

NFPA®

45

**Standard on
Fire Protection for
Laboratories
Using Chemicals**

2019



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NFPA® 45

Standard on

Fire Protection for Laboratories Using Chemicals

2019 Edition

This edition of NFPA 45, *Standard on Fire Protection for Laboratories Using Chemicals*, was prepared by the Technical Committee on Laboratories Using Chemicals. It was issued by the Standards Council on November 5, 2018, with an effective date of November 25, 2018, and supersedes all previous editions.

This edition of NFPA 45 was approved as an American National Standard on November 25, 2018.

Origin and Development of NFPA 45

The first edition of NFPA 45 was developed by the Technical Committee on Chemistry Laboratories. It was tentatively adopted at the 1974 NFPA Annual Meeting and was officially adopted at the 1975 NFPA Fall Meeting. The committee wishes to acknowledge that NFPA 45 is due in large part to the leadership and efforts of the late Russell H. Scott, who served as chairman of the committee during the planning and drafting stages of the first edition of NFPA 45. After the document had been in use for two years, the technical committee began an exhaustive review of the text; amendments were adopted for the 1982, 1986, and 1991 editions.

The 1996 edition of NFPA 45 included clarification on the scope and application of the standard as it applied to various types of educational, industrial, and medical laboratory facilities. Clarification of objectives was made to ensure a fire is contained to the room of origin. The requirements for maximum quantities of flammable and combustible liquids, construction, and fire protection in laboratory units were separated into two tables, one for sprinklered laboratory units and the other for nonsprinklered laboratory units. In addition, the committee revised the fire hazard classifications to recognize that clinical laboratories were using this standard as directed by NFPA 99, *Standard for Health Care Facilities*, and to identify that NFPA 101®, *Life Safety Code*®, no longer addresses laboratory occupancies.

The 2000 edition of NFPA 45 included modified laboratory separation requirements, and nonsprinklered laboratories of Class A or B and Class C [over 929 m² (10,000 ft²)] were prohibited. Expanded requirements and advisory information for compressed and liquefied gases were added. Additional changes included modified laboratory ventilating systems and hood requirements. Average face velocity is used to determine the safe operating levels for hood exhaust systems. Changes were made to address the current industry trend in the utilization of variable air volume (VAV) laboratory ventilation systems, which provide clear requirements for the containment of contaminants within the hood. The language was clarified regarding multiple or manifold exhaust ducts within buildings.

The 2004 edition of NFPA 45 included a new requirement that all new laboratories must be protected with automatic extinguishing systems. Pressurized liquid dispensing containers not previously recognized but indirectly prohibited because of quantity restrictions were defined, addressed, and regulated. Clarification of the scope was provided for labs containing the minimum quantity of either flammable and combustible liquids or gas that would qualify the lab for coverage under NFPA 45. Clarification was also made that the minimum quantity of gas does not include low-pressure utility gas in accordance with NFPA 54, *National Fuel Gas Code*.

The 2004 edition included expanded advisory material on biological safety cabinets and recognition of listed Class II, Type B2 biological safety cabinets in lieu of chemical fume hoods under certain circumstances. All flammable and combustible liquids requirements were consolidated into one chapter. Requirements were incorporated to limit hazchem storage spill scenarios to less than 20 L (5 gal). Expanded requirements and advisory information were created for compressed and liquefied gases. Maximum quantity requirements were clarified for outside cylinder storage.

The 2011 edition of NFPA 45 included major modifications to Chapters 4, 5, 9, 10, and 11 to modify the design, construction, and operational requirements for laboratories located in buildings over 1 story in height. Height restrictions were added for Class A and B laboratory units. The fire resistance rating of laboratory units, height restrictions, and quantities of hazardous materials were modified for laboratory units depending upon the height of the building containing the laboratories. Laboratories located in health care facilities previously covered by NFPA 99 were added to NFPA 45. Hazardous materials in storage or use in a laboratory work area that could present an explosion hazard were quantified. Requirements for the management of time-sensitive chemicals were clarified.

The 2015 edition of NFPA 45 included a new chapter on educational and instructional laboratories. The standard applies to all educational and instructional laboratories, independent of the quantity of chemicals present. Requirements for Class A, B, C, and D laboratory units permitted below grade were clarified in Chapter 5, and requirements for fire-retardant clothing, inert atmosphere glove boxes, handling pyrophoric reagents and water reactive materials, and open flame operations were added in Chapters 6, 7, and 11. Supplementary information on laboratory units was expanded to provide additional guidance. Because explosion hazard protection is no longer within the scope of NFPA 45, the chapter by that title was removed and the information was relocated to Annex C.

The 2019 edition of NFPA 45 adds definitions for *use*, *closed system use*, and *open system use* as the terms are found throughout the standard. The 2019 edition also incorporates requirements for laboratory units in health care facilities, particularly flammable and combustible liquid quantity limitations; lab unit classifications; fire separation; and specific provisions for distillation and solvent recycling equipment and tissue processors. Area limitations for lab units have been removed, because the quantity of flammable liquids is limited by the volume and density limits. Language has been revised to clarify that curbing of laboratory floors can be used to prevent liquids from migrating to lower floor levels, and new annex text has been added to list other preventative means. Requirements for exit doors have been revised to clarify that the methods need to also comply with NFPA 101 egress requirements. The section on emergency lighting has been revised to require emergency lighting in all laboratory work areas, not only those that require a second means of access to an exit. Requirements for Class I wet standpipe systems have been clarified, and requirements for manual fire alarm systems have been revised to include all buildings with laboratory units. Terminology related to flame-resistant clothing has been revised to align with NFPA 2112. Requirements for laboratory exhaust systems have been expanded to prohibit sound attenuation devices within them. Laboratory exhaust ducts, dampers, and exhaust ducting through fire barriers has been addressed to clarify the installation of exhaust ducts through fire-rated barriers and to align with the current editions of NFPA 90A and 91. Inspection, testing, and maintenance of fire-extinguishing systems in ductwork or chemical fume hoods has been revised from a specified time interval to a schedule appropriate for the type of system. A new retroactivity clause has been added to clarify that the chapter on chemical storage, handling, and waste disposal contains operational requirements that need to be applied to existing laboratories, not only new construction. Hazardous chemical containers stored and handled in laboratory work areas are now limited to 20 L (5 gal), where previous language about limiting spill scenarios was ambiguous. A minimum inspection frequency of 1 year has been added for chemical storage. Annex material has been added to reinforce the need to evaluate the effects of any mixing of wastes, to clarify the process of dispensing Class I liquids in a ventilated area, to explain why pyrophoric reagents and water-reactive materials in glove boxes need to be sealed in airtight containers when not in use, to describe flame-jetting hazards, and to explain the need for hazard evaluations and risk assessments before new or changed experiments. Language has been added to reference NFPA 30 for quantities of flammable and combustible liquids within inside liquid storage areas, and requirements for gas cylinders have been aligned with NFPA 55. Requirements for emergency gas shutoffs and overpressure protection have been clarified, and new language has been added to address the potential explosion hazards associated with mixing flammable and oxidizing materials. The sections on heating operations and heating equipment have been combined into one section for consistency, and new requirements to perform hazard analysis and risk assessment before use of pressure containing equipment have been added.

