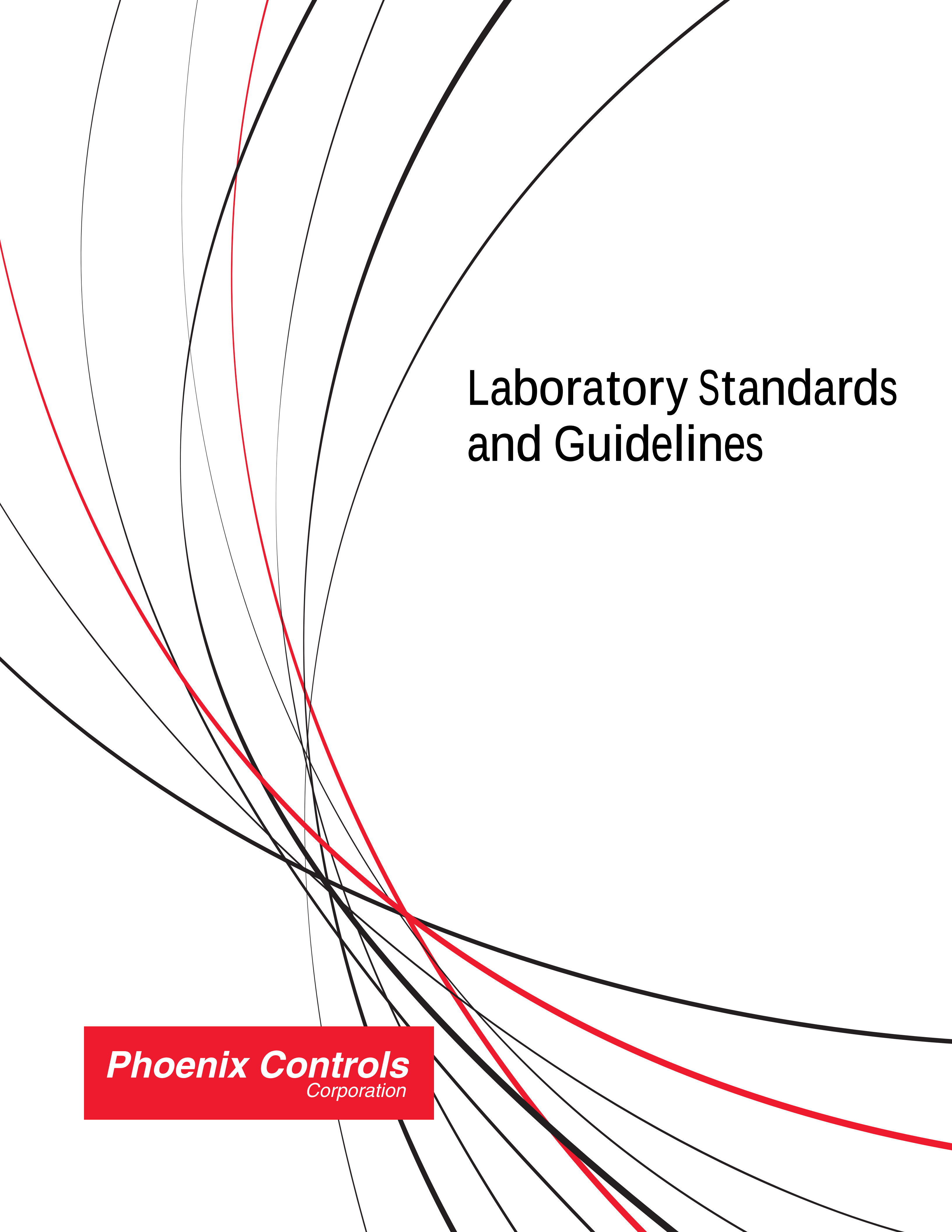

Laboratory Standards and Guidelines

Phoenix Controls
Corporation

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Laboratory Standards and Guidelines Table of Contents

Rev. 4/02

Laboratory Standards and Guidelines

Contained herein is a compilation of excerpts from many of the applicable laboratory standards and guidelines used within the industry today. The intent of this section is to provide the owner, engineers, architect, or laboratory user an overview of those standards and/or guidelines that are applicable to the design and/or use of today's laboratory. Individuals should consult all relevant local, state, and federal building codes to define what applicable standards and guidelines from this section might pertain to a particular facility.

Fume Hood Face Velocity

Federal Register—OSHA

p. 492

"(g) *Quality*...airflow into and within the hood should not be excessively turbulent; hood face velocity should be adequate (typically 60-100 lfm)."

Prudent Practices

p. 178

"In most cases, the recommended face velocity is between 80 and 100 feet per minute (fpm). Face velocities between 100 and 120 fpm may be used for substances of very high toxicity or where outside influences adversely affect hood performance. However, energy costs to operate the fume hood are directly proportional to the face velocity. Face velocities approaching or exceeding 150 fpm should not be used, because they may cause turbulence around the periphery of the sash opening and actually reduce the capture efficiency of the fume hood."

