LABORATORY GUIDELINES AND STANDARDS

APPLICATION NOTE LC-125

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.

Table of Contents

Laboratory Chemical Hoods

Topic	Standard
Usage	**ANSI/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **2.1.1 Laboratory Chemical Hoods** 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/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **3.1.1.4 Automatic Sash Closers** The following factors shall be considered before automatic sash closing devices are installed on a laboratory chemical hood: • The adverse effect on energy consumption when the operators feel it is their responsibility to close the sash; and • The adverse effect on energy consumption when the operators do not feel it is their responsibility to close the sash. The following conditions shall be met before using automatic sash closing devices: • All users must be aware of any limitations imposed on their ability to use the hood. • Automatic sash positioning systems shall have obstruction sensing capable of stopping travel during sash closing operations without breaking glassware, etc. • Automatic sash positioning shall allow manual override of positioning with forces of no more than 10 lbs (45 N) mechanical both when powered and during fault modes during power failures.
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/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **3.3.4 Hood Location** 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
Face Velocity	**ANSI/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **3.3.1 Face Velocity** The average face velocity of the hood shall produce sufficient capture and containment of hazardous chemicals 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.

Topic	Standard
Face Velocity *(cont.)*	**3.3.1 (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 chemical hoods. 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 hoods. Room and operator dynamics have significant effects 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/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **3.3.3 Flow-Measuring Device for Laboratory Chemical 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 airflows at the design flow and ±20% of the design flow. The device shall be calibrated at least annually and whenever damaged. **3.3.3 (notes): Flow-Measuring Device for Laboratory Chemical Hoods** The means of alarm or warning chosen should be provided in a manner readily visible or audible to the hood user. The alarm should warn when the flow is 20% low, that is 80% of the setpoint value. The choice of audible vs. visible alarms should be made considering the potential needs of a physically disabled user. 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/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **3.1.1.1 Vertical Sashes** …Where the design sash opening area is less than the maximum sash opening area, the hood shall be equipped with a mechanical sash stop and alarm to indicate openings in excess of the design sash opening area.
Flow Visualization Testing	**ANSI/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** ***6.3.6 Airflow Visualization Tests*** Airflow visualization tests shall be conducted as described in the ANSI/ASHRAE 110-1995, *Method of Testing Performance of Laboratory Fume Hoods.* The tests shall consist of small-volume generation and large-volume generation smoke to identify areas of reverse flow, stagnation zones, vortex regions, escape, and clearance. Visible escape beyond the plane of the sash when generated 6 in. (15.2 cm) into the hood shall constitute a failure during the performance test. **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/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **6.3.3 Face Velocity Tests** The average face velocity shall be determined by the method described in the ANSI/ASHRAE 110-1995 *Method of Testing Performance of Laboratory Fume Hoods.* Face velocity measurements shall be made by dividing the hood opening into equal area grids with sides measuring no more than 12 in. (30.5 cm). The tip of the probe shall be positioned in the plane of the sash opening and fixed (not handheld) at the approximate center of each grid. Grid measurements around the perimeter of the hood opening shall be made at a distance of approximately 6 in. (15.2 cm) from the top, bottom, and sides of the opening enclosure. The average face velocity shall be the average of the grid velocity measurements. Each grid velocity shall be the average of at least 10 measurements made over at least 10 seconds. The plane of the sash shall be located at the midpoint of the sash frame depth. **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/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **6.3.5 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. Over a period of 10–30 sec., cross-draft velocities shall be recorded approximately 1 reading per second using a thermal anemometer with an accuracy of ±5% at 50 fpm (0.25 m/s). The average and maximum cross-draft velocities at each location shall be recorded and not be sufficient to cause escape from the hood. Cross draft velocities shall not be of such magnitude and direction as to negatively affect containment. **6.3.6 (notes): Cross-Draft Velocity Tests** …Excessive cross-draft velocities (>50% of the average face velocity) have been demonstrated to significantly affect hood containment and should be identified and alleviated. Ideally, cross-draft velocities should be less than 30%. If the supply tracks the exhaust, measure the cross drafts at the maximum conditions.
VAV Response Time Testing	**ANSI/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **6.5.3.2 VAV Hood Performance Tests** …VAV Response shall be sufficient to increase or decrease flow within 90 % of target flow or face velocity in a manner that does not increase potential for escape. VAV Stability shall be sufficient to prevent flow variations in excess of 10% from design at each sash configuration or operating mode. **6.5.3.2 (notes)**: **VAV Hood Performance 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 < 3 sec. after the completion of the sash movement is considered acceptable for most operations. Faster response times may improve hood containment following the sash movement.