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Committee Scope: This Committee shall have primary responsibility for documents for the prevention of loss of life and damage to property from fire and explosion in chemical laboratories.

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Information on referenced publications can be found in Chapter 2 and Annex G.

Chapter 1 Administration

1.1 Scope.

1.1.1* This standard shall apply to laboratory buildings, laboratory units, and laboratory work areas whether located above or below grade in which chemicals, as defined in NFPA 704 with one or more of the following hazard ratings are handled or stored: health — 2, 3, or 4; flammability — 2, 3, or 4; or instability — 2, 3, or 4. (See also Section B.2.)

Δ 1.1.2 This standard shall apply to all educational laboratory units and instructional laboratory units in which any quantity of chemicals, as defined in NFPA 704 with one or more of the following hazard ratings, is handled or stored: health — 2, 3, or 4; flammability — 2, 3, or 4; or instability — 2, 3, or 4. (See also Section B.2.)

1.1.3 With the exception of 1.1.2, this standard shall not apply to the following:

- (1)* Laboratories for which the following conditions apply:
 - (a) Laboratory units that contain less than or equal to 4 L (1 gal) of flammable or combustible liquid
 - (b) Laboratory units that contain less than 2.2 standard m³ (75 scf) of flammable gas, not including piped-in low-pressure utility gas installed in accordance with NFPA 54
- (2)* Pilot plants
- (3) Laboratories that handle only chemicals with a hazard rating of 0 or 1 for all of the following: health, flammability, and instability, as defined by NFPA 704
- (4) Laboratories that are primarily manufacturing plants
- (5) Incidental testing facilities
- (6) Physical, electronic, instrument, laser, or similar laboratories that use chemicals only for incidental purposes, such as cleaning
- (7)* Hazards associated with radioactive materials, as covered by NFPA 801
- (8) Laboratories that work only with explosive material, as covered by NFPA 495
- (9)* A laboratory work area containing an explosion hazard great enough to cause property damage outside that laboratory work area or injury outside that laboratory work area requiring medical treatment beyond first aid

Δ 1.1.4* A laboratory work area contains an explosion hazard if an explosion of quantities or concentrations of reactive materials could result in serious or fatal injuries to personnel within that laboratory work area.

N 1.1.4.1 Quantities or concentrations that pose an explosion hazard include, but are not limited to, the following:

- (1) Storage of more than 0.45 kg (1 lb) of materials with an instability hazard rating of 4 (see Table B.2.5)
- (2) Use or formation of more than 0.11 kg (0.25 lb) of materials with an instability hazard rating of 4 (see Table B.2.5)
- (3)* Presence of highly exothermic reactions in glass or open reaction vessels involving more than 10 g (0.35 oz) of materials such as polymerizations, oxidations, nitrations, peroxidations, hydrogenations, or organo-metallic reactions
- (4) Use or formation in glass or open reaction vessels involving more than 10 g (0.35 oz) of materials whose chemical structures indicate a potential hazard, but whose properties have not been established, such as salts of alkenes, triple bonds, epoxy radicals, nitro and nitroso compounds, and peroxides
- (5) Other explosion hazards as determined by a qualified person

N 1.1.4.2 In such cases where a laboratory work area contains an explosion hazard, NFPA 45, supplemented by appropriate shielding, handling, and similar protective measures, does apply.

1.1.5 A laboratory work area contains an explosion hazard if an explosion of quantities or concentrations of flammable gases or vapors or other explosion hazards as determined by a qualified person could result in serious or fatal injuries to personnel within that laboratory work area — in which case, NFPA 45 shall apply.

1.1.6 This standard contains requirements, but not all-inclusive requirements, for handling and storage of chemicals where laboratory-scale operations are conducted and shall not cover the following:

- (1) The special fire protection required when handling explosive materials (*See NFPA 495.*)
- (2) The special fire protection required when handling radioactive materials

1.2 Purpose.

1.2.1 The purpose of this standard shall be to provide basic requirements for the protection of life and property through prevention and control of fires and explosions involving the use of chemicals in laboratory-scale operations.

1.2.2 This standard is designed to control hazards and protect personnel from the toxic, corrosive, or other harmful effects of chemicals to which personnel might be exposed as a result of fire or explosion.

1.2.3 The goal of this standard shall be to achieve a comprehensive laboratory fire prevention and protection program to prevent injury or death to occupants and emergency response personnel.

1.2.4 The objectives of this standard shall be as follows:

- (1) Limit injury to the occupants at the point of fire origin
- (2) Limit injury to emergency response personnel
- (3) Limit property loss to a maximum of a single laboratory unit

▲ **1.2.5** It is not the objective of this standard to address financial losses such as business interruption or property loss of a laboratory unit.

1.3* Application.

1.3.1 The provisions of this document shall be considered necessary to provide a reasonable level of protection from loss of life and property from fire and explosion. They reflect situations and the state of the art prevalent at the time the standard was issued.