Industrial Ventilation—ACGIH

p. 10-40

"*Supply Air Distribution:* For typical operation of a laboratory hood, the worker stands at the face of the hood and manipulates the apparatus in the hood. The indraft at the hood face creates eddy currents around the worker's body which can drag contaminants in the hood along the worker's body and up to the breathing zone. The higher the face velocity, the greater the eddy currents. For this reason, higher face velocities do not result in greater protection as might be supposed."

p. 10-40

"*Selection of Hood Face Velocity:* The interaction of supply air distribution and hood face velocity makes any blanket specification of hood face velocity inappropriate. Higher hood face velocities will be wasteful of energy and may provide no better or even poorer worker protection. The ANSI/ASHRAE Hood

Performance Test may be used as a specification. The specified performance should be required of both the hood manufacturer and the designer of the room air supply system."

p. 10-41, Table 10.35.1. Laboratory Hood Ventilation Rates

Condition	cfm/ft^2 Open Hood Face
1. Ceiling panels properly located with average panel face velocity < 40 fpm. Horizontal sliding sash hoods. No equipment in hood closer than 12 inches to face of hood. Hoods located away from doors and trafficways.*	60
2. Same as 1 above; some traffic past hoods. No equipment in hoods closer than 6 inches to face of hood. Hoods located away from doors and trafficways.*	80
3. Ceiling panels properly located with average panel face velocity < 60 fpm or ceiling diffusers properly located; no diffuser immediately in front of hoods; quadrant facing hood blocked; terminal throw velocity < 60 fpm. No equipment in hood closer than 6 inches to face of hood. Hoods located away from doors or trafficways.*	80
4. Same as 3 above; some traffic past hood. No equipment in hood closer than 6 inches to face of hood.	100
5. Wall grilles are possible but not recommended for advance planning of new facilities.	

* Hoods near doors are acceptable if 1) there is a second safe egress from the room; 2) traffic past hood is low; and 3) door is normally closed.

NFPA 45

p. 45-12, section 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."

p. 45-28, section A.6.4.6

"Laboratory fume hood containment can be evaluated using the procedures contained in the 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."

ANSI/AIHA Z9.5

p. 13, section 5.7

"Each hood shall maintain an average face velocity of 80-120 fpm with no face velocity measurement more than plus or minus 20% of the average."

SEFA 1.2

p. 7, section 5.2

"A fume hood face velocity of 100 fpm is considered acceptable in standard practice. In certain situations face velocity of up to 125 fpm or as low as 75 fpm may be acceptable to meet required capture velocity of the fume hood."

Fume Hood Monitoring

Federal Register—OSHA

p. 492

"(b) *Hoods*...each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use."

Prudent Practices

p. 180

"Make sure that a continuous monitoring device for adequate hood performance is present, and check it every time the hood is used."

Industrial Ventilation—ACGIH

p. 10-45

"13. Provide adequate maintenance for the hood exhaust system and the building supply system. Use static pressure gauges on the hood throat, across any filters in the exhaust system, or other appropriate indicators to ensure flow is appropriate."

NIH Reference Materials for Design Policy and Guidelines—Mechanical

pp. D-141 to D-142, section D.16.22

"Fume hoods in new laboratory facilities shall have a pressure-independent flow-monitoring device connected to a local audiovisual alarm within the laboratory area. For existing facilities the implementation of airflow devices for fume hoods occurs during the renovation phase. When the fume exhaust falls below a preset safety level, the alarm will sound and the alarm light will come on."

Fume Hood Use

Federal Register—OSHA

p. 495

"(n) *Use of hood*:...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'."

Prudent Practices

p. 179

"In addition to protecting the laboratory worker from toxic or unpleasant agents used in them, fume hoods can provide an effective containment device for accidental spills of chemicals. There should be at least one hood for every two workers in laboratories where most work involves hazardous chemicals, and the hoods should be large enough to provide each worker with at least 2.5 linear feet of working space at the face. If this amount of hood space is not available, other types of local ventilation should be provided, and special care should be exercised to monitor and restrict the use of hazardous substances."

ANSI/AIHA Z9.5

p. 4, section 4.3

"Adequate laboratory fume hoods, special purpose hoods, or other controls shall be used when there is a likelihood of employee overexposure to air contaminants generated by a laboratory activity."

Laboratory Air Recirculation

Federal Register—OSHA

p. 492

"4. *Ventilation*...ensure that laboratory air is continually replaced, preventing increase of air concentrations of toxic substances during the working day..."

Prudent Practices

p. 192

"All air from chemical laboratories should be exhausted outdoors and not recirculated. Thus, the air pressure in chemical laboratories should be negative with respect to the rest of the building unless the laboratory is also a clean room."

ASHRAE Handbook

p. 13.9

"Laboratories in which chemicals and compressed gases are used generally require nonrecirculating or 100% outside air supply systems. The selection of 100% outside air supply systems versus return air systems should be made as part of the hazard assessment process, which is discussed in the section on Hazard Assessment. A 100% outside air system must have a very wide range of heating and cooling capacity, which requires special design and control.

Supply air systems for laboratories include both constant volume and variable volume systems that incorporate either single-duct reheat or dual-duct configurations, with distribution through low-, medium- or high-pressure ductwork."

NFPA 45

p. 45-12, section 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."

p. 45-12, section 6.4.1

"Air exhausted from laboratory hoods and other special local exhaust systems shall not be recirculated."

Industrial Ventilation—ACGIH

pp. 7-20

"*Industrial Exhaust Recirculation:* Where large amounts of air are exhausted from a room or building in order to remove particulate, gases, fumes or vapors, an equivalent amount of fresh tempered replacement air must be supplied to the room. If the amount of replacement air is large, the cost of energy to condition the air can be very high. Recirculation of the exhaust air after thorough cleaning is one method that can reduce the amount of energy consumed. Acceptance of such recirculating systems will depend on the degree of health hazard associated with the particular contaminant being exhausted as well as other safety, technical, and economic factors."

