Laboratory Regulations, Standards & Guidelines

A collection of excerpts from many of the applicable laboratory standards and guidelines comprising information pertinent to the Laboratory & Fume Hood Velocity, Flow and Pressure Control Field as set forth in the industry standard documents.

The intent of this information is to provide laboratory owners , users, designers and safety officers an overview of those regulations, standards and/or guidelines which may be applicable to the design, testing, and/or use of their particular facility.

Those using this document should consult all relevant building codes to determine which sections of the information contained herein might apply to their particular facility and/or project.

Laboratory Regulations, Standards & Guidelines
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Identification and General Intent Description

ANSI/AIHA Z9.5-1992 American National Standard for Laboratory Ventilation
p. 1, paragraph 1.2, Purpose
"The purpose of this standard is to establish minimum requirements and procedures for laboratory ventilation systems that are used to prevent personnel from overexposure to harmful or potentially harmful contaminants generated within the laboratory. It does not apply to comfort or energy considerations unless they have an effect on containment control ventilation."

Federal Register, OSHA 29 CFR 1910 Subpart Z Toxic and Hazardous Substances Section 1910.1450 Occupational exposure to hazardous chemicals in laboratories
p. 291, section (a), Scope and application
" (1) This section shall apply to all employers engaged in the laboratory use of hazardous chemicals as defined below.

(2) Where this section applies, it shall supersede, for laboratories, the requirements of all other OSHA health standards in 29 CFR part 1910, subpart Z, except as follows:

(i) For any OSHA health standard, only the requirement to limit employee exposure to the specific permissible exposure limit shall apply for laboratories, unless that particular standard states otherwise or unless the conditions of paragraph (a)(2)(iii) of this section apply.

(ii) Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.

(iii) Where the action level (or in the absence of an action level, the permissible exposure limit) is routinely exceeded for an OSHA regulated substance with exposure monitoring and medical surveillance requirements, paragraphs (d) and (g)(1)(ii) of this section shall apply.

(3) This section shall not apply to:

(i) Uses of hazardous chemicals which do not meet the definition of laboratory use, and in such cases, the employer shall comply with the relevant standard in 29 CFR part 1910, subpart Z, even if such use occurs in a laboratory.

(ii) Laboratory uses of hazardous chemicals which provide no potential for employee exposure. Examples of such conditions might include:

(A) Procedures using chemically-impregnated test media such as Dip-and-Read tests where a reagent strip is dipped into the specimen to be tested and the results are interpreted by comparing the color reaction to a color chart supplied by the manufacturer of the test strip; and

(B) Commercially prepared kits such as those used in performing pregnancy tests in which all of the reagents needed to conduct the test are contained in the kit."

Industrial Ventilation, 21st Edition, A Manual of Recommended Practice, 1992
Chapter #3 Local Exhaust Hoods
p. vii, FOREWORD
"INDUSTRIAL VENTILATION: A Manual of Recommended Practice is the outgrowth of years of experience by Committee members and a compilation of research data and information on design, maintenance, and evaluation of industrial exhaust ventilation systems. The Manual attempts to present a logical method of designing and testing these systems. It has found wide acceptance as a guide for official agencies, as a standard for industrial ventilation designers, and as a textbook for industrial hygiene courses. The Manual is not intended to be used as law, but rather as a guide. Because of new information on industrial ventilation becoming available through research projects, reports from engineers, and articles in various periodicals and journals, review and revision of each section of the Manual is an ongoing Committee project. ...."

p. 3-2, paragraph 3.1, Introduction
"Local exhaust systems are designed to capture and remove process emissions prior to their escape into the workplace environment The local exhaust hood is the point of entry into the exhaust system and is defined herein to include all suction openings regardless of their physical configuration. The primary function of the hood is to create an air flow field which will effectively capture the contaminant and transport it into the hood. ...."

ASHRAE Guideline, ANSI/ASHRAE 110-1995, Method of Testing Performance of Laboratory Fume Hoods
p. 2, section #1 & #2, Purpose and Scope
"The purpose of this standard is to specify a quantitative and qualitative test method for evaluating the fume containment of a laboratory fume hood."
"2.1 This method of testing applies to conventional, bypass, auxiliary air, and VAV laboratory fume hoods.
2.2 This method of testing is intended primarily for laboratory and factory testing but may be used as an aid in evaluating installed performance."

Scientific Equipment & Furniture Association, SEFA 1.1-1994, Laboratory Fume Hoods Recommended Practices
p. 1, section #1, Scope
"1.1 This Recommended Practice is limited to the design, materials of construction, use and testing of laboratory fume hoods. It is not intended to cover related laboratory devices such as laminar flow cabinets, glove boxes or canopy hoods.
1.2 This Recommended Practice is not intended to cover other elements of a fume removal system,

such as blowers or ducts. Information on these items, as they relate to laboratory fume hood operation, is found in the Appendices.

1.3 In this Recommended Practice, a laboratory fume hood is defined as a ventilated, enclosed work space intended to capture, contain and exhaust fumes, vapors and particulate matter generated inside the enclosure. It consists basically of side, back and top enclosure panels, a floor or counter top, an access opening called the face, sash(es) and an exhaust plenum equipped with a baffle system for airflow distribution. The supporting unit(s) is (are) not covered in this standard."

p. 1, section #2, Purpose

"The purpose of this Recommended Practice is to enable manufacturers, users, and testing and evaluation agencies to determine whether a laboratory fume hood meets the performance and safety requirements given below. ***Note: Additional procedures may be necessary for testing or evaluating a complete laboratory fume removal system.***"

1995 ASHRAE Handbook, HVAC Applications

Preface

"This Handbook describes heating, ventilating, and air conditioning practices for a broad range of applications. Many chapters have been revised to reflect continued evolutionary changes and improvements in technology. These revisions reflect current requirements and design approaches. In addition, the technical committees responsible for preparing the chapters have added information or made notable revisions in the following chapters:...."