Topic	Standard
VAV Response Time Testing *(cont.)*	**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.
Containment Testing	**ANSI/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **6.3.7 Tracer Gas Containment 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. A control level for 5-minute average tests at each location conducted at a generation rate of 4 L/m shall be no greater than 0.05 ppm for "as manufactured" tests and 0.10 ppm for "as installed" or "as used" (AM 0.05, AI 0.1). Escape more than the control levels stated above shall be acceptable at the discretion of the design professional in agreement with the responsible person (2.4.2). The "as used" 0.10 ppm level or more is at the discretion of the responsible person (2.3). **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/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **3.3.2 Periodic Face Velocity Measurement** Once adequate performance (see 2.1.1) has been established for a particular hood at a given benchmark face velocity using the methods described above, that benchmark face velocity shall be used as a periodic check for continued performance as long as no substantive changes have occurred to the hood. Face velocity measurements shall be made with the sash in the Design Sash Position. The Design Sash Position is the maximum opening or configuration allowed by user standards, SOPs, or the Chemical Hygiene Plan, whichever is applicable, and used in the design of the exhaust system to which the hood is connected. The sash position at which benchmark face velocity is measured shall be recorded with the face velocity measurement and reproduced each time measurements are taken. A decrease in the average face velocity below 90% of the benchmark velocity shall be corrected prior to continued hood use. Face velocity increases exceeding 20% of the benchmark shall be corrected prior to continued use. **6.4 Ongoing or Routine Hood and System Tests** Routine performance tests shall be conducted at least annually or whenever a significant change has been made to the operational characteristics of the hood system. A hood that is found to be operating with an average face velocity more 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. Each hood shall be posted with a notice giving the date of the routine performance test, and the measured average face velocity. If it 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 hood.

Topic	Standard
Frequency Of Testing *(cont.)*	**6.4 (notes)**: **Ongoing or Routine Hood and System Tests** ANSI/ASHRAE 110-1995 may be used in the laboratory as an accepted test with specific values for the controls levels … It may also be used for routine periodic testing, but it is somewhat expensive and other less rigorous tests may be adequate if conditions have not changed since commissioning tests. In addition to the hood tests, periodic testing at a minimum of 1-year intervals should ensure that: ▪ All other room exhaust provisions are within specifications; ▪ Room differential pressure is within specifications (if applicable); ▪ Room differential airflow is within specifications (if applicable) Periodic tests concerning face velocity or hood exhaust volume are valid indications of hood operation provided no changes have been made in that hood structure, supply air distribution, or other factors … that affect hood performance. The hood sash should not be lowered below design position to increase face velocity during routine tests. A decrease in face velocity at the design opening may be indicative of a problem with operation of the exhaust system. **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. **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.