1.3.2 When interface with existing NFPA or other consensus codes and standards occurs, reference shall be made to the appropriate source in the text.

1.3.3 Due to the special nature of laboratories using chemicals, this standard modifies and supplements existing codes and standards so as to apply more specifically to buildings or portions of buildings devoted to laboratory-scale operations.

1.3.4 Where a construction or protection requirement of a governmental agency having jurisdiction is more stringent than a requirement in this standard, the more stringent requirement shall apply.

1.4 Retroactivity. The provisions of this standard reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this standard at the time the standard was issued.

1.4.1 Unless otherwise specified, the provisions of this standard shall not apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the standard. Where specified, the provisions of this standard shall be retroactive.

1.4.2 In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retroactively any portions of this standard deemed appropriate.

1.4.3 The retroactive requirements of this standard shall be permitted to be modified if their application clearly would be impractical in the judgment of the authority having jurisdiction, and only where it is clearly evident that a reasonable degree of safety is provided.

1.5 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.

1.5.1 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.5.2 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

Chapter 2 Referenced Publications

2.1 General. The documents referenced in this chapter are referenced within this standard and shall be considered part of the requirements of this standard, and the following shall also apply:

- (1)* Documents referenced in this chapter, or portion of such documents, shall only be applicable to the extent called for within other chapters of this standard.
- (2) Where the requirements of a referenced code or standard differ from the requirements of this standard, the requirements of this standard shall govern.
- (3)* Existing buildings or installations that do not comply with the provisions of the codes or standards referenced in this chapter shall be permitted to be continued in service, provided that the lack of conformity with these documents does not present a serious hazard to the occupants as determined by the authority having jurisdiction.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1, *Fire Code*, 2018 edition.

NFPA 10, *Standard for Portable Fire Extinguishers*, 2018 edition.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2016 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2018 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, 2018 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 2019 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2017 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 2017 edition.

NFPA 17A, *Standard for Wet Chemical Extinguishing Systems*, 2017 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, 2017 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2018 edition.

NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*, 2018 edition.

NFPA 54, *National Fuel Gas Code*, 2018 edition.

NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, 2016 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2019 edition.

NFPA 70®, *National Electrical Code®*, 2017 edition.

NFPA 72®, *National Fire Alarm and Signaling Code*, 2019 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, 2019 edition.

NFPA 86, *Standard for Ovens and Furnaces*, 2019 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 2018 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids*, 2015 edition.

NFPA 101®, *Life Safety Code®*, 2018 edition.

NFPA 400, *Hazardous Materials Code*, 2019 edition.

NFPA 495, *Explosive Materials Code*, 2018 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, 2017 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 2017 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2019 edition.

NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*, 2019 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2018 edition.

NFPA 2112, *Standard on Flame-Resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire*, 2018 edition.

2.3 Other Publications.

2.3.1 ANSI Publications. American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.

ANSI/AIHA Z9.5, *Laboratory Ventilation*, 2012.

ANSI Z535.1, *Safety Colors*, 2017.

ANSI Z535.2, *Environmental and Facility Safety Signs*, 2017.

ANSI Z535.3, *Criteria for Safety Symbols*, 2017.

ANSI Z535.4, *Product Safety Signs and Labels*, 2017.

2.3.2 ASME Publications. ASME International, Two Park Avenue, New York, NY 10016-5990.

ASME *Boiler and Pressure Vessel Code*, Section VIII, 2017.

2.3.3 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D5/D5M, *Standard Test Method of Penetration of Bituminous Materials*, 2013.

ASTM D4359, *Standard Test for Determining Whether a Material is a Liquid or a Solid*, 2012.

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 2017a.

2.3.4 NSF Publications. NSF International, P.O. Box 130140, 789 N. Dixboro Road, Ann Arbor, MI 48113-0140.

NSF/ANSI 49, *Biosafety Cabinetry: Design, Construction, Performance, and Field Certification*, 2016.

2.3.5 UL Publications. Underwriters Laboratories, Inc. 333 Pfingsten Road, Northbrook, IL 60062-2096.

ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*, 2008, revised 2017.

UL 1275, *Standard for Flammable Liquid Cabinets*, 2014.

UL 1805, *Standard for Laboratory Hoods and Cabinets*, 2006, revised 2007.

2.3.6 Other Publications.

Merriam-Webster's *Collegiate Dictionary*, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections.

NFPA 30, *Flammable and Combustible Liquids Code*, 2018 edition.

NFPA 54, *National Fuel Gas Code*, 2018 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 2018 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids*, 2015 edition.

NFPA 99, *Health Care Facilities Code*, 2018 edition.

NFPA 101®, *Life Safety Code®*, 2018 edition.

NFPA 400, *Hazardous Materials Code*, 2019 edition.

NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*, 2014 edition.

NFPA 5000®, *Building Construction and Safety Code®*, 2018 edition.

Chapter 3 Definitions

3.1 Definitions. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.4* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.5 Shall. Indicates a mandatory requirement.

3.2.6 Should. Indicates a recommendation or that which is advised but not required.

3.2.7 Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase “standards development process” or “standards development activities,” the term “standards” includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

3.3 General Definitions.

3.3.1 Apparatus. Furniture, chemical fume hoods, centrifuges, refrigerators, and commercial or made-on-site equipment used in a laboratory.

3.3.2 Auxiliary Air. Supply or supplemental air delivered near the outside face of a chemical fume hood to reduce room air consumption.

3.3.3 Baffle. An object placed in an appliance to change the direction of or to retard the flow of air, air–gas mixtures, or flue gases. [54, 2018]

3.3.4* Biological Safety Cabinet. A ventilated cabinet for personnel, product, and environmental protection having an open front with inward airflow for personnel protection, downward HEPA-filtered laminar airflow for product protection, and HEPA-filtered exhausted air for environmental protection.

3.3.5 Business Occupancy. See 3.3.46.1.

3.3.6 Bypass. An airflow-compensating opening that maintains a relatively constant volume exhaust through a chemical fume hood regardless of sash position, serving to limit the maximum face velocity as the sash is lowered.