"Chapter 13, Laboratory Systems, has been reorganized for clarity and has more information on fume hoods and exhaust systems."

p. 13.1, Introduction, Chapter 13, Laboratory Systems

"Modern laboratories require the regulation of temperature, humidity, relative static pressure, air motion, air cleanliness, sound and exhaust. This chapter addresses biological, chemical, animal, and physical laboratories. Within these generic descriptions, some laboratories have their own unique requirements. This chapter provides an overview of the heating, ventilating, and air conditioning characteristics and design criteria applicable to laboratories and provides a brief overview of architectural and utility concerns. This chapter does not cover scale-up process laboratories, commonly called pilot plants, which are small manufacturing units."

NFPA 45, Fire Protection for Laboratories Using Chemicals 1991

p. 45-5, section 1-1 Scope & 1-2 Purpose, General

"1-1.1 This standard shall apply to laboratory buildings, laboratory units, and laboratory work areas in which hazardous chemicals are handled or stored.

Exception No. 1: It does not apply to laboratory work areas in laboratories that are covered by

NFPA 99, Standard for Health Care Facilities.
Exception No. 2: It does not apply to laboratories that are, in fact, pilot plants.
Exception No. 3: It does not apply to laboratories that are, in fact, primarily manufacturing plants.
Exception No. 4: It does not apply to incidental testing facilities.
Exception No. 5: It does not apply to physical, electronic, instrument, or similar laboratories that use small quantities of chemicals for incidental purposes, such as cleaning.
1-1.2 This standard contains requirements, but not all-inclusive requirements, for conducting laboratory experiments and for handling and storage of hazardous chemicals in laboratories.
Exception No. 1: It does not cover the special fire protection required when handling explosive materials. (See NFPA 495, Explosive Material Code.)
Exception No. 2: It does not cover the special fire protection required when handling radioactive material.*
1-1.3 Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard, provided technical documentation is made available to the authority having jurisdiction to demonstrate equivalency and the system, method, or device is approved for the intended purpose."
"1-2.1 This standard provides basic requirements for the protection of life and property in laboratory work areas where hazardous chemicals are handled through prevention and control of fires and explosions The unique nature of some laboratory operations may make more stringent requirements necessary.
1-2.2 This standard is designed to protect personnel from the effects of toxic, corrosive, or otherwise hazardous chemicals to which they may be exposed as a result of fire or explosion. Although it does not attempt to deal with health hazards unrelated to fires or explosions, many of the requirements to protect against fire or explosion, such as those for hood exhaust systems, also serve to protect personnel from exposure to nonfire health hazards of chemicals."

p. 45-11, section 6-1, Scope, Chapter #6 Laboratory Ventilating Systems and Hood Requirements
"6-1.1 This chapter applies to laboratory exhaust systems, including laboratory hoods, biological safety cabinets, special local exhaust devices, and other systems for exhausting air from laboratory work areas in which hazardous gases, vapors, or particulate matter may be released.
6-1.2 This chapter also contains certain requirements for laboratory air supply systems.
6-1.3 This chapter also contains requirements for labeling, inspection, and maintenance of laboratory ventilating systems and hoods."

CRC Handbook of Laboratory Safety
Comprehensive discussion of design, implementation and use of laboratory equipment, services and mechanical systems pertaining to maintenance of the best possible safety for lab users.

Prudent Practices for Handling Hazardous Chemicals in Laboratories
A manual outlining the methods for safe handling and use of chemicals in laboratories. Pertinent sections are associated with the proper use and operation of laboratory ventilation equipment.

FUME HOODS

Face Velocities

Definition

ANSI/AIHA Z9.5-1992 American National Standard for Laboratory Ventilation
p. 3, Definitions and Units, 3.8 Face Velocity
"The air velocity at the plane of and perpendicular to the opening of an exhaust hood."

Industrial Ventilation, 21st Edition, A Manual of Recommended Practice, 1992
Chapter #3 Local Exhaust Hoods
p. 3-3, Figure 3-1, Hood Nomenclature Local Exhaust
"Face Velocity - Air Velocity at the Hood Opening"

ASHRAE Guideline, ANSI/ASHRAE 110-1995, Method of Testing Performance of Laboratory Fume Hoods
p. 2, Section #3, Definitions, face velocity
"average velocity of air moving perpendicular to the hood face, usually expressed in feet per minute (fpm) or meters per second (m/s)."

Scientific Equipment & Furniture Association, SEFA 1.1-1994, Laboratory Fume Hoods Recommended Practices
p. 2, Section #3, Definitions, face velocity
"Speed of air moving past the fume hood access opening, usually expressed in feet per minute (fpm) or meters per second (mps)."

NFPA 45, Fire Protection for Laboratories Using Chemicals 1991
p. 45-12, Section 6-3, Definitions, Face Velocity
"The rate of flow or velocity of air moving into the laboratory hood entrance or face, as measured at the plane of the laboratory hood face."

Setpoints

ANSI/AIHA Z9.5
p. 13, Section 5.6.2, Periodic performance test
"...adequate face velocities range from 60 lo 120 fpm. A face velocity of 60 fpm is adequate only under near-perfect conditions (including special work practices), which would not be appropriate to specify as a general standard. If the requirements of this standard are met, a face velocity of 100 fpm should be adequate--perhaps more than adequate."

p. 13, Section 5.7, Face Velocities
"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. The user should select an appropriate average hood face velocity for each hood based on the criteria presented in the *Industrial Ventilation* manual.[6)] ...."

OSHA 1910.1450
p. 298, Section C. The Laboratory Facility, paragraph (g) Quality
"...airflow into and within the hood should not be excessively turbulent (200); hood face velocity should be adequate (typically 60-100 lfm)(200,204)."

Industrial Ventilation
p. 10-37, Table 10.35-1, Face Velocity Guidelines
"TABLE 10.35-1

Condition	**cfm/ft2 Open Hood Face**
1. Ceiling panels properly located with average panel face velocity < 40 fpm.[(10.35.2)] Horizontal sliding sash hoods. No equipment in hood closer than 12 inches to face of hood. Hoods located away from doors and traffic ways. *	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 traffic ways. *	80
3. Ceiling panels properly located with average panel face velocity < 60 fpm[(10.35.2)] 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 traffic ways.*	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.	

p. 3-17, Section 3.7, Special Hood Requirements
"....an operator must be located at an opening, such as in front of a laboratory hood, the maximum control velocity should not exceed 125 fpm. Air velocities higher than this value will create eddies in front of the operator which may pull contaminants from the hood into the operator's breathing zone."