Topic	Standard
Frequency Of Testing *(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** **(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/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **3.3.1 Face Velocity** …The mechanism that controls the exhaust fan speed or damper position to regulate the hood exhaust volume shall be designed to ensure a minimum exhaust volume in constant volume systems equal to the larger of 50 cfm/ft of hood width, or 25 cfm/ft^2 of hood work surface area, except where a written hazard characterization indicates otherwise, or if the hood is not in use. **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/secd/m^2 (25 ft^3/min/ft^2) of internal hood work surface even when the sash is fully closed.
Emergency Modes	**ANSI/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **3.2.6 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** **6.10.4** 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/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **5.3.2.9 Fire Dampers** Fire dampers shall not be installed in exhaust system ductwork (NFPA 45). **5.3.2.10 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/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **3.2.4 Perchloric Acid Laboratory Chemical Hoods** Perchloric acid hoods are laboratory hoods that meet the requirements in Sections 3.2.1 and 3.3 and NFPA 45. • In addition: All inside hood surfaces shall use materials that will be stable and not react with perchloric acid to form corrosive, flammable, and/or explosive compounds or byproducts; • All interior hood, duct, fan, and stack surfaces shall be equipped with water wash-down capabilities; • All ductwork shall be constructed of materials that will be stable to and not react with perchloric acid and/or its byproducts and will have smooth welded seams; • No part of the system shall be manifolded or joined to nonperchloric acid exhaust systems; • No organic materials, including gaskets, shall be used in the hood construction unless they are known not to react with perchloric acid and/or its byproducts; Perchloric acid hoods shall be prominently labeled “Perchloric Acid Hood.” **5.3.2.2 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** **6.11.1** 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… **6.11.7** 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). Non reactive 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/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **5.3.2.2 Manifold Requirements** …Where there is a potential contamination from hood operations as determined from the Hazard Evaluation and Analysis of Section 2.4, 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... **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/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **4.2 Ductless Hoods** Ductless hoods shall meet the general requirements of Sections 3.1 and 3.3 as applicable. A Hazard Evaluation and Analysis shall be conducted as directed in ANSI/AIHA Z9.7 and Section 2.1.1. Compliance with the general requirements of Sections 2, 3.3, and 5.3.6.2 shall be evaluated by qualified persons. Ductless hoods that do not meet the requirements specified in Sections 9.3 and 9.4 shall be used only for operations that normally would be performed on an open bench without presenting an exposure hazard. 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.

Topic	Standard
Ductless Hoods *(cont.)*	**4.2 (notes): Ductless Hoods** Ductless hoods have limited application because of the wide variety of chemicals used in most laboratories. the contament collection efficiency and retention for the air-cleaning system used in the ductless hood must be evaluated for each hazardous chemical… 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 must be adequate to provide an early indication that the filtration media are not operating properly. **4.2.1 Airborne Particulates** Ductless hoods that utilize air-cleaning filtration systems for recirculating exhaust air contaminated with toxic particulates shall meet the requirements of Section 9.3.1 **4.2.2 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 9.3.2 **4.2.3 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/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **5.2.3 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. **2.1.2 Volume Flowrates/Room Ventilation Rate** The specific room ventilation rate shall be established or agreed upon by the owner or his/her designee. **2.1.3 General Ventilation** The general ventilation system shall be designed to replace exhausted air and provide the temperature, humidity, and air quality required for the laboratory procedures without creating drafts at laboratory chemical hoods. **2.1.4 Dilution Ventilation** Dilution ventilation shall be provided to control the buildup of fugitive emissions and odors in the laboratory. **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. **ASHRAE, 1995 HVAC Applications Handbook** **Chapter 13 Laboratory Systems** **Laboratory Ventilation Systems** Minimum ventilation rates are generally in the range of 6 to 10 air changes per hour when occupied; however, some spaces … have minimum ventilation rates established by specific standards or may have ventilation rates established by internal facility policies. The maximum ventilation rate for the laboratories should be reviewed to ensure that appropriate supply air delivery methods are chosen so supply airflows do not impede the performance of the exhaust devices. **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** **(f) Performance** "Rate: 4-12 room air changes/hour is normally adequate general ventilation…"

Topic	Standard
Ventilation Rates *(cont.)*	**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.
Fume Hood Diversity	**ANSI/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **5.1.2 Diversity** The following issues shall be evaluated in order to design for diversity: • Use patterns of hoods • Type, size, and operating times of facility • Quantity of hoods and researchers • Sash management (sash habits of users) • Requirements to maintain a minimum exhaust volume for each hood on the system • Type of ventilation system • Type of laboratory chemical hood controls • Minimum and maximum ventilation rates for each laboratory • Capacity of any existing equipment • Expansion considerations • Thermal loads • Maintenance department's ability to perform periodic maintenance 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/AIHA Z9.5-2003** **American National Standards for 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.