3.3.7* Canopy Hood. A suspended ventilating device used only to exhaust heat, water vapor, odors, and other nonhazardous materials.

3.3.8* Chemical Fume Hood. A ventilated enclosure designed to contain and exhaust fumes, gases, vapors, mists, and particulate matter generated within the hood interior.

3.3.9 Combustible Liquid. A liquid that has a closed-cup flash point at or above 37.8°C (100°F).

3.3.10 Compressed Gas Cylinder. Any portable pressure vessel of 45.4 kg (100 lb) water capacity or less designed to contain a gas or liquid that is authorized for use at gauge pressures over 276 kPa (40 psi) at 21°C (70°F) by the U.S. Department of Transportation (DOT) or Transport Canada (T.C.).

ures over 276 kPa (40 psi) at 21°C (70°F) by the U.S. Department of Transportation (DOT) or Transport Canada (T.C.).

3.3.11* Cryogenic Fluid. Substance that exists only in the vapor phase above −73°C (−99°F) at one atmosphere pressure and that is handled, stored, and used in the liquid state at temperatures at or below −73°C (−99°F) while at any pressure.

3.3.12 Deflector Vane. An airfoil-shaped vane along the bottom of the hood face that directs incoming air across the work surface to the lower baffle opening. The opening between the work surface and the deflector vane is open even with the sash fully closed.

3.3.13 Educational Laboratory Unit. A laboratory unit that is under direct supervision of an instructor and used for educational purposes for students through the twelfth grade.

3.3.14 Educational Occupancy. See 3.3.46.2.

3.3.15 Exit Access Corridor. A corridor used as exit access that leads to an exit that is separated from other parts of the building by walls.

3.3.16 Explosive Material. Any explosive, blasting agent, emulsion explosive, water gel, or detonator.

3.3.17* Face (of hood). The hood opening or the plane of the inside surface of the sash.

3.3.18 Face Velocity. The rate of flow or velocity of air moving into the chemical fume hood entrance or face, as measured at the plane of the chemical fume hood face.

3.3.19 Fire Separation. A horizontal or vertical fire resistance-rated assembly of materials that have protected openings and are designed to restrict the spread of fire.

3.3.20 Flammable Gas. Any substance that exists in the gaseous state at normal atmospheric temperature and pressure and is capable of being ignited and burned when mixed with the proper proportions of air, oxygen, or other oxidizers. [99, 2018]

3.3.21 Flammable Liquid. A liquid that has a closed-cup flash point that is below 37.8°C (100°F) and a maximum vapor pressure of 2068 mm Hg (absolute pressure of 40 psi) at 37.8°C (100°F).

3.3.22* Flammable Solid. A solid, other than a blasting agent or explosive, that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or that can be ignited readily and when ignited, burns so vigorously and persistently as to create a serious hazard.

3.3.23 Flash Point. The minimum temperature at which a liquid or a solid emits vapor sufficient to form an ignitable mixture with air near the surface of the liquid or the solid.

3.3.24 Glove Box. A sealed enclosure in which items inside the box are handled exclusively using long gloves sealed to ports in the walls of the enclosure. [801, 2014]

3.3.25* Health Care Facilities. Buildings, portions of buildings, or mobile enclosures in which medical, dental, psychiatric, nursing, obstetrical, or surgical care is provided. (FUN) [99, 2018]

3.3.26 Health Care Occupancy. See 3.3.46.3.

3.3.27 Hood Interior. The volume enclosed by the side, back, and top enclosure panels, the work surface, the access opening (called the face), the sash or sashes, and the exhaust plenum, including the baffle system for airflow distribution.

3.3.28 Incidental Testing Facility. An area within a production facility set aside for the purpose of conducting in-process control tests that are related to the production process.

3.3.29 Industrial Occupancy. See 3.3.46.4.

3.3.30* Inside Liquid Storage Area. A room or building used for the storage of liquids in containers or portable tanks, separated from other types of occupancies.

3.3.31 Instructional Laboratory Unit. A laboratory unit under the direct supervision of an instructor that is used for purposes of instruction for students beyond the twelfth grade.

3.3.32 Instructor. A person whose job includes teaching or instructing students in educational or instructional laboratories. This can include science teachers, professors, assistant professors, associate professors, lecturers, substitute teachers, and teaching assistants.

3.3.33 Laboratory. A facility where the containers used for reactions, transfers, and other handling of chemicals are designed to be easily and safely manipulated by one person. A laboratory is a workplace where chemicals are used or synthesized on a nonproduction basis.

3.3.34 Laboratory Building. A structure consisting wholly or principally of one or more laboratory units.

3.3.35 Laboratory Equipment. See 3.3.1, Apparatus.

3.3.36 Laboratory Scale. Work with chemicals in which the containers used for reactions, transfers, and other handling of chemicals are designed to be easily and safely manipulated by one person.

3.3.37* Laboratory Unit. An enclosed space used for experiments or tests.

3.3.38 Laboratory Unit Separation. All walls, partitions, floors, and ceilings, including openings in them, that separate a laboratory unit from adjoining areas.

3.3.39* Laboratory Work Area. A room or space for testing, analysis, research, instruction, or similar activities that involve the use of chemicals.

3.3.40 Laminar Flow Cabinet. A ventilated, partially enclosed cabinet primarily intended to provide filtered airflow over the work surface by use of laminar airflow methods.

3.3.41 Lecture Bottle. A small compressed gas cylinder up to a size of approximately 5 cm × 33 cm (2 in. × 13 in.).

3.3.42 Liquefied Gas Cylinder. A compressed gas cylinder used for liquefied gas.

3.3.43 Liquid. Any material that has a fluidity greater than that of 300 penetration asphalt when tested in accordance with ASTM D5/D5M, *Standard Test Method of Penetration of Bituminous Materials*, and is a viscous substance for which a specific melting point cannot be determined but that is determined to be a liquid in accordance with ASTM D4359, *Standard Test for Determining Whether a Material Is a Liquid or a Solid*. Unless otherwise specified, the term *liquid* includes both flammable and combustible liquids.