ANSI/AIHA Z9.5

p. 6, section 4.10.2

"Air exhausted from the general laboratory space (as distinguished from exhaust hoods) shall not be recirculated unless one of the following sets of criteria is met:

1) Criteria A
    a) There are no extremely dangerous or life-threatening materials used in the laboratory;
    b) The concentration of air contaminants generated by the maximum credible accident will be lower than short-term exposure limits...;
    c) The system serving the exhaust hoods is provided with installed spares, emergency power, and other reliability features as necessary.
2) Criteria B
    a) Recirculated air is treated to reduce contaminant concentrations...;
    b) Recirculated air is monitored continuously for contaminant concentrations or provided with a secondary backup air cleaning device that also serves as a monitor (i.e., a HEPA filter in a series with a less efficient filter, for particulate contamination only);
    c) Air cleaning and monitoring equipment is maintained and calibrated under a preventive maintenance program;
    d) A bypass to divert the recirculated air to atmosphere is provided."

NIH Research Laboratory Design Policy and Guidelines

p. D-16, section D.7.6

"Laboratory HVAC systems shall utilize 100% outdoor air, conditioned by central station air-handling systems to offset exhaust air requirements. Laboratory supply air shall not be recirculated or reused for other ventilation needs."

Laboratory/Building Pressurization

Federal Register—OSHA

p. 492

"4. *Ventilation*...direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building."

Prudent Practices

p. 192

"In all cases, air should flow from the offices, corridors, and support spaces into the laboratories. All air from chemical laboratories should be exhausted outdoors and not recirculated. Thus, the air pressure in chemical laboratories should be negative with respect to the rest of the building unless the laboratory is also a clean room."

ASHRAE Handbook

p. 13.12

"For the laboratory to act as a secondary confinement barrier, the air pressure in the laboratory must be maintained slightly negative with respect to adjoining areas. Exceptions are sterile facilities or clean spaces that may need to be maintained at a positive pressure with respect to adjoining spaces."

NIH Research Laboratory Design Policy and Guidelines

p. D-17, section D.7.8

"Laboratory air shall flow from low-hazard to high-hazard use areas. In general, laboratories shall be maintained at 47 L/s per module negative relative to non-laboratoy spaces. Administrative areas in laboratory building (sic) must always be positive with respect to corridors and laboratories."

NFPA 45

p. 45-12, sections 6.3.3

"Laboratory units in which chemicals are present shall be continuously ventilated."

p. 45-12, sections 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."

ANSI/AIHA Z9.5

p. 7, section 4.11.4

"As a general rule, airflow shall be from areas of low hazard, unless the laboratory is used as a Clean Room (such as Class 10 000 or better). When flow from one area to another is critical to emission and exposure control, airflow monitoring devices shall be installed to signal or alarm a malfunction.

"Air may 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 short-term exposure limits required by 4.3.

"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 airflow velocity (usually 50 to 100 fpm) through any openings; and some openings such as doors are frequently, but not always, open. Therefore, serious attempts to maintain the specified pressure differential require very complex fast-acting and expensive controls. Attempts to design for pressure differential with such controls result either in loss of pressure differential when doors are open or excessive pressure differentials when doors are closed, sufficient to affect the performance of low pressure fans.

"Relative volumes of supply air and exhaust air to each room should be such that air flows through any opening, including open doorways, at a minimum velocity of 50 fpm and a preferred velocity of 100 fpm in the desired direction."

p. 7, section 4.11.5

"Air locks (i.e., vestibules with a door at each end arranged and provided with door-closing mechanisms so that both doors are not open at the same time) may be used to minimize the volume of supply air required by 4.11.4."

p. 7, section 4.11.6

"If the direction of airflow between spaces is deemed critical, airflow monitoring devices shall be used to signal or alarm inadequate or wrong direction of airflow."

ANSI/AIHA Z9.5 (Clarification Letter)

pp. 1-3

"The intent of this paragraph was to discourage the use of a numerical pressure differential between rooms as a basis for design. Although it is true that the difference in pressure is the driving force that causes air flow through any openings from one room to another, specifying quantitative pressure differential is a poor basis for design. What is really desired is an offset air volume (defined below). Attempts to design using direct pressure differential measurement and control vs. controlling the offset volume results in either short or extended periods of the loss of pressure when the doors are open or excessive pressure differentials when doors are closed, sufficient to affect the performance of low pressure fans.

The direct pressure control systems are also hard to stabilize, and can cause building pressure problems and result in excessively large volume offsets in 'porous' rooms.

"The need to maintain directional airflow at every instant and the magnitude of airflow needed will depend on individual circumstances. For example, 'clean' rooms may have very strict requirements while teaching laboratories may only need to maintain directional airflow during certain activities or emergency conditions. In the later cases, one would simply use the appropriate offset to maintain directional airflow as needed and operational procedures during emergencies (i.e. close doors during a chemical spill)...

"The amount of offset should be based on two considerations:

(1) The airflow required to keep the room negative (or in some positive) with regard to surrounding air spaces. The 10% offset suggested in the comments may be appropriate in some cases, but has no general validity.

(2) The required 'stringency' of the requirement for direction of air flow, into or out of any openings in the walls. Is the requirement really stringent, 'we really mean it', or less stringent, 'most of the time' or 'except when a door is open'.

"If the requirement is stringent, two seldom considered factors become important. First, if there is any appreciable temperature difference between the lab and the adjoining space, when a door is opened there will be a thermal exchange of warmer air flowing in one direction at the top of the doorway, and cooler air flowing in an opposite direction near the floor. An airflow velocity of at least 50 fpm is required to inhibit this exchange under normal conditions, a flow rate of 100 fpm is more positive. For a typical 3 ft. x 7 ft. open doorway, this translates to 1050 to 2100 cfm. The volume is independent of the size of the room or the cfm of lab supply and exhaust; an arbitrary 10% 'offset' of the lab total ventilation rate is not the proper basis. If there is no airlock, and if there is a definite but not 'stringent' need for direction of airflow, this phenomenon should be made a design consideration...