SEFA
p. 6, Section 5.2, 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.
Note: Governmental codes, rules and regulations may require specific face velocities. 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 the required capture velocity of the fume hood."

p. 15, Appendix E, General Information, paragraph E1.2.1
"Careful selection of face velocities, 100 feet per minute (30.48 m/min) (.51 m/s) will meet most requirements. 75 to 80 feet per minute (22.9 m/min to 24.4 m/min) (.38 m/s to .41 m/s) is acceptable for some applications. Excessive velocities may actually hamper fume hood function and create hazardous conditions."

NFPA 45
p. 45-12, Section 6-5, Exhaust Air Discharge, paragraph 6-5.5
"Laboratory hood face velocities shall be sufficient to prevent the escape of contaminants generated in the hood. The hood shall provide confinement of the possible hazards and protection for personnel."

Prudent Practices
p. 200, paragraph 2
"Hoods should be evaluated before use to ensure adequate face velocity (typically 60-100 lfm) ... and the absence of excessive turbulence..."

p. 203
"If the hood and the general ventilating system are properly designed, face velocities in the range of 60-100 lfm will provide a laminar flow of air over the floor and sides of the hood. Higher face velocities (125 lfm or more), which exhaust the general laboratory air at a greater rate, are both wasteful of energy and likely to degrade hood performance by creating air turbulence at the hood face and within the hood. Such air turbulence can cause the vapors within the hood to spill out into

the general laboratory atmosphere."

p. 204
"The optimum face velocity of a hood (also called the capture velocity) will vary depending on its configuration. As noted above, too high a face velocity is likely to increase the turbulence within the hood and cause gases or vapors to spill from the hood into the room."

Monitoring Devices

ANSI/AIHA Z9.5
p. 14, Section 5.8, Flow-measuring Device
"New and remodeled hoods shall be equipped with a flow-measuring device. One popular method is the Hood Static Pressure measuring device (see the *Industrial Ventilation* manual [6]), which can be related to flow. This method measures the static suction in the exhaust duct close to the hood throat and, if there are no adjustable dampers between the hood and the measuring station, is related to the flow volume. Other methods include various exhaust volume or flow velocity sensors."

OSHA 1910.1450
p. 298, Section C. The Laboratory Facility, paragraph (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 (199); each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use (200, 209). If this is not possible work with substances of unknown toxicity should be avoided (13) or other types of local ventilation devices should be provided (199). See pp 201-206 for a discussion of hood design, construction, and evaluation."

SEFA
p. 4, Section 4, Design Requirements, paragraph 4.1.10, Low Air Flow Monitor
"When furnished, a monitoring device, by a visible or audible signal, or both shall give warning when the air flow through the hood falls outside a predetermined range."

ASHRAE Applications Handbook
p. 13.11, Hood Alarms
"Airflow indicators shall be installed on new laboratory hoods or on existing laboratory hoods, when modified."(para. 6-9.7)" a reference to NFPA 45.

NFPA 45

p.45-14, Section 6-9.7, Airflow Indicators

"Airflow indicators shall be installed on new laboratory hoods or on existing laboratory hoods, when modified."

Prudent Practices

p. 200

"...some continuous monitoring device for adequate hood performance should be present and should be checked before each hood is used."

p. 206

"After the face velocity of each hood has been measured (and the air flow balanced if necessary), each hood should be fitted with an inexpensive manometer or other pressure-measuring device (or a velocity-measuring device) to enable the user to determine that the hood is operating as it was when evaluated. This pressure measuring device should be capable of measuring pressure differences in the range of 0.1-2.0 in. of H_2O and should have the lower-pressure side connected to the duct above the hood and the higher-pressure side open to the general laboratory atmosphere."

General Hood Use

ANSI/AIHA Z9.5

p. 4 & 5, Section #4 General Requirements, Paragraph 4.3 Laboratory exhaust fume hoods

"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. The confinement and capture of an exhaust hood shall be considered adequate if, in combination with good laboratory practice, the exposure of workers resulting from use of the hoods is lower than applicable regulations, standards, and recommendations of OSHA; the U.S. Department of Labor; the Threshold Limits committee of the American Conference of Governmental Industrial Hygienists; and the American National Standards Institute."

p. 11, Section #5 Laboratory Fume Hoods, paragraph 5.2 Design and Construction features

"b) An airfoil, preferably a 90° arc with a minimum radius of 1-1/2 inches (1-inch air gap between the foil and comer of the bench), is provided at the front edge of the bench external to the sash;"

p. 12, Section #5 Laboratory Fume Hoods, paragraph 5.5 Work practices

"b) Equipment in the hood should not block air-flow 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;"

OSHA 1910.1450

p. 300, Section E Basic Rules and Procedures for Working with Chemicals, Paragraph 1 (n) Use of Hoods

"Use the hood for operations which might result in the release of toxic chemical vapors or dust. (198-9). 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 (13). Confirm adequate hood performance before use; keep hood closed at all times except when adjustments within the hood are being made (200); keep materials stored in hoods to a minimum and do not allow them to block vents or air flow (200). 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' (200)."

Industrial Ventilation

p.10-36, Section 10.35.1 Laboratory Hoods

"Several features are essential to the proper performance of the hood. The most important aspect of the hood is the aerodynamic entry characteristics. For the hood to adequately control contaminants, the entry must be smooth. This usually is achieved with an airfoil sill at the leading edge of the workbench. Often, beveled jambs at the side wall entry will improve the air flow. In many cases, good performance correlates with uniform face velocity. To achieve a uniform face velocity, many hood manufacturers provide adjustable slots in the plenum at the back of the hood. Although the adjustment will allow for unusual conditions such as large hot plates for sample digestions. inappropriate adjustment of the slots can have a detrimental effect on hood performance. [10.35.1]"

SEFA

p. 14 & 15, Appendix D, Section D2 General Operations

"D2.4 Set-ups and apparatus should be as far back from the fume hood face as possible for safety and optimum performance. A set back of six inches (15.2 cm) (152 mm) is necessary for proper fume hood operation. Avoid blocking off baffle openings."

