Airlock doors shall be arranged with interlocking controls so that one door must be fully closed before the other door may be opened.
Room Pressure Alarms	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **5.1.1.2 Critical Air Balance** If the direction of airflow between adjacent spaces is deemed critical, provision shall be made to locally indicate and annunciate inadequate airflow and improper airflow direction.
Directional Air Flow	**US OSHA, 29 CFR Part 1910.1450 Occupational Exposure to Hazardous Chemicals in Laboratories** Appendix A - National Research Council Recommendations Concerning Chemical Hygiene in Laboratories **C. The Laboratory Facility** 4. *Ventilation* — (g) *Quality.* General air flow should not be turbulent and should be relatively uniform through the laboratory, with no high velocity or static areas…
Exhaust Ductwork Design	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **5.3.1.1 Design** Laboratory exhaust system ductwork shall comply with the appropriate sections of Sheet Metal and Air Conditioning Contractors' National Association (SMACNA, 1995) standards. Systems and ductwork shall be designed to maintain negative pressure within all portions of the ductwork inside the building when the system is in operation. … **National Fire Protection Association, Standard NFPA 45-2000** **6.4.3** Air exhausted from laboratory work areas shall not pass unducted through other areas. **6.4.4** Air from laboratory units and laboratory work areas in which chemicals are present shall be continuously discharged through duct systems maintained at a negative pressure relative to the pressure of normally occupied areas of the buildings. **6.4.5** Positive pressure portions of the lab hood exhaust system (e.g., fans, coils, flexible connections and ductwork) located within the laboratory building shall be sealed airtight or located in a continuously mechanically ventilated room.

Topic	Standard
Exhaust Ductwork Design *(cont.)*	**Scientific Equipment Furniture Association, Standard SEFA 1.2-2002** **5.4.3 Exhaust Unit and Duct Considerations** Where laboratory building design permits, the exhaust unit should be located on the roof of the building to provide a negative pressure in that portion of the duct system located within the building… …for minimal friction losses within the duct, smooth interior surfaces are recommended. Elbows, bends and offsets within a duct system should be kept to a minimum and should be long sweep in design configuration in order to minimize static pressure losses.
Exhaust Ductwork Construction	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **6.4.2.2. Materials** Exhaust system materials shall be in accordance with the current version of ACGIH's Industrial Ventilation: A Manual of Recommended Practice, the ASHRAE Handbook – Fundamentals, Duct Design, and NFPA 45. Exhaust system materials shall be resistant to corrosion by the agents to which they are exposed. Exhaust system materials shall be noncombustible if perchloric acid or similar oxidizing agents that pose a fire or explosive hazard are used. **National Fire Protection Association, Standard NFPA 45-2000** **6.5 Duct Construction for Hoods and Local Exhaust Systems** **6.5.1** Ducts from laboratory hoods and from local exhaust systems shall be constructed entirely of noncombustible materials. Exception No. 1: Flexible ducts of combustible construction shall be permitted to be used for special local exhaust systems within a laboratory work areas (See 6.5.2.) *Exception No. 2: Combustible ducts shall be permitted to be used if enclosed in a shaft of noncombustible or limited-combustible construction where they pass through nonlaboratory areas or through laboratory units other than the one they serve (See 6.5.2.)* *Exception No. 3: Combustible ducts shall be permitted to be used if all areas through which they pass are protected with an approved automatic fire extinguishing system, as described in Chapter 4. (See 6.5.2.)* **6.5.2** Combustible ducts or duct linings shall have a flame spread index of 25 or less when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials.* Test specimens shall be of the minimum thickness used in the construction of the duct or duct lining. **6.5.3** Linings and coatings containing such fill as fiberglass, mineral wool, foam, or other similar material that could accumulate chemical deposits shall not be permitted within laboratory exhaust systems. **6.5.8** Controls and dampers, where required for balancing or control of the exhaust system, shall be of a type that, in event of failure, will fail open to ensure continuous draft. *(See 6.10.3.)* **6.5.9** Hand holes, where installed for damper, sprinkler, or fusible link inspection or resetting and for residue clean-out purposes, shall be equipped with tight-fitting covers provided with substantial fasteners.