3.3.44 Maximum Allowable Working Pressure. The maximum gauge pressure permissible at the top of completed equipment, a container, or a vessel in its operating position for a design temperature.

3.3.45 Nonlaboratory Area. Any space within a building not included in a laboratory unit. (See also 3.3.37.)

3.3.46 Occupancy.

3.3.46.1 Business Occupancy. An occupancy used for the transaction of business other than mercantile. [5000, 2018]

3.3.46.2* Educational Occupancy. An occupancy used for educational purposes through the 12th grade by six or more persons for 4 or more hours per day or more than 12 hours per week.

3.3.46.3 Health Care Occupancy. An occupancy used to provide medical or other treatment or care simultaneously to four or more patients, on an inpatient basis, where such occupants are mostly incapable of self-preservation due to age, physical or mental disability, or because of security measures not under the occupants' control. [5000, 2018]

3.3.46.4* Industrial Occupancy. An occupancy in which products are manufactured or in which processing, assembling, mixing, packaging, finishing, decorating, or repair operations are conducted. [5000, 2018]

3.3.47 Open Plan Building. A building having rooms, spaces, and corridors delineated by tables, chairs, desks, bookcases, counters, low-height partitions, floor patterns, or any similar finishes or furnishings.

3.3.48 Organic Peroxide. Any organic compound having a double oxygen or peroxy (-O-O-) group in its chemical structure.

3.3.49* Oxidizer. Any material that readily yields oxygen or other oxidizing gas, or that readily reacts to promote or initiate combustion of combustible materials.

3.3.50 Pilot Plant. An experimental assembly of equipment for exploring process variables or for producing semicommercial quantities of materials.

3.3.51 Pressurized Liquid Dispensing Container (PLDC). DOT-, United Nations- (UN-), or ASME-approved containers which are designed for the pressure dispensing of liquids at the specified maximum allowable working pressure of the container.

3.3.52 Pyrophoric Gas. A gas that will spontaneously ignite in air at or below a temperature of 54.4°C (130°F).

3.3.53* Pyrophoric Reagent. A solid or liquid substance that ignites at 54°C (130°F) or below on exposure to water vapor in air-producing flammable gas and heat.

3.3.54 Qualified Person. A person who, by possession of a recognized degree, certificate, professional standing, or skill, and who, by knowledge, training, and experience, has demonstrated the ability to deal with problems relating to a particular subject matter, work, or project.

3.3.55 Reactive Material. A material that, by itself, is readily capable of detonation, explosive decomposition, or explosive reaction at normal or elevated temperatures and pressures. (See B.2.5 for definitions of Instability 2, 3, or 4.)

3.3.56 Refrigerating Equipment. Any mechanically operated equipment used for storing materials below normal ambient temperature, including refrigerators, freezers, and similar equipment. (See 11.3.2 and A.11.3.2.2.)

3.3.57 Safety Can. A listed container, of not more than 5.3 gal (20L) capacity, having a screen or strainer in each fill and pour opening and having a spring-closing lid and spout cover designed to safely relieve internal pressure when exposed to fire. [30, 2018]

3.3.58 Sash. A movable panel or panels set in the hood entrance. (See C.6.1.)

3.3.59 Street Floor. A story or floor level accessible from the street or from outside the building at the finished ground level, with the floor level at the main entrance located not more than three risers above or below the finished ground level, and arranged and utilized to qualify as the main floor. [101, 2018]

3.3.60* Unattended Laboratory Operation. A laboratory procedure or operation at which there is no person present who is knowledgeable regarding the operation and emergency shutdown procedures.

N 3.3.61 Use. To place a material, including solids, liquids, and gases, into action. [400, 2019]

N 3.3.61.1* Closed System Use. Use of a solid or liquid hazardous material in a closed vessel or system that remains closed during normal operations where vapors emitted by the product are not liberated outside of the vessel or system and the product is not exposed to the atmosphere during normal operations and all uses of compressed gases. [400, 2019]

N 3.3.61.2 Open System Use. Use of a solid or liquid hazardous material in a vessel or system that is continuously open to the atmosphere during normal operations and where vapors are liberated or the product is exposed to the atmosphere during normal operations. [400, 2019]

Chapter 4 Laboratory Unit Hazard Classification

4.1 General. This chapter shall classify laboratory units based on the amount of flammable and combustible liquids in use within the unit.

4.2 Laboratory Unit Fire Hazard Classification.

4.2.1* Classifications. Laboratory units shall be classified as Class A (high fire hazard), Class B (moderate fire hazard), Class C (low fire hazard), or Class D (minimal fire hazard), according to the quantities of flammable and combustible liquids specified in Table 9.1.1(a) and Table 9.1.1(b).

4.2.2 Additional Requirements for Educational and Instructional Laboratory Units.

4.2.2.1 Instructional laboratory units shall be classified as Class C or Class D laboratory units.

4.2.2.2 Educational laboratory units shall be classified as Class D or shall be limited to 50 percent of the flammable and combustible liquids quantity for Class C laboratory units presented in Table 9.1.1(a) and Table 9.1.1(b).

N 4.2.3 Additional Requirements for Laboratory Units in Health Care Facilities.

N 4.2.3.1 Laboratory units in health care facilities shall be classified as Class C or D.

N 4.2.3.2 Class C laboratory units in health care facilities shall be limited to 50 percent of the flammable and combustible liquid quantity for Class C laboratory units presented in Table 9.1.1(a) and Table 9.1.1(b).

Chapter 5 Laboratory Unit Design and Construction

5.1 Laboratory Unit Enclosure.

Δ 5.1.1 The required construction of laboratory units shall be in accordance with Table 5.1.1.

5.1.2 A single Class C or Class D laboratory unit on a floor shall not be required to have fire separation.

5.1.3 Regardless of the construction and fire protection requirements for laboratory units that are specified in Table 5.1.1, laboratory units in educational occupancies or Class C laboratory units in health care facilities shall be separated from nonlaboratory areas by 1-hour construction.