"D2.5 Large bulky objects should not be placed directly on fume hood working surface. Block up two to three inches (5.08 cm) (50.8 mm) to (7.6 cm) (76 mm) to permit a flow of air under the object and into lower rear baffle exhaust opening."

"D2.6 Avoid rapid movement and excessive personnel passage in front of the fume hood. Air disturbances so created may draw fumes out of the hood."

"D2.7 The laboratory fume hood sash is designed to be used as a safety shield. Move vertical type sash to the lowest position that provides proper access and carry out manipulations with sash protecting head and upper body. When feasible, use horizontal sliding sash as a face and body shield."

ASHRAE Handbook 1995

p. 13.5, Fume Hood Performance

"Components of the fume hood that affect its performance include entrance conditions and intermediate posts, deep deck lip projections, baffle and slot adjustments, and service fittings near the face of the fume hood. Plain entrance edges, on either of the sides, the bottom, or on intermediate posts can produce a vena contracta within 1 in. of the surface and to a depth of 6 in. Fumes generated in this area are disturbed and may escape the hood enclosure. Airfoil shapes at the entry edges correct this condition. Correcting this defect on existing hoods may make satisfactory hoods from previously unacceptable units. Deep deck lip depressions also produce similar vena contracta. Flow from most fume hoods is controlled by horizontal slots in the back baffle. A slot at the bottom of the back baffle draws air across the working surface, another slot at the top exhausts the canopy, and a third slot is frequently located midway on the baffle. These adjustable openings regulate the flow distribution for specific applications. The openings should be set and locked by the commissioning engineer."

Prudent Practices

p. 200

"If laboratory workers are certain that adequate general laboratory ventilation will be maintained when the hoods are not running, hoods not in use should be turned off to conserve energy. If any doubt exists, however, or if toxic substances are being stored in the hood, the hood should be left on. Energy can also be conserved by the use of variable-volume hoods that modulate exhaust flow with sash position."

Performance Testing

ANSI/AIHA Z9.5

p. 13, Section 5.6 Hood performance testing, paragraph 5.6.2 Periodic performance test

"Periodic tests concerning face velocity or hood exhaust volume are valid indications of hood status provided no changes have been made in the hood structure, supply air distribution, or other factors listed above that affect hood performance. If face velocity is to be used as the periodic test, the open face of the hood shall be divided into 12 or more imaginary rectangles of approximately equal area and velocity measured with an instrument meeting the requirements of measurement (see the *Industrial Ventilation* manual, Section 9[6]). Smoke tests are valuable because they indicate the direction of airflow when the smoke plume is visible. The smoke particles are rapidly diluted to the extent they are not visible, even though there might be a significant particulate concentration in the invisible plume. Smoke tests should be used only as an indication of flow direction, and absence of visible smoke should not be interpreted as absence of smoke."

ASHRAE 110-1995

p. 10, Section #4 Instrumentation and Equipment, paragraph 4.7 Face Velocity Measuring Instruments

"Face velocity measurements shall be made with a recently calibrated mechanical or electrical anemometer. Refer to *ANSI/ASHRAE 111-1988, Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air-Conditioning, and Refrigeration Systems.*[2] The anemometer shall be capable of measuring in the range of 50 to 400 fpm (0.25 m/s to 2.0 m/s) with an accuracy of +5% of the reading."

p. 12, Section 6 Flow Visualization and Velocity Procedure

"6.2 **Face Velocity Measurements**

A 1.0 ft2 (300 mm x 300 mm) imaginary grid pattern shall be formed by equally dividing the design hood opening into vertical and horizontal dimensions. Velocity readings shall be taken with a calibrated anemometer fixed at the center of the grid spaces. The anemometer shall be held in the plane of the hood sash and perpendicular to the opening.

6.2.1 Face velocities shall be integrated over a period of at least five seconds. If an anemometer is used that measures instantaneous point velocities, a minimum of four readings shall be taken at each point.

6.2.2 Care shall be taken to stand to the side during measurement so as to affect the airflow as little as possible.

6.2.3 The average of the velocity measurements shall be calculated, and the highest and lowest readings shall be noted.

6.3 **Test Method for Variable-Air-Volume (VAV) Fume Hoods**

6.3.1 Verification shall be made that the VAV controls have been calibrated as defined by their manufacturer. This shall include calibration and adjustment of controllers, sensors, and VAV supply and exhaust boxes that are part of the system.

6.3.2 The sash shall be adjusted to 25% of the design hood opening, and the face velocity allowed to stabilize. Face velocity measurements shall be conducted as defined in 6.2 and results recorded.

6.3.3 The sash shall be adjusted to 50% of the design hood opening, and the face velocity allowed to stabilize. Face velocity measurements shall be conducted as defined in 6.2 and results recorded.

6.3.4 The sash shall be opened to the full design hood opening, and the face velocity allowed to stabilize. Face velocity measurements shall be conducted as defined in 6.2 and results recorded. All measurements shall be recorded.

6.3.5 Average face velocities for all sash positions shall be compared with design specifications.

6.4 VAV Response Test

6.4.1 For this test, an anemometer must be used that has a display update frequency of at least 1 second and an internal time constant of 0.3 seconds or less.

6.4.2 The hood sash shall be closed to 25% of the design hood opening, and the velocity probe mounted in a secure stand with the probe in the center of this opening. The probe shall be properly oriented to detect velocity perpendicular to the plane of the hood face. The face velocity shall be allowed to stabilize.

6.4.3 The sash shall be fully opened in a smooth motion at a velocity between 1.0 ft/s (0.3 m/s) and 1.5 ft/s (0.5 m/s). Note: The tester shall stand to the side of the hood while opening the sash. On larger hoods, a tester on either side may be required. 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."