Topic	Standard
Fume Hood Diversity *(cont.)*	**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.
Recirculation	**ANSI/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **5.2.1 (notes): Supply Air Volume** In general, return air is not used in laboratories with hazardous chemicals or biological hazards… **5.3.6 Recirculation of Room Exhaust Air** Nonlaboratory 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. **5.3.6.1 General 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: 1) Criteria A • There are no extremely dangerous or life-threatening materials used in the laboratory; • The concentration of air contaminants generated by maximum credible accident will be lower than short-term exposure limits required by 2.1.1; • The system serving the laboratory chemical hoods is provided with installed redundancy, emergency power, and other reliability features as necessary. 2) Criteria B • Recirculated air is treated to reduce contaminant concentrations to those specified in 2.1.1; • Recirculated air is monitored continuously for contaminant concentrations or provided with a secondary backup air-cleaning device that also serves as a monitor (via a HEPA filter in a series with a less efficient filter, for particulate contamination only). Refer to Section 9.3.1; • Provision of 100% outside air, whenever continuous monitoring indicates an alarm condition. **5.3.6.1 (notes): General Room Exhaust** …Devices that are intended to provide heating and/or cooling by recirculating the air within a laboratory space (i.e., fan coil units) are exempt from this requirement. **5.3.6.2 Exhaust Hood Air** Exhaust air from laboratory hoods shall not be recirculated to other areas. Hood exhaust air meeting the same criteria as noted in Section 5.3.6.1 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.

Topic	Standard
Recirculation *(cont.)*	**5.3.6.2 (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/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **5.1.4 Laboratory Ventilation—Emergency Modes** When the type and quantity of chemicals or compressed gases that are present in a laboratory room could pose a significant toxic or fire hazard, the room shall be equipped with provision(s) to initiate emergency notification and initiate the operation of the ventilation system in a mode consistent with accepted safety practices. A hazard assessment (see Section 2.4) shall be performed to identify the credible emergency conditions that may occur.

Topic	Standard
Emergency Modes *(cont.)*	Emergency situations (see NFPA 92A-2000) that shall be anticipated and the appropriate ventilation system responses shall include: • CHEMICAL EMERGENCY (Chemical Spill, Eye-Wash or Emergency Shower Activation, Flammable Gas Release, etc.) – A means such as a clearly marked wall switch, pull station, or other readily accessible device should enable the room occupants to initiate appropriate emergency notification and simultaneously activate the ventilation system's chemical emergency mode of operation if one exists. For rooms served by VAV ventilation systems, the Chemical Emergency mode of operation should maximize the room ventilation (air change per hour) rate and, if appropriate, increase negative room pressurization. For rooms served by CAV ventilation systems that utilize a reduced ventilation level for energy savings, the Chemical Emergency mode of operation should ensure that the room ventilation and negative pressurization are at the maximum rate. Operation of the room ventilation system in a chemical emergency mode should not reduce the room ventilation rate, room negative pressurization level, or hood exhaust airflow rate. • FIRE – A means such as a wall-mounted "FIRE ALARM" pull station should enable the room occupants to initiate a fire alarm signal and simultaneously activate an appropriate fire emergency mode of operation for the room and/or building ventilation system. For rooms served by VAV ventilation systems, the fire emergency mode of operation should maximize the exhaust airflow rate from the hoods and other room exhaust provisions, and also shut off the room supply makeup air. For rooms served by CAV ventilation systems that utilize a reduced ventilation level for energy savings, the fire emergency mode of operation should ensure that the maximum exhaust airflow rate from the hoods and other room exhaust provisions are in effect, and should also shut off the room supply makeup air.
Room Pressure Differential	**ANSI/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **5.1.1 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 (such as Class 10,000 or better), 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.

<table>
<tr><th>Topic</th><th>Standard</th></tr>
<tr><td>Room Pressure Differential (cont.)</td><td>
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 2.1.1.