"For situations less than those requiring stringent control, VAV systems should be adequate. The 'offset' volume should be based on the cfm needed to provide at least 50 fpm (100 fpm is better) through the doorway opening. The increased offset volume can be operated by a mechanical optical switch at or near the door. The volume of offset air required is not related to the ventilation rate of the laboratory.

"A secondary intent of this paragraph is to encourage the operation of laboratories with the doors closed. The 'note' was intended to demonstrate that a significant volume of air would be needed to maintain adequate directional airflow through an open door. This was not meant to be a design recommendation for airflow through open doors."

Laboratory Airflow Exchange Rates

Federal Register—OSHA

p. 492

"(f) *Performance*. Rate: 4-12 room air changes/hour is normally adequate general ventilation if local exhaust systems such as hoods are used as the primary method of control."

Prudent Practices

p. 192

"A general ventilation system that gives 6 to 12 room air changes per hour is normally adequate. More airflow may be required to cool laboratories with high internal heat loads, such as those with analytical equipment, or to service laboratories with large specific exhaust system requirements."

ASHRAE Handbook

p. 13.8

"The total airflow rate for a laboratory is dictated by one of the following:

1. Total amount of exhaust from containment and exhaust devices
2. Cooling required to offset internal heat gains
3. Minimum ventilation rate requirements...

"Minimum airflow rates are generally in the range of 6 to 10 air changes per hour when the space is occupied; however, some spaces (e.g., animal holding areas) may have minimum airflow rates established by specific standards or by internal facility policies...The maximum airflow rate for the laboratory should be reviewed to ensure that appropriate supply air delivery methods are chosen such that supply airflows do not impede the performance of the exhaust devices."

Industrial Ventilation—ACGIH

p. 7-16

"'Air changes per hour' or 'air changes per minute' is a poor basis for ventilation criteria where environmental control of hazards, heat, and/or odors is required. The required ventilation depends on the generation rate and toxicity of the contaminant not on the size of the room in which it occurs."

NFPA 45

p. 45-27, section A.6.3.3

"A minimum ventilation rate for 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."

NIH Research Laboratory Design Policy and Guidelines

p. D-18, section D.7.10

"The ventilation rate for laboratory HVAC systems is driven by three factors: fume hood demand, cooling loads, and removal of fumes and odors from the general laboratory work area. The minimum air-change rate for laboratory space is six air changes per hour regardless of space cooling load."

Manifolded Exhaust Systems

ASHRAE Handbook

p. 13.9

"Each fume hood may have its own exhaust fan, or fume hoods may be manifolded and connected to central exhaust fans…

"These can be classified as pressure-dependent or pressure-independent. **Pressure-dependent systems** are constant volume only and incorporate manually adjusted balancing dampers for each exhaust device. If an additional fume hood is added to a pressure-dependent exhaust system, the entire system must be rebalanced, and the speed of the exhaust fans may need to be adjusted. Because pressure-independent systems are more flexible, pressure-dependent systems are not common in current designs.

"A **pressure-independent system** can be constant volume, variable volume, or a mix of the two. It incorporates pressure-independent volume regulators with each device. The system offers two advantages: (1) the flexibility to add exhaust devices without having to rebalance the entire system and (2) variable volume control...

"Running many exhaust devices into the manifold of a common exhaust system offers the following benefits:

- Lower ductwork cost
- Fewer pieces of equipment to operate and maintain
- Fewer roof penetrations and exhaust stacks
- Opportunity for energy recovery
- Centralized locations for exhaust discharge
- Ability to take advantage of exhaust system diversity
- Ability to provide a redundant exhaust system by adding one spare fan per manifold"

ANSI/AIHA Z9.5

p. 21, section 7.1.1

"Exhaust ducts from two or more hoods may be connected to an exhaust manifold, frequently to avoid a multiplicity of small stacks on the roof of the building or to reduce the pipe chase space that would be required in a multi-story laboratory."

p. 21, section 7.1.4

"Unless the use of all laboratory exhaust hoods connected to a manifold can be stopped completely without creating a hazardous situation, provision should be made for continuous maintenance of adequate suction in the manifold. This requirement would be satisfied by providing

- an installed spare manifold exhaust fan that can be put into service rapidly by energizing its motor and switching a damper;
- emergency power to the manifold exhaust fans.

"Alternative methods of maintaining manifold suction, if acceptable to all parties involved, will satisfy this requirement."

Exhaust Stack Height

NFPA 45

p. 45-12, section 6.4.11

“Air exhausted from laboratory hoods and special exhaust systems shall be discharged above the roof at a location, height, and velocity sufficient to prevent re-entry of chemicals and to prevent exposures to personnel.”

p. 45-28, section A.6.4.11

“Exhaust stacks should extend at least 3 m (10 ft) above the highest point on the roof to protect personnel on the roof. Exhaust stacks might need to be much higher to dissipate effluent effectively, and studies might be necessary to determine adequate design.”

ASHRAE Handbook

p. 13.13

“Chapter 15 of the 1997 *ASHRAE Handbook—Fundamentals* describes a geometric method to determine the stack discharge height high enough above the turbulent zone around the building that little or no effluent gas impinges on air intakes of the emitting building. The technique is conservative and generally requires tall stacks that may be visually unacceptable or fail to meet building code or zoning requirements. Also, the technique does not ensure acceptable concentrations of effluents at air intakes (e.g., if there are large releases of hazardous materials or elevated intake locations on nearby buildings)...