SEFA

p. 7, Section 6.4 Performance Tests

"6.4.2 **Test Procedure.** The following test should be performed in the order listed:

"6.4.2.1 **Room Conditions.** After the fume hood is installed, and with make-up air being introduced into the room, check room condition in front of the fume hood using a thermal anemometer and a cotton swab dipped in titanium tetrachloride to verify that the velocity of cross drafts does not exceed 20 feet per minute (6.1 m/min) (.10 m/s), or 20 percent of the average fume hood velocity, whichever is greater. Any cross drafts that exceed these values shall be eliminated before proceeding with hood test.

Caution: Titanium tetrachloride fumes are toxic and corrosive; use sparingly, avoid inhalation and exposure to body, clothing and equipment that might be affected by corrosive fumes."

"6.4.2.2 **Face Velocity.** With the sash(es) in the appropriate position (as indicated below). turn on the exhaust blower and adjust to the proper face velocity for the class of fume hood being tested. (See Section 5 2.) The face velocity shall be determined by averaging readings taken at the fume hood face. Readings shall be taken at the center of a grid made up of sections of equal area, as shown in the diagrams. (see Figures 1 through 5 on page 18 for grid design). Readings shall conform to criteria stated in Section 5.2."

Note: SEFA no longer classifies hoods by use in this Recommended Practice, the reference above is carried over from an older documented. Also, the reference to figures 1 through 5 for sampling grid design should indicate page 20 of the Recommended Practice, the reference to page 18 is also carried over from an older document.

"6.4.2.2.1 Bench-mounted hoods with vertical rising sash(es) shall be rated and tested with all sashes in full open position.

6.4.2.2.2 Walk-in or distillation hoods with vertical rising sash(es) shall be rated and tested with one sash in the full open position.

6.4.2.2.3 Fume Hoods with horizontal sliding sash(es) shall be rated and tested with sash(es) in the maximum open position."

ASHRAE Handbook 1995
p. 13.5, Fume Hood Performance Criteria
"*Face Velocity Test*
The desired face velocity should be determined by the facility safety officer and researcher. The velocity is a balance between safe operation of the fume hood, airflow needed for the hood operation, and energy costs. Face velocity measurements are taken on a vertical/horizontal grid, with each measurement point representing not more than 1 ft^2. The measurements should be taken with a device that is accurate in the intended operating range, and an instrument holder should be used to improve accuracy. Computerized multi-point grid measurement devices provide the greatest accuracy."

LABORATORIES

Air Recirculation

ANSI/AIHA Z9.5
p.6, Section 4.10.2 General room exhaust
"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 required by 4.3;
   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 to those specified in 4.3;
   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.

NOTE - Many laboratories, especially those handling high-hazard materials, have a sufficient number of exhaust hoods so that the entire flow of supply air to the room necessary for air conditioning is removed through exhaust hoods (in other words, there is no surplus supply to be exhausted or recirculated.)"

p.6, Section 4.10.3, Exhaust hood air

"For most laboratories recirculation of exhaust hood air should be avoided. Exhaust 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.

Some single purpose laboratories might find it practical to recirculate exhaust hood air; the requirements are similar to those in 4.10.2 Criteria B."

OSHA 1910.1450

p. 297, Section C The Laboratory Facility, paragraph 4 Ventilation

"(a) General laboratory ventilation. This system should: Provide a source of air for breathing and for input to local ventilation devices (199); it should not be relied on for protection from toxic substances released into the laboratory (198); ensure that laboratory air is continually replaced, preventing increase of air concentrations of toxic substances during the working day (194); direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building (194)."

Industrial Ventilation

p. 7-15, Recirculation of Air from Industrial Exhaust Systems

"Where large amounts of air are exhausted from a room or building in order to remove particulates, 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...."

SEFA

p. 13, Appendix B, Section B5 Make-up Air, paragraph B5.5

"Due to the possibility of toxic and/or hazardous material being handled within the laboratories, air exhausted from these laboratories should not be recirculated"

ASHRAE Handbook 1995

p. 13.11, Recirculation

""Air exhausted from laboratory hoods or other special local exhaust systems shall not be recirculated." (para.6-5.1)" Excerpt from NFPA 45

NFPA 45

p. 45-12, Section 6-5 Exhaust Air Discharge

"6-5.1* Air exhausted from laboratory hoods and other special local exhaust systems shall not be recirculated.

6-5.2 If energy conservation devices are used, they shall not recirculate laboratory exhaust air or otherwise compromise the safety of the laboratory hood. Energy conservation devices designed to recover latent heat shall not be used in laboratory hood exhaust systems that could contain flammable or toxic chemicals because of the risk of returning contaminants to the fresh air supply.

6-5.3 Air exhausted from laboratory work areas shall not pass unducted through other areas.

6-5.4* Air from laboratory units and laboratory work areas in which hazardous 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 building."

CRC Handbook of Laboratory Safety

p. 104

"Active laboratory areas should be provided with 100% fresh air. No air should be recirculated. There are laboratories for which this would not necessarily be essential, but ... the character of research conducted in a given space may change."

Prudent Practices

p. 194

"All air from laboratories should be exhausted outdoors and not recycled."

<u>Air Change Rates</u>

OSHA 1910.1450

p. 298, Section C The Laboratory Facility, paragraph 4 Ventilation

"(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 (194)"

Industrial Ventilation
p. 7-5, Section 7.6 Air Changes
"Number of air changes per minute or per hour" is the ratio of the ventilation rate (per minute or per hour) to the room volume. "Air changes per hour" or "air changes per minute" is a poor basis for ventilation criteria where environmental control or hazards, heat, and/or odors is required. The required ventilation depends on the problem, not on the size of the room in which it occurs. For example, let us assume a situation where 11,650 cfm would be require to control solvent vapors by dilution. The operation may be conducted in either of two rooms, but in either case, 11,650 cfm is the required ventilation . The " air changes, " however would be quite different for the two rooms, as can be seen in Table 7-3. As can be seen, for the same "air change" rate, a high ceiling space will require more ventilation than a low ceiling space of the same floor area. Thus, there is little relationship between "air changes" and the required contaminant control.