5.1.4* Penetrations through fire-rated floor/ceiling, floor, and wall assemblies shall be protected in accordance with NFPA 101 and the applicable fire code or building code.

5.1.5* Floors, Floor Openings, Floor Penetrations, and Floor Firestop Systems.

N 5.1.5.1 Floors, floor openings, floor penetrations, and floor firestop systems shall be sealed or curbed to prevent liquid leakage to lower floors.

N 5.1.5.2 The sealing material shall be compatible with the chemicals being stored or used in the laboratory, or a program shall be in place to inspect and repair, if necessary, after exposure to leakage.

Δ Table 5.1.1 Separation Requirements and Height Allowances for Laboratory Units

Laboratory Unit ^a	Permitted Stories Above Grade	Permitted Stories Below Grade	Fire Separation ^b
A	1–3	Not permitted	2 hours
B	1–3 4–6	1	1 hour 2 hours
C	1–6 Over 6	1–2	1 hour ^c 2 hours
D	No limit	No limit	1 hour ^c

^aRefer to Table 9.1.1 for laboratory unit classification.

^bSeparation in this table refers to fire separation from laboratory unit(s) to nonlaboratory areas or fire separations from laboratory unit(s) of equal or lower hazard classification.

^cSee 5.1.2.

5.1.6 Door assemblies in required 1-hour-rated fire separations shall be $\frac{3}{4}$ -hour rated. Door assemblies in required 2-hour-rated fire separations shall be 1 $\frac{1}{2}$ -hour rated.

5.1.7 Window assemblies shall be permitted in fire-rated wall assemblies having a required fire resistance rating of 1 hour or less.

5.1.7.1 Window assemblies shall be of an approved type and shall have a fire protection rating in accordance with NFPA 101.

5.1.7.2 Fire window assemblies shall be installed in accordance with NFPA 80.

5.2 Requirements for Life Safety. Life safety features for laboratory buildings, laboratory units, and laboratory work areas shall comply with NFPA 101 unless otherwise modified by other provisions of this standard.

5.2.1 Class A, B, and C laboratory units shall be classified as industrial occupancies in accordance with NFPA 101.

5.2.2 Educational laboratory units shall be classified as educational occupancies in accordance with NFPA 101.

5.2.3 Class D laboratories located in facilities classified as business occupancies shall be in accordance with the requirements for business occupancies of NFPA 101.

5.3 Means of Access to an Exit.

5.3.1* A second means of access to an exit shall be provided from a laboratory work area if any of the following situations exist:

- (1) A laboratory work area contains an explosion hazard located so that an incident would block escape from or access to the laboratory work area.
- (2) A laboratory work area within a Class A laboratory unit exceeds 46.5 m² (500 ft²).
- (3) A laboratory work area within a Class B, Class C, or Class D laboratory unit exceeds 93 m² (1000 ft²).
- (4) A hood in a laboratory work area is located adjacent to the means of exit access.
- (5) A compressed gas cylinder larger than lecture bottle size [approximately 5 cm × 33 cm (2 in. × 13 in.)] is located so that it could prevent safe egress in the event of accidental release of cylinder contents.
- (6) A cryogenic container is located so that it could prevent safe egress in the event of accidental release of container contents.

5.3.2 The required exit access doors of all laboratory work areas within Class A or Class B laboratory units shall swing in the direction of exit travel.

5.3.3* The required exit access doors of all laboratory work areas within Class C or Class D laboratory units shall be allowed to be installed in accordance with one of the following if permitted by the egress provisions of NFPA 101:

- (1) Swing in the direction of exit travel
- (2) Swing against the direction of exit travel
- (3) A horizontal sliding door

5.4* Furniture, Casework, and Equipment. Furniture, casework, and equipment in laboratory units shall be arranged so that means of access to an exit can be reached easily from any point.

5.5 Electrical Installation. All electrical installations, including wiring and appurtenances, apparatus, lighting, signal systems, alarm systems, remote control systems, or parts thereof, shall comply with NFPA 70.

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

5.5.2* Laboratory work areas, laboratory units, and chemical fume hood interiors shall be considered as unclassified electrically with respect to Article 500 of NFPA 70 unless operations are determined to cause a hazardous atmosphere. (See 9.5.5 and 11.3.2.2.)

N 5.5.3 Emergency Lighting.

Δ 5.5.3.1 Emergency lighting shall be provided for laboratory work areas.

Δ 5.5.3.2 Emergency lighting shall be installed in accordance with Section 7.9 of NFPA 101.

Chapter 6 Fire Protection

6.1 Automatic Fire Extinguishing Systems.

6.1.1 Automatic Sprinkler Systems.

6.1.1.1 Automatic sprinkler system protection shall be required for all new laboratories in accordance with the following:

- (1) Automatic sprinkler system protection for Class A and Class B laboratories shall be in accordance with NFPA 13 for ordinary hazard (Group 2) occupancies.
- (2) Automatic sprinkler system protection for Class C and Class D laboratories shall be in accordance with NFPA 13 for ordinary hazard (Group 1) occupancies.

6.1.1.2* Fire sprinklers in laboratory units shall be the quick-response (QR) sprinkler type installed in accordance with NFPA 13.

6.1.1.3 Automatic sprinkler systems shall be regularly inspected, tested, and maintained in accordance with NFPA 25.

6.1.2* Other Automatic Extinguishing Systems.

N 6.1.2.1 Where water will create a serious fire or personnel hazard, a suitable nonwater automatic extinguishing system shall be permitted to be an acceptable substitute for sprinklers.

N 6.1.2.2 Where required or used in place of automatic sprinkler systems, special hazard extinguishing systems and nonwater automatic extinguishing systems shall be designed, installed, and maintained in accordance with NFPA 11, NFPA 12, NFPA 12A, NFPA 15, NFPA 17, NFPA 17A, NFPA 69, NFPA 750, and NFPA 2001, as applicable.