<table>
<tr><th>Topic</th><th>Standard</th></tr>
<tr><td>Exhaust Ductwork Construction (cont.)</td><td>Scientific Equipment Furniture Association, Standard SEFA 1.2-2002

5.4.3 Exhaust Unit and Duct Considerations

…Ductwork shall be designed and constructed in accordance with approved standards (ASHRAE, NFPA, SMACNA) and regulations,…</td></tr>
<tr><td>Duct Velocities</td><td>National Fire Protection Association, Standard NFPA 45-2000

6.6 Duct Velocities. Duct velocities of laboratory exhaust systems shall be high enough to minimize the deposition of liquids or condensable solids in the exhaust systems during normal operations in the laboratory hood.</td></tr>
<tr><td>Manifolded Exhaust</td><td>ANSI/ASSP Z9.5-2022: Laboratory Ventilation

6.4.3.1. Manifold Requirements

Laboratory chemical hood ducts may be combined into a common manifold with the following exceptions and limitations:

Each control branch shall have a flow-regulating device to buffer the fluctuations in pressure inherent in manifolds.

Perchloric acid hoods shall not be manifolded with nonperchloric acid hoods unless a scrubber is installed between the hood and the manifold.

Where there is a potential contamination from hood operations as determined from … section 3.4, radioisotope hoods shall not be manifolded with nonradioisotope hoods unless in-line HEPA filtration and/or another necessary air-cleaning system is provided between the hood and the manifold.

Note- additional information is contained in the full standard.

6.4.3.2. Compatibility of Sources

Exhaust streams that contain concentrations of flammable or explosive vapors at concentrations above the Lower Explosion Limit (LEL) as well as those that might form explosive compounds (i.e., perchloric acid hood exhaust) shall not be connected to a centralized exhaust system. Exhaust streams comprised of radioactive materials shall be adequately filtered to ensure removal of radioactive material before being connected to a centralized exhaust system. Biological exhaust hoods shall be adequately filtered to remove all hazardous biological substances prior to connection to a centralized exhaust system.

6.4.3.8. Continuous Operation

Exhaust systems shall operate continuously to provide adequate ventilation for any hood at any time it is in use and to prevent backflow of air into the laboratory when the following conditions are present:

• Hazardous chemicals are present in any hood (opened or unopened).
• Exhaust system operation is required to maintain minimum ventilation rates and room pressure control.
• There are powered devices connected to the manifold. Powered devices include, but are not limited to: biological safety cabinets, in-line scrubbers, motorized dampers, and booster fans.</td></tr>
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Topic	Standard
Manifolded Exhaust (*cont.)*	**6.4.3.9. Constant Suction, Redundancy and Emergency Power** Manifolds shall be maintained under negative pressure at all times and be provided with at least two exhaust fans for redundant capacity. Emergency power shall be connected to one or more of the exhaust fans where exhaust system function must be maintained even under power outage situations. *NOTE: The manifold fans and controls should be designed so that sufficient static pressure is available to each connected exhaust source for all conditions that do not exceed the system diversity. Since each critical connected source (i.e., laboratory hoods) should have continuous performance monitors, exceeding system capacity should also result in flow alarms.* **National Fire Protection Association, Standard NFPA 45-2000** **6.5.10 Manifolding of Laboratory Hood and Ducts** **5.3.2.8 System Classification** Laboratory hood exhaust systems shall not be classified as “Hazardous Exhaust Systems” as defined in Building Officials and Code Administrators International (BOCA), Uniform, or International Mechanical Codes. **6.5.10.1** Exhaust ducts from each laboratory unit shall be separately ducted to a point outside the building, to a mechanical room, or to a shaft. *(See 3.1.5 and 6.10.3)* **National Fire Protection Association, Standard NFPA 45-2000** **6.5.10 Manifolding of Laboratory Hood and Ducts** **6.5.10.2** Connection to a common laboratory hood exhaust duct system shall be permitted to occur within a building o9nlyu in any of the following locations: **1.** Mechanical room protected in accordance with Tables 3.1.1(a) and 3.1.1(b) **2.** Shaft protected in accordance with the chapter for protection of vertical openings of NFPA *101, Life Safety Code* **3.** A point outside of the building **6.5.10.1** Exhaust ducts from each laboratory unit shall be separately ducted to a point outside the building, to a mechanical room, or to a shaft. *(See 3.1.5 and 6.10.3)* **6.5.10.2** Connection to a common laboratory hood exhaust duct system shall be permitted to occur within a building o9nlyu in any of the following locations: 1. Mechanical room protected in accordance with Tables 3.1.1(a) and 3.1.1(b) 2. Shaft protected in accordance with the chapter for protection of vertical openings of NFPA *101, Life Safety Code* 3. A point outside of the building