“To increase the effective height of the exhaust stacks, both the volumetric flow and the discharge velocity can be increased to increase the discharge momentum (Momentum Flow = Density x Volumetric Flow x Velocity). The momentum of the large vertical flow in the emergent jet lifts the plume a substantial distance above the stack top, thereby reducing the physical height of the stack and making it easier to screen from view. This technique is particularly suitable when (1) many small exhaust streams can be clustered together or manifolded prior to the exhaust fan to provide the large volumetric flow and (2) outside air can be added through automatically controlled dampers to provide constant exhaust velocity under variable load. The drawbacks to the second arrangement are the amount of energy consumed to achieve the constant high velocity and the added complexity of the controls to maintain the constant flow rates. Dilution equations presented in Chapter 15 of the 1997 *ASHRAE Handbook—Fundamentals* or mathematical plume analysis (e.g., Halitsky 1989) can be used to predict the performance of this arrangement, or performance can be validated through wind tunnel testing. Current mathematical procedures tend to have a high degree of uncertainty, and the results should be judged accordingly.”

ANSI/AIHA Z9.5

p. 5, section 4.8

“Exhaust discharge from stacks shall be in accordance with the latest applicable ASHRAE standards, and it shall

- be in a vertical-up direction at a minimum of 10 feet above the adjacent roof line and so located with respect to openings and air intakes of the laboratory or adjacent buildings to avoid reentry.”

p. 6, section 4.9

"Two or more exhaust systems may be combined into a single manifold and stack..."

Exhaust Duct Velocity

Industrial Ventilation—ACGIH

p. 3-18, Table 3-2. (partial) Range of Minimum Duct Design Velocities

Nature of Contaminant	Examples	Design Velocity
Vapors, gases, smoke	All vapors, gases and smoke	Any desired velocity (economic optimum velocity usually 1000-2000 fpm)
Fumes	Welding	2000-2500
Very fine light dust	Cotton lint, wood flour, litho powder	2500-3000
Dry dusts & powders	Fine rubber dust, Bakelite molding powder dust, jute lint, cotton dust, shavings (light), soap dust, leather shavings	3000-4000

NFPA 45

p. 45-13, section 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."

ANSI/AIHA Z9.5

p. 5, section 4.8

"- have a discharge velocity of at least 3000 fpm for a stack without internal condensation; or

- have a discharge velocity of 2000 fpm or less if internal condensation might occur."

General Air Distribution Guidelines

ASHRAE Handbook

p. 13.5

"Caplan and Knutson (1977, 1978) conducted tests to determine the interactions between room air motion and fume hood capture velocities with respect to the spillage of contaminants into the room. Their tests indicated that the effect of room air currents is significant and of the same order of magnitude as the effect of the hood face velocity. Consequently, improper design and/or installation of the replacement supply air lowers the performance of the fume hood.

"Disturbance velocities at the face of the hood should be no more than one-half and preferably one-fifth the face velocity of the hood. This is an especially critical factor in designs that use low face velocities. For example, a fume hood with a face velocity of 100 fpm could tolerate a maximum disturbance velocity of 50 fpm. If the design face velocity were 60 fpm, the maximum disturbance velocity would be 30 fpm.

"To the extent possible, the fume hood should be located so that traffic flow past the hood is minimal. Also, the fume hood should be placed to avoid any air currents generated from the opening of windows and doors. To ensure the optimum placement of the fume hoods, the HVAC system designer must take an active role early in the design process."

NFPA 45

p. 45-12, section 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 detection or extinguishing systems."

p. 45-28, section A.6.3.5

"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."

Prudent Practices

p. 178

"Tracer gas containment testing of fume hoods has revealed that air currents impinging on the face of a hood at a velocity exceeding 30 to 50% of the hood face velocity will reduce the containment efficiency of the hood by causing turbulence and interfering with the laminar flow of the air entering the hood. Thirty to fifty percent of a hood face velocity of 100 fpm, for example, is 30 to 50 fpm, which represents a *very* low velocity that can be produced in many ways. The rate of 20 fpm is considered to be still air because that is the velocity at which most people first begin to sense air movement."

ANSI/AIHA Z9.5

p. 6, section 4.11.2

"Supply air distribution shall be provided to create air jet velocities less than half (preferably less than one-third) of the capture or face velocity of the exhaust hoods."

p. 12, section 5.4

"Hoods should be located more than 10 feet from any door or doorway (emergency exits excepted), and should not be located on a main traffic aisle."

Controls—Pressure-independent

ASHRAE Handbook

p. 13.9

"Airflow monitoring and pressure-independent control may be required even with constant volume systems...Because pressure-independent systems are more flexible, pressure-dependent systems are not common in current designs…(Pressure-independent) volume regulators can incorporate either direct measurement of the exhaust airflow rate or positioning of a calibrated pressure-independent air valve."

NIH Reference Materials for Design Policy and Guidelines—Mechanical

p. D-132, section D.16.17

"Exhaust air from laboratory equipment such as fume hoods and biosafety cabinets connected to a general central laboratory exhaust main is preferably connected through pressure-independent terminal units."

AIA

p. 33

"Chemical fume hood systems may be constant-volume or variable-volume types depending on user and facility management considerations of function, first cost, and life cycle cost issues. The exhaust of the hood should be provided with a pressure-independent flow-monitoring device connected to a local audiovisual alarm within the laboratory."

Controls—General

ASHRAE Handbook

p. 13.11

"Laboratory controls must regulate temperature and humidity, control and monitor laboratory safety devices that protect personnel, and control and monitor secondary safety barriers used to protect the environment outside the laboratory from laboratory operations (West 1978). Reliability, redundancy, accuracy, and monitoring are important factors in controlling the lab environment. Many laboratories require the precise control of temperature, humidity, and airflows; components of the control system must provide the necessary accuracy and corrosion resistance if they are exposed to corrosive environments.