The desired directional airflow between rooms shall be identified in the design and operating specifications.
ANSI/AIHA Z9.5-2003
American National Standards for Laboratory Ventilation
5.1.1 (notes): Differential Pressure and Airflow Between Rooms
The intent of this section is to require the reader to carefully consider the critical need to maintain directional airflow between spaces and to understand how best to accomplish the desired outcome. Although it is true a difference in pressure is the driving force that causes air to flow through any openings from one room to another, specifying quantitative pressure differential is a poor basis for design. What really is desired is an offset air volume (as defined below). Attempts to design using direct pressure differential measurement and control vs. controlling the offset volume may result in either short or extended periods of the loss of pressure when the doors are open or excessive pressure differentials when the doors are closed, sufficient to affect the performance of low pressure fans. (See information below on the need for directional airflow.)
When the differential pressure design basis is used, the relative volumes of supply and exhaust air to each room should be set so that air flows through any opening, including open doorways, at a minimum velocity of 50 fpm (0.25 m/s) and a preferred velocity of 100 fpm (0.51 m/s) in the desired direction.
NOTE: When an ordinary 3 ft x 7 ft = 21 ft^2 (0.9 m x 2.1 m = 1.95 m^2) door is open, under the above conditions, the airflow through the door would be from 1050 to 2100 cfm (496 to 991 L/s) and the differential pressure will be about 0.0001 to 0.0006 in.wg (0.025 to 0.15 Pa). If a differential pressure of only 0.01 in. wg (2.5Pa) was specified and actually maintained, when the door was open it would generate an air velocity and airflow through the door of 400 fpm (2.0 m/s) and 8400 cfm (3964 L/s) respectively. These latter values would be impractical in operation.
Double door airlocks do not have the same difficulties as opening a normal door and do not require the 1050 cfm to 2100 cfm (496 to 991 L/s) mentioned above as long as only one door is opened at one time. Without an airlock, the actual opening of a door into a corridor will usually draw contaminants with it because of the speed of the door’s movement despite the effects of the negative pressurization. So, it is important to keep door openings to a minimum as well as the amount of time that the laboratory doors are kept open.
</td></tr>
</table>

Topic	Standard
Room Pressure Differential *(cont.)*	The need to maintain directional airflow at every instance and the magnitude or airflow needed will depend on individual circumstances. For example, “clean rooms” (designed primarily to protect the product not the worker) may have very strict requirements for directional airflow and pressure control to limit the movement of contaminants into the clean room. Pharmaceutical laboratories governed by the Food and Drug Administration (FDA) current Good Laboratory Practices (cGLP) are other examples of stricter control requirements. Some people recommend a 10% “offset” in ventilation rate with lab exhaust being 10% greater than the lab supply air as a means of maintaining negative pressurization in the laboratory and keeping air flowing from the corridor into the laboratory. For example a laboratory with 1000 cfm (472 L/s) of exhaust would have 900 cfm (425 L/s) of supply air and 100 cfm (47.2 L/s) coming from adjoining spaces. This 10% design offset is merely a rule of thumb and may not be adequate to maintain directional airflow and pressurization, especially when the laboratory door is open. The amount of offset should be based on two considerations: • The airflow required to keep the laboratory room negative with regard to surrounding air spaces. The 10% offset may be appropriate in some cases but has no general validity. • The “stringency” of the requirements for direction of airflow… If the requirement is stringent, two seldom considered factors become important. First, if there is any appreciable temperature difference between the laboratory and adjoining space, when a door is opened there will be a thermal exchange or warmer air at the top of the doorway and cooler air flowing in the opposite direction near the floor. An airflow velocity of at least 50 fpm (0.25 m/s) is needed to inhibit this exchange as calculated in the note above. Second, the air volume needed to control airflow through a door in this way is independent of the size of the room or its need for supply or exhaust air and is only related to the number and square footage of doors into the laboratory. Consequently, if the requirement is stringent, an airlock door is the only current available solution. In the absence of an airlock, an arbitrary 10% offset of the laboratory ventilation rate is not the proper basis for design.