TABLE 7-3 Air Exchanges Vs. Room Size

Room Size	Room ft3	Air Changes/Minute	Air Changes/Hour
40 x 40 x 12 high	19200	11,650/19200=0.61	36
40 x 40 x 20 high	32000	11,650/32000=0.364	22

ASHRAE Handbook 1995
p. 13.8, Laboratory Ventilation Systems
"Minimum ventilation rates are generally in the range of 6 to 10 air changes per hour when occupied; however, some spaces (e.g. animal holding areas) 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."

Handbook of Laboratory Safety
p. 76
"**Laboratory Class Characteristics.** In the following four sections, oriented primarily toward chemistry laboratories, the reader already familiar with laboratory classification guidelines established by the Centers for Disease Control will note that, in many respects, the recommendations for low, moderate, substantial, and high risk categories closely parallel those for biosafety levels 1 to 4."

p. 76, p. 78
"**Low-Risk Facility.** Normal building ventilation is sufficient. However, it is recommended that 6 air changes per hour of 100% fresh air be provided as standard."

p. 80, p. 84
"**Moderate-Risk Facility.** Six air changes per hour of 100% fresh air shall be supplied to the facility. No air shall be recirculated."

p. 85, p. 90
"**Substantial-Risk Facility.** At least six air changes per hour of 100% fresh air shall be supplied to the facility. No air shall be recirculated."

p. 105
"In the absence of specific requirements, there are guidelines. The book, *Prudent Practices for Handling Hazardous Chemicals in Laboratories*, recommends between 4 to 12 air changes per hour. Guidelines for animal care facilities recommend between 10 to 20. Storage facilities used for flammables are required by OSHA to have six air changes per hour."

Prudent Practices
p. 194
"Provided that auxiliary local exhaust systems ... are available and are used as the primary method of controlling concentrations of airborne substances, a ventilation system that changes the room air 4-12 times per hour is normally adequate."

Space Pressure

ANSI/AIHA Z9.5
p.7, Section 4.11.4 Differential pressure and airflow between rooms
"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 without such controls result either in loss of the 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.

NOTE - When an ordinary 3 ft. x 7 ft. door (21 sq. ft.) is open, under the above conditions the airflow through the door would be from 1050 to 2100 cfm and the differential pressure about 0.0001 to 0.002 in.w.g. If the commonly specified differential pressure of 0.1 in.w.g. actually was maintained, the air velocity through the door would be about 760 fpm, or 16,000 cfm. At air velocities below 50 fpm, a small temperature difference between rooms will cause cold air to flow one way through the bottom of the opening and warm air the other way through the top."

OSHA 1910.1450

p. 297, Section C The Laboratory Facility, paragraph 4 Ventilation

"...direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building (194)."

SEFA

p. 13, Appendix B, Section B5 Make-up Air, paragraph B5.6

"Laboratories using chemicals should operate at a slight negative pressure as compared to the remainder of the building."

ASHRAE Handbook 1995

p. 13.11, Room Pressure Control

" In order for the laboratory to act as a secondary confinement barrier (see Chapter 25 for example of secondary confinement), 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. The common methods of room pressure control include manual balancing, direct pressure, flow tracking, and cascade control. All methods modulate the same control variable--supply airflow rate; however, each method measures a different variable."

NFPA 45

p. 45-12, section 6-4 Supply Systems, paragraph 6-4.2

"Laboratory units and laboratory work areas in which hazardous chemicals are present shall maintain a continuous airflow at an air pressure that is negative relative to the corridors or adjacent nonlaboratory areas.

Exception No. 1: Where operations such as those requiring clean rooms preclude a negative pressure relative to surrounding areas, special precautions shall be taken to prevent escape of the atmosphere in the laboratory work area or unit to the surrounding spaces.

Exception No. 2: Laboratory work areas in which not more than one liter of flammable liquids or not more than 30 standard cu ft (0.85 m^3) of liquefied flammable gas or compressed flammable gas are used are excluded from this requirement."

p. 45-23, Appendix A, paragraph A-6-4.2

"The overall building pressure should be positive to the outside atmosphere to prevent infiltration of unconditioned air into the building. This also ensures a positive flow of air through hoods and their ducts in event of exhaust fan failure. If a positive pressure cannot be maintained, the exhaust fans should be run continuously. Air conservation can be obtained by the use of multispeed fans that can be operated at low speed when the hood is not in use or by two-position dampers that reduce the airflow. Gravity-operated dampers can become inoperative due to corrosion and should not be used. Positive shutoff power-operated dampers are subject to malfunction and also are not recommended. If used, they should be of a type that will fail open if malfunction does occur *(see 6-11.3)*."

"Where conditions of use allow the recirculation of room air, provisions should be made to change immediately from recirculation to full exhaust in the event of a spill or release of dangerous quantities of toxic or flammable materials."

Handbook of Laboratory Safety

p. 108

"If there are administrative, classroom, or service areas within the same building as laboratories, the entire laboratory area should be at a modest negative pressure with respect to these spaces so that any airflow that exists will be from the nonresearch areas into the space occupied by laboratories."

p. 108

". . .the design of the air exhaust system from a laboratory must be done carefully to provide continuing replacement of fresh air in the room. The fume hood system and the supplementary exhaust system should be interlocked so as to insure a stable room air balance at all times."

Prudent Practices

p. 194

"In all cases, the movement of air in the general (laboratory) ventilation system for a building should be from the offices, corridors, and such into the laboratories. All air from laboratories should be exhausted outdoors and not recycled. Thus, the air pressure in the laboratories should always be negative with respect to the rest of the building."

Thermal Control

ASHRAE Handbook 1995

p. 13.11, Thermal Control

"The temperature in laboratories with a constant volume air supply is generally regulated with a thermostat that controls the position of a control valve on a reheat coil, thereby regulating the supply air temperature. Laboratories with a variable volume ventilation system, in addition to regulating the supply air temperature and volume, generally regulate room exhaust device(s) as well, the general room exhaust device(s) are modulated to provide greater airflow in the laboratory when additional cooling is needed. The exhaust device(s) potentially determine the total supply air quantity for that laboratory.