"Laboratory controls should provide **fail-safe operation**, which should be defined jointly with the safety officer. A fault tree can be developed to evaluate the impact of the failure of a control system component and to ensure that safe conditions are maintained."

p. 13.12

"A true CAV (Constant Air Volume) system requires volume controls on the supply and exhaust systems."

p. 13.16

"Energy can be conserved in laboratories by reducing the exhaust air requirements. For example, the exhaust air requirements for fume hoods can be reduced by closing part of the hood opening during operation, thereby reducing the airflow needed to obtain the desired capture velocities (an exception is bypass hoods, which require similar quantities of exhaust air whether open or fully closed). The sash styles that may be adjusted are described in the section on Laboratory Exhaust and Containment Devices.

"Another way to reduce exhaust airflow is to use variable volume control of exhaust air through the fume hoods to reduce exhaust airflow when the fume hood sash is not fully open. A variation of this arrangement incorporates a user-initiated selection of the fume hood airflow from a minimum flow rate to a maximum flow rate when the hood is in use. Any airflow control must be integrated with the laboratory control system, described in the section on Control, and must not jeopardize the safety and function of the laboratory.

"A third energy conservation method uses night setback controls when the laboratory is unoccupied to reduce the exhaust volume to one-quarter to one-half the minimum volume required when the laboratory is occupied. Timing devices, sensors, manual override, or a combination of these can be used to set back the controls at night. If this strategy is considered, the safety and function of the laboratory must be considered, and appropriate safety officers should be consulted."

ANSI/AIHA Z9.5

p. 14, section 5.10

"Variable volume hoods also shall modulate supply air to maintain the design air balance between the laboratory and adjacent areas. The mechanism that controls the exhaust fan speed or control damper position to regulate hood exhaust volume should be designed so exhaust volume is not reduced until the sash is half-closed. Then, it is reduced in proportion with the sash closure to a minimum of 10% full-open face volume (i.e., if the exhaust volume is not reduced to zero by the control, a separate on-off switch is required)...

"If the maximum exhaust volume of variable volume hoods in one room exceeds 10% of the room air supply volume, and if the laboratory is designed for controlled airflow between laboratory and adjacent spaces, automatic flow control devices shall be provided to reduce the supply air volume by the same amount that hood exhaust volume is reduced."

ANSI/AIHA Z9.5
Clarification Letter

p. 3

"There is a statement in this section that suggests that it may be desirable to maintain constant volume through the hood with the sash at or above half opening. This enables the user to instantly attain twice the normal face velocity for unusual or more hazardous operations than normal, i.e. spills, etc. In some cases it may not be desirable. This is not intended to be a requirement.

"It may be more important to establish a minimum exhaust flow rate, i.e. as the sash is lowered below a specific sash height the hood becomes a constant volume by-pass hood. This will allow the exhaust to stay at or above the minimum desired for the space while not resulting in excessive face velocities as the sash continues to be lowered below this trigger point."

NFPA 45

p. 45-13, section 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."

p. 45-14, section 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."

p. 45-14, section 6.10.3

"Automatic file 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. The design and installation of ducts from laboratory hoods shall be in accordance with NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*, except that specific requirements in NFPA 45 shall take precedence.

"Exception No. 1: Where a gaseous fire extinguishing system is used to protect a laboratory hood, the protected laboratory hood shall be independent of all other laboratory hoods, and its exhaust system shall be permitted to be interlocked to shut down upon actuation of the fire extinguishing system.

"Exception No. 2: Where a branch duct connects to an enclosed exhaust riser located inside a shaft, which has a required fire resistance rating of 1 hour or more and in which the airflow moves upward, protection of the opening into the fire resistance rated enclosure shall be made with a steel subduct turned upward a minimum of 0.6 m (22 in.) in length and of a minimum thickness of 22 gauge [0.76 mm (0.030 in.)]. The steel subduct shall be carried up inside the riser from each inlet duct penetration. This riser shall be appropriately sized to accommodate the flow restriction created by the subduct."

p. 45-14, section 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."

p. 45-13, section 6.7.5

“Motors and their controls shall be located outside the location where flammable or combustible vapors or combustible dusts are generated or conveyed, unless specifically approved for that location and use.”

p. 45-10, section 3.6.1

“Electrical receptacles, switches, and controls shall be located so as not to be subject to liquid spills.”

AIA

p. 69

“Fire dampers shall not be provided on any fume hood system.”

Testing and Monitoring

Prudent Practices

p. 180

“All fume hoods should be tested, before they leave the manufacturer, by using ASHRAE/ANSI standard 110, Methods of Testing Performance of Laboratory Fume Hoods. The hood should pass the low- and high-volume smoke challenges with no leakage or flow reversals and have a control level of 0.05 parts per million (ppm) or less on the tracer gas test. ASHRAE/ANSI 110 testing of fume hoods after installation in their final location by trained personnel is highly recommended.”

ANSI/AIHA Z9.5

p. 10, section 4.14.5

“If practical, the exhaust flow rate from hoods shall be tested by measuring the flow in the duct by the hood throat suction method (see the *Industrial Ventilation* manual, Section 9[6]) or by a flowmeter. If a flowmeter is used, care shall be taken to ensure that the sensing element has not been compromised by chemical action or deposition of solids...

“If flow measurement in the duct is not practical, velocity at the hood face or opening shall be measured at a sufficient number of points to obtain a realistic average velocity, and multiplied by the open area in the plane of the velocity measurements to obtain the flow rate.