Topic	Standard
Room Pressure Differential *(cont.)*	If the door phenomenon is not considered, there will be no safety isolation when the door is open. In many laboratories, momentary door opening to allow the movement of materials and personnel in and out of the laboratory will not cause a significant safety condition because of the short duration of time for any contaminants to escape from the laboratory to the corridor. Where the toxicity of the escaping contaminants would be a concern during the 15 sec opening of a door, then double door airlocks should be employed. However, for both fire contaminant reasons and hazardous materials contaminant, laboratory doors should be closed except when in actual use. The speed of response of the laboratory pressure controls should be in proportion to the danger of the hazardous materials contained in the laboratory. For most laboratories, speed of response should be in the range of 0.5 sec to 3 sec. **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.

Topic	Standard
Room Pressure Differential *(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*—(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 …
Use Of Airlocks	**ANSI/AIHA Z9.5-2003** **American National Standards for 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/AIHA Z9.5-2003** **American National Standards for 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/AIHA Z9.5-2003** **American National Standards for 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. …

Topic	Standard
Exhaust Ductwork Design *(cont.)*	**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. **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/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **5.3.1.2 Materials** Exhaust system materials shall be in accordance with Chapter 5 of ACGIH's *Industrial Ventilation: A Manual of Recommended Practice*, Chapter 34 on Duct Design of the ASHRAE 2001 Handbook – *Fundamentals*, and Chapter 6-5 of NFPA 45 – 2000. **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.**

Topic	Standard
Exhaust Ductwork Construction *(cont.)*	**ANSI/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **5.3.1.2 (note): Materials** Solid metal ductwork has good fire characteristics but in some cases has inferior corrosion resistance for some chemicals. Solid plastic ductwork generally has good corrosion resistance but may not be acceptable to the local fire authority. An economical material that can be used when appropriate and if proper care is used in installation and maintenance is a metal duct with a protective coating. However, because of the thin coatings generally used, pinhole defects in the coating may be relatively common, which would eventually lead to a very small amount of leakage. Any mechanical damage or scratching of the coating in installation or maintenance would have to be immediately and properly repaired or the bare metal revealed in the scratch will be eaten away. Owner's representatives must spend more time and money during installation to make sure contractor coats all exposed metal during initial installation and similar care must be exercised whenever the coated exhaust duct is modified during renovations." **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.

Topic	Standard
Exhaust Ductwork Construction *(cont.)*	**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,…
Duct Velocities	**ANSI/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **5.** **5.3.1.1 (note): Design** …Exhaust duct sizes should be selected to ensure sufficiently high airflow velocity to retard condensation of liquids or the adherence of solids within the exhaust system. **In some cases, accumulation of solids material within the duct system may be prevented by providing water spray nozzles in the duct at frequent intervals and sloping the duct down to an appropriate receptor (e.g., a wet dust collector)…** **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.
Manifolded Exhaust	**ANSI/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **5.3.2.2 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 2.4, 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. Carbon bed filters shall be added for gasses. **5.3.2.3 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.

Topic	Standard
Manifolded Exhaust *(cont.)*	**5.3.2.4 Exhaust System Reliability** Unless all individual exhausts connected to the centralized exhaust system can be completely stopped without creating a hazardous situation, provision shall be made for continuous maintenance of adequate negative static pressure (suction) in all parts of the system… **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. **National Fire Protection Association, Standard NFPA 45-2000** **6.5.10 Manifolding of Laboratory Hood and Ducts** **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 **6.5.10.3** Exhaust ducts from laboratory hoods and other exhaust systems within the same laboratory unit shall be permitted to be combined within that laboratory unit *(See 6.4.1)*
Exhaust Fan Operation	**ANSI/AIHA Z9.5-2003** **American National Standards for Laboratory Ventilation** **5.3.2.4 (notes): Exhaust System Reliability** …Emergency backup power should be provided to all exhaust fans and the associated control system… **5.3.2.11 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:* • 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.