Most microprocessor-based laboratory control systems are able to use proportional-integral-derivative (PID) algorithms to eliminate the error between the measured temperature and the temperature set point. The use of anticipatory control strategies (Marsh 1988) increases accuracy in the regulation of laboratory temperatures. Anticipatory control strategies recognize the increased reheat requirements associated with changes in the ventilation flow rates and make adjustments in the position of reheat control valves prior to space temperature changes measured by the thermostat."

Air Distribution

ANSI/AIHA Z9.5

p. 6, Section 4.11 Supply Air, paragraph 4.11.2 Supply Air Distribution

"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 5.3 Supply Air Distribution

"Proper distribution of room air supply is as important--perhaps more important than hood face velocity and refinements of design. Air supply systems for rooms containing chemical fume hoods shall not create room airdrafts at the face of any hood greater than half the face velocity of the hood."

SEFA

p. 5 & 6, Section 5 Face Velocity, paragraph 5.1.1 Room Conditions That Prevail in the Area Where the Fume Hood Is To Be Installed.

"Cross drafts, created by the room ventilation system or from an open window or corridor, if located adjacent to the hood, can drastically disturb the flow of air entering the fume hood face and even cause a reverse flow of air out of the front of the fume hood. Room conditions such as these should be avoided, if at all possible, by the location of the fume hood or modifying the hood exhaust system so an appropriate increase in face velocity can be made to overcome their effect. In no case should the velocity of the cross drafts exceed 20 percent of the fume hood face velocity."

p. Appendix A, Section A1 Room Cross Drafts

"A1.1 Air moving through an open door located adjacent to the fume hood can cause cross drafts."
"A1.2 An open window or a room air supply grill located to one side or across from the fume hood can cause disturbing cross drafts."
"A1.3 High velocity air from ceiling-mounted diffusers can cause a flow of air down and into the top half of the fume hood face that can cause reverse flows of air out of the bottom half of the face."

ASHRAE Handbook 1995

p. 13.9 Supply Air Distribution

"Air supplied to a laboratory must keep temperature gradients and air currents to minimum, Air outlets (preferably nonaspirating diffusers) must not discharge into the face of a fume hood. Acceptable room air velocities ate covered in the section on Fume Hoods and Biological Safety Cabinets."

p. 13.5 Fume Hood Performance

"Air currents external to the fume hood can jeopardize the fume hood's effectiveness and expose the researcher to materials used in the hood. Detrimental air currents can be produced by the following:

· Air supply distribution patterns in the laboratory
· Movements of the researcher
· People walking past the fume hood
· Thermal convection
· Opening of doors and windows

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. Test conclusions 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 air supply negatively affects the performance of the fume hood.

Terminal air supply at the face of the hood should be no more than one half and, preferably, one fifth the face velocity of the hood. This becomes an especially critical factor in designs that use low face velocities. As an 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 is 60 fpm, the maximum disturbance velocity would be reduced to 30 fpm.

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

Laboratory Exhaust Systems

Stack Heights

ANSI/AIHA Z9.5

p. 5, Section 4.7 Exhaust discharge

"The discharge of air that is (or might be) contaminated to 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 (4.10);

- in compliance with applicable federal, state or local regulations with respect to air emissions.

  NOTE--The in-stack concentrations of contaminants allowed under such regulations typically range from 100 to 1000 times higher than safe breathing concentrations.

- discharged in a manner and location to avoid reentry into the laboratory building or adjacent buildings at concentrations above 20% of the allowable concentrations inside the laboratory under any wind or atmospheric conditions (see the American Society of Heating, Refrigerating, and Air Conditioning Engineers' 1989 *Fundamentals* handbook, Chapter 1 4[7]).

p. 5, Section 4.8 Exhaust stack discharge

"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. (For technical information, see Chapter 14 of the 1989 *fundamentals* handbook.[7]); and

- 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.

Aesthetic considerations concerning external appearance of the building shall not be allowed to overcome the requirements of 4.7 and 4.8. In case those requirements conflict, the conflict should be solved in a manner that preserves the intent of 4.8. Some solutions that may be used are:

- architectural structures to mask the un-wanted appearance of the stack, as long as the stack extends vertically one stack diameter or more above the masking structure and otherwise meets the requirements of 4.8;

- treatment of the discharge gas so that a lower and aesthetically acceptable stack meets the stack requirements;

- treatment of the discharge gas so its quality is acceptable for return air to the laboratory.

NOTE - The technology of gas-treating equipment is not within the scope of this standard, except as set forth in 4.12 2."

Industrial Ventilation
p. 5-28, Section 5.16 Exhaust Stack Outlets
"The type and location of exhaust stacks are important to permit good dispersion of contaminated air from exhaust systems even when an efficient air cleaner is used. Poor discharge conditions result in low level contamination which can re-enter the building due to wind effect (building turbulence), negative pressure, or the action of mechanical air supply systems."
"Whenever there is doubt about the proper height and location of outlets, simple observations and tests with smoke candles will be helpful in determining the air flow pattern across the building roof."

ASHRAE Handbook 1995
p. 13.12, Stack/Air Intake Separation
"Separation of the stack discharge and air intake locations allows the atmosphere to dilute the effluent. Separation with the use of short to medium height stacks is simple to apply; however, to achieve adequate atmospheric dilution of the effluent, greater distances than are physically possible may be required and the building roof near the stack will be exposed to higher concentrations of the effluent."

p. 13.12, Stack Height
"Chapter 14 of the 1993 *ASHRAE Handbook - Fundamentals* describes a technique to determine the discharge height of a stack sufficiently above the turbulent zone around the building so that little or no effluent gas impinges on air intakes of the emitting building. The technique is conservative and generally requires tall slacks that may be visually unacceptable, or may not 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). *Note:* NFPA *Standard* 45 requires a minimum 7 ft stack height and ANSI/AIHA *Standard* Z 9.5 requires a minimum 10 ft stack height.