“If the flow rate is more than 10% different from design, corrective action shall be taken.”

pp. 10-11, section 4.14.6

“The proper direction and velocity of air movement between laboratory spaces will have different degrees of importance, varying from desirable to important to critical. The degree of importance will vary with many factors, among them the objective assessment of potential health hazard and whether the potential health effects are acute or chronic...

“The laboratory organization should establish the degree of importance of proper airflow balance as desirable, important, or critical...

"4.14.6.1 Critical air balance

"Monitoring devices shall be inspected and tested at intervals no longer than one week.

"4.14.6.2 Important air balance

"Direction and velocity of airflow shall be tested at intervals no longer than one month.

"4.14.6.3 Desirable air balance

"Direction and velocity of airflow should be tested at intervals not to exceed six months."

p. 13, section 5.6.1

"Specification and procurement of fume hoods shall be based on a performance test of the hood (or a prototype) demonstrating that the hood performance is adequate for the intended use. The recommended performance test is ANSI/ ASHRAE 110."

p. 13, section 5.6.2

"A routine performance test shall be conducted on every fume hood at least annually or whenever a significant change has been made to the operational characteristics of the system."

ASHRAE Handbook

p. 13.5

"**Fume Hood Performance Criteria**. ASHRAE *Standard* 110, Method of Testing Performance of Laboratory Fume Hoods, describes a quantitative method of determining the containment performance of a fume hood. The method requires the use of a tracer gas and instruments to measure the amount of tracer gas that enters the breathing zone of a mannequin; this simulates the containment capability of the fume hood as a researcher conducts operations in the hood.

"The following tests are commonly used to judge the performance of the fume hood: (1) face velocity test, (2) flow visualization test, (3) large volume flow visualization, (4) tracer gas test, and (5) sash movement test. These tests should be performed under the following conditions:

- Usual amount of research equipment in the hood; the room air balance set
- Doors and windows in their normal positions
- Fume hood sash set in varying positions to simulate both static and dynamic performance

"All fume hoods should be tested annually and their performance certified."

NFPA 45

p. 45-15, sections 6.13.1 to 6.13.6

“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

“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.

“Laboratory hood face velocity profile or hood exhaust air quantity shall be checked after any adjustment to the ventilation system balance.

“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.

“Fans and Motors.

“Air supply and exhaust fans, motors, and components shall be inspected at least annually.

“Where airflow detectors are not provided or airflow-rate tests are not made, fan belts shall be inspected quarterly. Frayed or broken belts shall be replaced promptly. When double sheaves and belts are employed, the inspection frequency shall be permitted to be semiannual.

“Fixed fire extinguishing systems protecting filters shall be inspected quarterly for accumulation of deposits on nozzles. Nozzles shall be cleaned as necessary.”

Work Practices

ANSI/AIHA Z9.5

pp. 12-13, section 5.5

“Many work practices might affect the overall safety and health situation in a laboratory. The following list concerns only those work practices related directly to hood performance and applies only when hazardous materials are to be used in the hood:

a) The worker shall not lean into the hood so that his/her head is inside the plane of the hood face without adequate respiratory and personal protection, except for setup work or hood maintenance;

b) Equipment in the hood should not block airflow to slots in the baffle;

c) Equipment that might be a source of emission (including in case of breakage) should not be placed closer than 6 inches from the plane of the hood face;

d) Flammable liquids should not be stored permanently in the cabinet under the hood unless that cabinet meets the requirements of ANSI/NFPA 30 and 45 for flammable liquid storage;

e) The hood sash or panels shall not be removed except for setup work without hazardous chemicals in the hood;

f) The hood sash or panels should be closed to the maximum position possible while still allowing comfortable working conditions;

g) A hood that is more than 10% below standard in exhaust volume shall not be used unless its condition is labeled and the maximum sash opening marked clearly.

“Each hood shall be posted with a notice giving the date of the last periodic field test. If the hood 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 and any other requisite precautions concerning the type of work and materials permitted or prohibited.”

Prudent Practices

p. 179

“Many factors can compromise the efficiency of a hood operation. Most of these are avoidable; thus, it is important to be aware of all behavior that can, in some way, modify the hood and its capabilities. The following should always be considered when using a hood:

- Keep fume hood exhaust fans on at all times.
- If possible, position the fume hood sash so that work is performed by extending the arms under or around the sash, placing the head in front of the sash, and keeping the glass between the worker and the chemical source. The worker views the procedure through the glass, which will act as a primary barrier if a spill, splash, or explosion should occur.
- Avoid opening and closing the fume hood sash rapidly, and avoid swift arm and body movements in front of or inside the hood. These actions may increase turbulence and reduce the effectiveness of fume hood containment.
- Place chemical sources and apparatus at least 6 inches behind the face of the hood. In some laboratories, a colored stripe is painted on, or tape applied

to, the hood work surface 6 inches back from the face to serve as a reminder. Quantitative fume hood containment tests reveal that the concentration of contaminant in the breathing zone can be 300 times higher from a source located at the front of the hood face than from a source placed at least 6 inches back. This concentration declines further as the source is moved farther toward the back of the hood.

- Place equipment as far to the back of the hood as practical without blocking the bottom baffle.
- Separate and elevate each instrument by using blocks or racks so that air can flow easily around all apparatus.
- Do not use large pieces of equipment in a hood, because they tend to cause dead spaces in the airflow and reduce the efficiency of the hood.
- If a large piece of equipment emits fumes or heat outside a fume hood, then have a special-purpose hood designed and installed to ventilate that particular device. This method of ventilation is much more efficient than placing the equipment in a fume hood, and it will consume much less air.
- Do not modify fume hoods in any way that adversely affects the hood performance. This includes adding, removing, or changing any of the fume hood components, such as baffles, sashes, airfoils, liners and exhaust connections."