6.2 Standpipe and Hose Systems.

6.2.1* Class I wet standpipe systems shall be installed in laboratory buildings where the floor level of the highest story is located more than 9.14 m (30 ft) above the lowest level of fire department vehicle access, or where the floor level of the lowest story is located more than 9.14 m (30 ft) below the highest level of fire department vehicle access in accordance with NFPA 14.

6.2.2 Standpipe systems shall be regularly inspected, tested, and maintained in accordance with NFPA 25.

6.3 Portable Fire Extinguishers.

6.3.1 Portable fire extinguishers shall be installed, located, and maintained in accordance with NFPA 10.

- ▲ **6.3.2** For purposes of sizing and placement of fire extinguishers for Class B fires (*see Table 6.3.1.1 of NFPA 10*), Class A laboratory units shall be rated as extra hazard, and Class B, Class C, and Class D laboratory units shall be rated as ordinary hazard.

6.4 Fire Alarm Systems.

6.4.1 Buildings with laboratory units shall have a manual fire alarm system installed and maintained in accordance with NFPA 72.

6.4.2 Automatic fire sprinkler or other extinguishing systems shall activate the fire alarm system.

6.4.3* The fire alarm system shall activate fire alarm notification appliances and notify the fire department.

6.5 Fire Prevention.

6.5.1 Fire Prevention Procedures.

6.5.1.1 Fire prevention procedures shall be established for all new and existing laboratories.

6.5.1.2 Fire prevention procedures shall include, but not be limited to, the following:

- (1) Handling and storage of chemicals, flammable and combustible liquids, pyrophoric and other reactive compounds, and compressed gases
- (2) Open flame and spark-producing equipment work permit system
- (3) Arrangements and use of portable electrical cords
- (4) Smoking area controls

6.5.2* Maintenance Procedures. Maintenance procedures shall be established for all new and existing laboratories.

6.5.3* Emergency Plans.

6.5.3.1 Provisions Within the Emergency Action Plan. Plans for laboratory emergencies shall be established for all new and existing laboratories. The emergency action plan shall include the following procedures in the event of a chemical emergency, fire, or explosion:

- (1) Procedures for sounding the alarm
- (2) Procedures for notifying and coordinating with the fire department, governmental agencies, or other emergency responders or contacts, as required
- (3) Procedures for evacuating and accounting for personnel, as applicable
- (4) Procedures for establishing requirements for rescue and medical duties for those requiring or performing these duties
- (5) Procedures and schedules for conducting drills
- (6) Procedures for shutting down and isolating equipment under emergency conditions to include the assignment of personnel responsible for maintaining critical functions or for shutdown of process operations
- (7) Appointment and training of personnel to carry out assigned duties, including steps to be taken at the time of initial assignment, as responsibilities or response actions change, and at the time anticipated duties change

- (8) Alternative measures for occupant safety, when applicable
- (9) Aisles designated as necessary for movement of personnel and emergency response
- (10) Maintenance of fire protection equipment
- (11) Safe procedures for startup to be taken following the abatement of an emergency

[400: 7.2.3.2]

6.5.3.2* Procedures for extinguishing clothing fires shall be established for all new and existing laboratories.

6.5.3.3* All laboratory users, including, but not limited to, instructors and students, shall be trained prior to laboratory use and at least annually thereafter on the emergency plan.

6.6 Flame-Resistant Clothing.

6.6.1 The provisions of 6.6.2 through 6.6.5 shall apply to all new and existing laboratories.

6.6.2* Flame-resistant lab coats shall be worn where pyrophoric reagents are used outside the inert atmosphere of a glovebox.

6.6.3* Flame-resistant gloves shall be worn whenever possible where pyrophoric reagents are used outside the inert atmosphere of a glovebox.

6.6.4* Natural-fiber clothing shall be worn under flame-resistant lab coats and on the legs and feet where pyrophoric reagents are used outside the inert atmosphere of a glovebox.

6.6.5 Flame-resistant clothing shall meet the requirements of NFPA 2112.

Chapter 7 Laboratory Ventilating Systems and Hood Requirements

7.1* General.

7.1.1 This chapter shall apply to laboratory exhaust systems, including chemical fume hoods, local ventilated enclosures, fume arms, special local exhaust devices, and other systems for exhausting air from laboratory work areas in which flammable gases, vapors, or particulate matter are released.

7.1.2 This chapter shall apply to laboratory air supply systems and shall provide requirements for identification, inspection, and maintenance of laboratory ventilation systems and hoods.

7.2 Basic Requirements.

7.2.1* Laboratory ventilation systems shall be designed to ensure that fire hazards and risks are minimized.

7.2.2 Continuous Ventilation.

■ **7.2.2.1*** Laboratory units and laboratory hoods in which chemicals are present shall be continuously ventilated under normal operating conditions.

7.2.2.2 If laboratory exhaust ventilation is out of service or inoperable, all laboratory operations shall be suspended until the deficiency is corrected. All hazardous materials shall be secured in a safe condition or removed from the laboratory during the time that the deficiency exists.

7.2.3* Chemical fume hoods shall not be relied upon to provide explosion (blast) protection unless specifically

designed to do so. (See also C.6.4 and C.6.5 for further information on explosion-resistant hoods and shields.)

7.2.4 Chemical fume hoods using perchloric acid shall be in accordance with Section 7.12.

7.2.5 Exhaust and supply systems shall be designed to prevent a pressure differential that would impede egress or ingress when either system fails or during a fire or emergency scenario. This design includes reduced operational modes or shutdown of either the supply or the exhaust ventilation system.

7.2.6 The release of chemical vapors 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.

7.3 Supply Systems.

7.3.1* Laboratory ventilation systems shall be designed to ensure that chemical fumes, vapors, or gases originating from the laboratory shall not be recirculated. (See also 7.4.2.)

7.3.2* The location and configuration of fresh air intakes shall be chosen so as to avoid drawing in chemicals or products of combustion coming either from the laboratory building itself or from other structures and devices.