Topic	Standard
Exhaust Fan Operation	**ANSI/ASSP Z9.5-2022: Laboratory Ventilation** **6.4.4. Exhaust Fans** Each fan applied to serve a laboratory exhaust system or to exhaust an individual piece of laboratory equipment (e.g., a laboratory chemical hood, biosafety cabinet, chemical storage, etc.) shall be adequately sized to provide the necessary amount of exhaust airflow in conjunction with the size, amount, and configuration of the connecting ductwork. In addition, each fan's rotational speed and motor horsepower shall be sufficient to maintain both the required exhaust airflow and stack exit velocity and the necessary negative static pressure (suction) in all parts of the exhaust system… **6.4.5. Discharge of Contaminated Air** The maximum plausible contamination concentration in the discharged air shall be limited by the user. Some laboratory scale processes emitting toxic or flammable gases may require pretreatment scrubbers, catalytic converters or incinerators before emissions are discharged through a laboratory ventilation system (see NFPA 55). The discharge of potentially contaminated air that contains a concentration more than the allowable breathing air concentration shall be: Direct to the atmosphere unless the air is treated to the degree necessary for recirculation (see Section 10.3); Discharged in a manner and location to avoid reentry into the laboratory building or adjacent buildings at concentrations above 20% of allowable concentrations inside the laboratory for routine emissions or 100% of allowable concentrations for emergency emissions under wind conditions up to the 1%-wind speed for the site, and in compliance with applicable federal, state, or local regulations with respect to air emissions. **6.4.6. Exhaust Stack Discharge** The exhaust stack discharge shall be in accordance with the current version of NFPA 45 and the ASHRAE Handbook − HVAC Applications, Building Air Intake and Exhaust Design chapter. In any event the discharge shall be a minimum of 10 ft (3 m) above adjacent roof lines and air intakes and in a vertical up direction. Exhaust stack discharge velocity shall be sufficient, as defined by the methodology described in Appendix 3, to reduce the concentration of hazardous materials in the exhaust to safe levels (see Section 3.1) at all potential receptor locations. Aesthetic conditions concerning external appearance shall not supersede the requirements of Sections 6.4.5 and 6.4.6. Any architectural structure that protrudes to a height close to the stack-top elevation (i.e., architectural structure to mask unwanted appearance of stack, penthouses, mechanical equipment, nearby buildings, trees or other structures) shall be evaluated for its effects on reentrainment. The air intake or exhaust grilles shall not be located within the architectural screen or mask unless it is demonstrated to be acceptable.

Topic	Standard
Commissioning	**ANSI/ASSP Z9.5-2022 Laboratory Ventilation** **7.1.1. Commissioning Process** All newly installed, renovated or modified lab ventilation systems shall be commissioned to verify proper performance prior to use by laboratory personnel. The commissioning process starts during design of the systems and extends through construction and operation to verify that the systems conform as specified by design and the requirements of this standard… 7.1.2. Commissioning Authority **The commissioning process shall be overseen by the Commissioning Authority in cooperation with the LVMP Responsible Person…** **7.1.3. Commissioning Plan** A written commissioning plan shall accompany design documents and be approved by the commissioning authority in advance of construction activities and updated as changes are made to the system configuration or operating specifications throughout construction. The commissioning plan shall be available to all potential suppliers and contractors prior to bid along with the other project documents. A commissioning plan shall address operation of the entire ventilation system where the hoods, laboratories, and associated exhaust and air supply systems are considered subsystems. The operating specifications, performance criteria and operational metrics such as minimum and maximum flow shall be extracted from the design documents and described in the commissioning plan. The plan shall include written procedures to verify or validate proper operation of all system components across the range of operating modes (e.g., occupied, unoccupied) as defined by the design sequences of operation. The functional commissioning tests shall include: • Tests of the Mechanical Exhaust and Air Supply Systems • Tests of the Lab Environments • Tests of the Laboratory Fume Hoods and Exposure Control Devices Note: ANSI/ASSP Z9.5-2022 Laboratory Ventilation contains extensive additional information on the commissioning process and requirements and should be consulted if more information is desired.

References

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"Occupational Exposure to Hazardous Chemicals in Laboratories," *Code of Federal Regulations* Title 29, Part 1910,1450, 1988.

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USA	**Tel:** +1 800 680 1220	**India**	**Tel:** +91 80 67877200
UK	**Tel:** +44 149 4 459200	**China**	**Tel:** +86 10 8251 6588
France	**Tel:** +33 4 91 11 87 64	**Singapore**	**Tel:** +65 6595 6388
Germany	**Tel:** +49 241 523030		

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