Selection of Specialty Hoods

Prudent Practices

pp. 184-185

"*Auxiliary Air Hoods*

"Quantitative tracer gas testing of many auxiliary air fume hoods has revealed that, even when adjusted properly and with the supply air properly conditioned, significantly higher worker exposure to the materials used in the hood may occur than with conventional (non-auxiliary air) hoods. Auxiliary air hoods should not be purchased for new installations, and existing auxiliary air hoods should be replaced or modified to eliminate the supply air feature of the hood. This feature causes a disturbance of the velocity profile and leakage of fumes from the hood into the worker's breathing zone.

"The auxiliary air fume hood was developed in the 1970s primarily to reduce laboratory energy consumption. It is a combination of a bypass fume hood and a supply air diffuser located at the top of the sash. These hoods were intended to introduce unconditioned or tempered air, as much as 70% of the air exhausted from the hood, directly to the front of the hood. Ideally, this unconditioned air bypasses the laboratory and significantly reduces air conditioning and heating costs in the laboratory. In practice, however, many problems are caused by introducing unconditioned or slightly conditioned air above the sash, all of which may produce a loss of containment."

p. 187

"Radioisotope Hoods

"Hoods used for work with radioactive sources or materials should be designed so that they can be decontaminated completely on a regular basis. A usual feature is a one-piece, stainless steel, welded liner with smooth, coved corners, which can be cleaned easily and completely. The superstructure of radioisotope hoods is usually made stronger than that of a conventional hood in order to support lead bricks and other shielding that may be required in the hood. Special treatment of the exhaust from radioisotope hoods may be required by government agencies to prevent the release of radioactive material into the environment. This usually involves the use of high-efficiency particulate air (HEPA) filters."

ASHRAE Handbook

p. 13.4

"**Auxiliary Air** (approximately constant volume airflow with approximately constant face velocity). A plenum above the face receives air from a secondary air supply that provides partially conditioned or unconditioned outside air.

"Application: Research laboratories—frequent or continuous use. Moderate to highly hazardous processes; varying procedures.

"Note: Many organizations restrict the use of this type of hood...

"**Radioisotope.** 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 should have flanged neoprene gasketed joints with quick disconnect fasteners that can be readily dismantled for decontamination. High-efficiency particulate air (HEPA) and/or charcoal filters may be needed in the exhaust dust.

"Application: Process and research laboratories using radioactive isotopes.

"**Perchloric Acid.** 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 washdown and drainage system, and the ductwork must be constructed of smooth, impervious, cleanable materials that are resistant to acid attack. The internal washdown system must completely flush the ductwork, exhaust fan, discharge stack, and fume hood inner surfaces. The ductwork should be kept as short as possible with minimum elbows. Perchloric acid exhaust systems with longer duct runs may need a zoned washdown system to avoid water flow rates in excess of the capacity to drain the water from the hood. 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. Ducts should be constructed of a stainless steel material, with a chromium and nickel content not less than that of 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.

"*Application:* Process and research laboratories using perchloric acid. Mandatory use because of explosion hazard."

ANSI/AIHA Z9.5

p. 15, section 5.11.3

"Auxiliary supplied air hoods are not recommended unless special energy conditions or design circumstances require their use."

pp. 15-16, section 5.12

"Perchloric acid fume hoods shall meet the following provisions:

a) All surfaces of the hood shall be materials that will not react with the acid to form flammable or explosive compounds;

b) The interior surfaces of the entire hood, duct, fan, and stack surface must be equipped with water wash capabilities;

c) The ductwork shall be stainless steel with smooth-welded seams;

d) The system shall not be manifolded or joined to other nonperchloric acid exhaust systems;

e) Organic materials, including gaskets, shall not be used unless it is known they will not react with perchloric acid;

f) The hood shall be labeled 'Perchloric Acid Hood.'"

NFPA 45

p. 45-14, section 6.11.1

"Perchloric acid heated above ambient temperatures shall only be used in a laboratory hood specifically designed for its use and identified as follows:

FOR PERCHLORIC ACID OPERATIONS

"Exception: Hoods not specifically designed for use with perchloric acid shall be permitted to be used where the vapors and trapped and scrubbed before they are released into the hood."

Sound Levels in Rooms

ASHRAE Handbook

p. 46.25

"Table 34 lists design guidelines for HVAC-related background sound appropriate to various occupancies."

Table 34. (partial) Design Guidelines for HVAC-Related Background Sound in Rooms

Room Types	RC(N); QAI ≤5 dB Criterion[a,b]
Office Buildings	
Executive and private offices	25-35
Open-plan offices	30-40
Hospitals and Clinics	
Private rooms	25-35
Laboratories (with fume hoods)	
Testing/research, minimal speech communication	45-55
Research, extensive telephone use, speech communication	40-50
Group teaching	35-45

[a] The values and ranges are based on judgement and experience, not on quantitative evaluations of human reactions. They represent general limits of acceptability for typical building occupancies. Higher or lower values may be appropriate and should be based on a careful analysis of economics, space use, and user needs.

[b] When the quality of sound in the space is important, specify criteria in terms of RC(N). If the quality of sound in the space is secondary concern, the criteria may be specified in terms of NC or NCB levels of similar magnitude.

AIA

p. 37

"The typical maximum noise coefficient (NC) levels generated by HVAC systems in a laboratory is approximately NC 50 with hoods in an operating position and in the midpoint of the room. For laboratory hoods, noise levels should not exceed NC 60 at the face of the hood unless permitted by the facility safety personnel."

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