Topic	Standard
Exhaust Fan Operation *(cont.)*	**5.3.2.12 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. **5.3.3 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… **5.3.4 Discharge of Contaminated Air** 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 9.3); • In compliance with applicable federal, state, or local regulations with respect to air emissions; • 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. **5.3.5 Exhaust Stack Discharge** The exhaust stack discharge shall be in accordance with the ASHRAE 1999 Handbook – *HVAC Applications*, Chapter 43. 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. A minimum discharge velocity of 3000 fpm (15.2 m/s) is required unless it can be demonstrated that a specific design meets the dilution criteria necessary to reduce the concentration of hazardous materials in the exhaust to safe levels (see Section 2.1) at all potential receptors…

<table>
<tr><th>Topic</th><th>Standard</th></tr>
<tr><td>Commissioning Instrumentation</td><td>
ANSI/AIHA Z9.5-2003
American National Standards for Laboratory Ventilation
6.1 Commissioning of Laboratory Ventilation Systems
Commissioning Test Instrumentation:

All test instrumentation utilized for the commissioning process shall be in good working order and shall have been factory calibrated within 1 year of the date of use. (See 8.6.1 Air Velocity, Air Pressure, Temperature and Humidity Instruments)

8.6.1 Air Velocity, Air Pressure, Temperature and Humidity Measurements
Pressure instrumentation and measurement shall be in compliance with ANSI/ASHRAE 41.3-1989. Temperature instruments and measurement techniques shall be in compliance with ANSI/ASHRAE 41.1-1986 (RA 01). All instruments using electrical, electronic, or mechanical components shall be calibrated no longer than 12 months before use or after any possible damage (including impacts with no apparent damage) since the last calibration. The accuracy of a scale used for a given parameter shall meet the following requirements:

<table>
<tr><th><u>Velocity—fpm</u></th><th><u>Accuracy</u></th></tr>
<tr><td>Below 100 fpm (0.51 m/s)</td><td>5 fpm (0.025 m/s)</td></tr>
<tr><td>100 fpm (0.51 m/s) and higher</td><td>5% of signal</td></tr>
</table>

<table>
<tr><th><u>Pressure— in. wg</u></th><th><u>Accuracy</u></th></tr>
<tr><td>0.1 in.wg (25 Pa)</td><td>10% of signal</td></tr>
<tr><td>0.5 in.wg (125 Pa) and higher</td><td>5% of signal</td></tr>
</table>

Between 25 Pa and 125 Pa, interpolate linearly.

Pitot-static tube measurements shall be in accordance with ANSI/ASHRAE's Method of Test Measurement of Flow of Gas, 41.7-1984 (RA 00). Inclined manometers shall be selected so that the nominal value of the measured parameter is at least 5% of full scale. U-tube manometers shall not be used for pressures less than 0.5 in. wg (125 Pa). Pitot tubes other than standard shall be calibrated.

Temperature measurement instrumentation shall have an accuracy of ±0.5°F or ±1°C over the entire measurement range.

Humidity measurement instrumentation shall have an accuracy of ±3.0% relative humidity over the entire measurement range.
8.6.2.1 Tolerance of Test Results
Allowable variance from design conditions, or conditions determined otherwise satisfactory, shall be:

For air velocity, +10%;
For ventilation air pressure or differential pressure, +20%; For pneumatic control system air pressure, <5%; and
For electronic control system, ±2% of full-scale values.

</td></tr>
</table>

References

ANSI/ASHRAE 110-1995: "Method of Testing Performance of Laboratory Fume Hoods," Atlanta, GA, *American Society of Heating, Refrigerating and Air Conditioning Engineers*, 1995.

ANSI/AIHA Z9.5, "American National Standard for Laboratory Ventilation," *American National Standards Institute, Inc./ American Industrial Hygiene Association,* ANSI/AIHA Z9.5, 2003.

ASHRAE 1995 Handbook – HVAC Applications (Inch-Pound Edition), Atlanta, GA, *Amercian Society of Heating, Refrigerating and Air Conditioning Engineers*, 1995.

NFPA45-2000: "Standard on Fire Protection for Laboratories Using Chemicals," Quincy, MA, *National Fire Protection Association*, 2000.

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

SEFA 1-2002, "Laboratory Fume Hoods Recommended Practices," *Scientific Equipment Furniture Association*, 2002.

UNDERSTANDING, ACCELERATED

TSI Incorporated – Visit our website www.tsi.com for more information.

USA	**Tel:** +1 800 874 2811	**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		

  Printed in U.S.A.