To increase the effective height of the exhaust stacks, both the volumetric flow and discharge velocity can be increased to increase the discharge momentum (Momentum Flow = Density x Volume 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 stack height and making it easier to screen from view."

NFPA 45
p. 45-13, Section 6-8 Exhausters (Fans), Controls, Velocities, and Discharge, paragraph 6-8.7
"Air exhausted from laboratory hoods and special exhaust systems shall be discharged above the roof at a location, height, and velocity sufficient to prevent reentry of hazardous chemicals."

p.45-24, Appendix A, paragraph A-6-8.7
"Exhaust stacks should extend at least 7 ft (2.14 m) above the roof to protect personnel on the roof. Exhaust stacks may need to be much higher to dissipate effluent effectively, and studies may be necessary to determine adequate design."

Handbook of Laboratory Safety
p. 109
"The exhausts from the building should discharge fumes outside the building 'envelope', i.e., the air volume surrounding the building where air may be recaptured. Physically, this can be done with tall, individual hood exhaust ducts or the exhausts from individual hoods can be brought to a common plenum and discharged through a common tall stack. The needed height of individual stacks often make this alternative a physically unattractive concept. Two 'rules of thumb' are employed to estimate needed heights. For one- or two-story buildings, the stack height above the roof should be about 1.5 times the building height. For taller buildings, this rule would lead to very high stacks, so a height equal to 0.5 times the building's width is often used in such cases."

p. 109

"In the former case, if it is desired to have the air escape from the vicinity of a building, inverted weather caps above duct outlets clearly should not be used since they would direct the air back toward the building. Updraft exhaust ducts with no weather caps are preferable, in which the outlets narrow to form a nozzle, thereby increasing the exit velocity. Since the exhaust air has a vertical velocity, it will initially continue to move upward, so the effective height of the duct will be higher than physical height. The gain in the effective height will depend upon a number of factors, viz.., the duct outlet diameter, d; the exit velocity of the gas, v; the mean wind speed, u; the temperature difference between the exhaust gas and outside air temperature ΔT; and the absolute temperature of the gas, T. The effective height gain is given by:

$$\text{Height gain} = d[v/u]\ 1.4\ [1 + \Delta T/T]$$

For simplicity's sake, assume that the indoor and outdoor temperatures are the same. For a duct diameter of 8 in., a nozzle velocity of 4900 fpm, and a mean wind speed of 700 fpm (equal to the annual average of approximately 8 mph at the site ...) the height gain would be about 10 ft. Under some weather conditions, the plume would continue to rise, while under others, it would fall. In gusty wind, it could be blown back down upon the building roof. In any case, the effective height above the roof of about 13 ft. (duct height plus height gain) would be helpful in reducing the amount recaptured by the building and obviously is far better than the alternative using weather caps, where the fumes are directed down toward the roof.

An examination of the equation used to determine height gain shows that, if the exit velocity could be maintained, it would be advantageous to have a larger duct diameter.

For example, if several hoods could be brought to a common final exhaust duct, 2 ft. in diameter, so that the exit velocity remained the same, the net gain would be 30 ft. instead of 10 ft., and it would be more acceptable to have a single tall chimney rather than a forest of exhaust stacks. With this arrangement, it would be possible to be reasonably certain that the fumes would not return to the level of the air intake until the plume left the vicinity of the building."

Exhaust Duct Velocities

SEFA

p. 12, Appendix B, Section B3 Duct System Design, paragraph B3.2

"In order to minimize static pressure loss and blower power consumption within a duct system, fume hood ducts should be of a sufficient size to permit the rated flow of air through the duct at a velocity no greater than 2000 feet per minute (609.6 m/min) (10.16 m/s).

Note: The static pressure loss of the duct system is proportional to the square of the velocity of the air through the duct. The higher the air velocity, the greater the static pressure loss that occurs. Duct velocities in excess of 2000 feet per minute (609.6 m/min) (10.16 m/s) should also be avoided for acoustical reasons and to conserve energy. Duct velocities in excess of 2000 feet per minute (609.6 m/min) (10.16 m/s) may be used if resulting increases in sound levels, static pressure and blower power requirements are acceptable."

Industrial Ventilation
p. 3-18, Table 3-2

TABLE 3-2 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 and powders	Fine rubber dust, Bakelite moulding powder dust, jute lint, cotton dust, shavings (light), soap dust, leather shavings	3000-4000
Average industrial dust	Grinding dust, buffing lint (dry), wool jute dust (shaker waste), coffee beans, shoe dust, granite dust, silica flour, general material handling, brick cutting, clay dust, foundry (general), limestone dust, packaging and weighing asbestos dust in textile industries	3500-4000
Heavy dusts	Sawdust (heavy and wet), metal turnings, foundry tumbling barrels and shake-out, sand blast dust, wood blocks, hog waste, brass turnings, cast iron boring dust, lead dust	4000-4500
Heavy or moist	Lead dusts with small chips, moist cement dust, asbestos chunks from transite pipe cutting machines, buffing lint (sticky), quick-line dust	4500 and up

NFPA 45

p. 45-13, Section 6.7 Duct Velocities

"Duct velocities of laboratory exhaust systems shall be high enough to minimize the deposition of materials in the exhaust systems"

Controls

ANSI/AIHA Z9.5

p. 10, paragraph 4.14.1.4 Fire dampers

"Fire dampers shall not be used in laboratory hood exhaust systems (ANSI/NFPA 45)"

NFPA 45

p. 45-13, Section 6-6.7

"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 assure continuous draft."

p. 45-14, Section 6-11.1

"Automatic fire protection systems shall not be required in laboratory hoods."

p. 45-14, Section 6-11.3

"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."

p. 45-13, Section 6-8.5

"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 the location and use."

p. 45-9, Section 3-6 Electrical Installation, paragraph 3-6.1

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

ASHRAE Handbook 1995

p. 13.11, Controls

"Laboratory control systems must suitably regulate the environment. Controls 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. In addition, components of the control system must provide the necessary accuracy and corrosion resistance if they are exposed to corrosive environments.

Controls for the laboratory 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 any failure of a control system component and to ensure that safe conditions are maintained."

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