7.3.3 The air pressure in the laboratory work areas shall be negative with respect to corridors and nonlaboratory areas of the laboratory unit except in the following instances:

- (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.
- (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 chemical fume hood sash positions, and other activities that can for a short term affect the static pressure level and its negative relationship.
- (3) Laboratory work areas located within a designated electrically classified hazardous area with a positive air pressure system as described in NFPA 496 in accordance with Chapter 7, Pressurized Control Rooms, shall be permitted to be positive with respect to adjacent corridors.

7.3.4* The location of air supply diffusion devices shall be chosen so as to avoid air currents that would adversely affect the performance of chemical fume hoods, exhaust systems, and fire detection or fire-extinguishing systems. (See Sections 6.1, and 6.4, and 7.9.1.)

N 7.3.5* Openings in fire-rated floor/ceiling and wall assemblies for supply air-handling ducts shall be protected in accordance with NFPA 90A.

7.4 Exhaust Air Discharge.

7.4.1* Air exhausted from chemical fume hoods and other special local exhaust systems shall not be recirculated. (See also 7.3.1.)

7.4.2* Energy Conservation Devices.

7.4.2.1 If energy conservation devices are used, they shall be designed in accordance with 7.3.1 and 7.3.2.

Δ 7.4.2.2* Energy conservation devices shall only be used in a laboratory ventilation system when evaluated and approved by a qualified person. These systems must meet, or exceed, the criteria established by Section 5.4.7 and Section 5.4.7.1 of ANSI/AIHA Z9.5, *Laboratory Ventilation*. Systems that recirculate within their respective laboratory work area, such as fan coil units for sensible heat loads, are exempt from these requirements.

7.4.2.3* Energy conservation devices shall be designed and installed in a manner that safely facilitates anticipated service and maintenance requirements and does not adversely impact the proper operation of the exhaust system.

7.4.3 Air exhausted from laboratory work areas shall not pass unducted through other areas.

7.4.4* Air from laboratory units and laboratory work areas in which chemicals are present shall be continuously discharged through duct systems maintained at a negative pressure relative to the pressure of normally occupied areas of the building.

7.4.5 Positive pressure portions of the lab hood exhaust systems (e.g., fans, coils, flexible connections, and ductwork) located within the laboratory building shall be sealed airtight or located in a continuously mechanically ventilated room.

7.4.6 Chemical fume hood face velocities and exhaust volumes shall be sufficient to contain contaminants generated within the hood and exhaust them outside of the laboratory building.

7.4.7* The hood shall provide containment of the possible hazards and protection for personnel at all times when chemicals are present in the hood.

7.4.8 Special local exhaust systems, such as snorkels or "elephant trunks," shall have sufficient capture velocities to entrain the chemical being released.

7.4.9* Canopy hoods, laminar flow cabinets, and ductless enclosures shall not be used in lieu of chemical fume hoods.

Δ 7.4.10 Only Class II, Type B2 biological safety cabinets listed by a nationally recognized testing laboratory as meeting NSF/ANSI 49, *Biosafety Cabinetry: Design, Construction, Performance, and Field Certification*, shall be permitted to be used in lieu of chemical fume hoods, as determined by a qualified person.

7.4.11* Air exhausted from chemical fume 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.

7.5 Duct Construction for Hoods and Local Exhaust Systems.

7.5.1 Ducts from chemical fume hoods and from local exhaust systems shall be constructed entirely of noncombustible materials except in the following cases:

- (1) Flexible ducts of combustible construction shall be permitted to be used for special local exhaust systems within a laboratory work area. (See 7.5.2.)
- (2) Combustible ducts shall be permitted to be used if enclosed in a shaft of noncombustible or limited-combustible construction where they pass through nonlaboratory areas or through laboratory units other than the one they serve. (See 7.5.2.)
- (3) Combustible ducts shall be permitted to be used if all areas through which they pass are protected with an

approved automatic fire-extinguishing system, as described in Chapter 6. (See 7.5.2.)

7.5.2 Combustible ducts or duct linings shall have a flame spread index of 25 or less when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*. Test specimens shall be of the minimum thickness used in the construction of the duct or duct lining.

7.5.3 Sound attenuation devices, linings, and coatings containing such fill as fiberglass, mineral wool, foam, or other similar material that could accumulate chemical deposits shall not be permitted within laboratory exhaust systems.

7.5.4 Duct systems for perchloric acid hoods shall be constructed in accordance with Section 7.12.

7.5.5 Ducts shall be of adequate strength and rigidity to meet the conditions of service and installation requirements and shall be protected against mechanical damage.

7.5.6 Materials used for vibration isolation connectors shall comply with 7.5.2.

7.5.7 Flexible connectors containing pockets in which conveyed material can collect shall not be used in any concealed space or where strong oxidizing chemicals (e.g., perchloric acid) are used.

7.5.8 Hand holes, where installed for damper, sprinkler, or fusible link inspection or resetting and for residue clean-out purposes, shall be equipped with tight-fitting covers provided with substantial fasteners.

7.5.9 Manifolding of Chemical Fume Hood and Ducts.

7.5.9.1 Exhaust ducts from each laboratory unit shall be separately ducted to a point outside the building, to a mechanical room, or to a shaft. (See 5.1.4 and 7.5.10.)

7.5.9.2 Connection to a common chemical fume hood exhaust duct system shall be permitted to occur within a building only in the following locations:

- (1) A mechanical room, not connected to a shaft, shall be protected in accordance with Table 5.1.1
- (2) A shaft or a mechanical room connected to a shaft, shall be protected in accordance with the chapter on protection of vertical openings of NFPA 101
- (3) A point outside the building

7.5.9.3 Exhaust ducts from chemical fume hoods and other exhaust systems within the same laboratory unit shall be permitted to be combined within that laboratory unit. (See 7.4.1.)

Δ **7.5.10*** The design and installation of laboratory exhaust ducts shall be in accordance with NFPA 91 except that the requirements in 7.5.10.1 through 7.5.12 shall take precedence.

7.5.10.1 Dampers.

N **7.5.10.1.1** Controls and dampers, where required for balancing or control of the exhaust system, shall be of a type that, in the event of failure, will fail open to ensure continuous draft.

7.5.10.1.2* Automatic fire dampers shall not be used in laboratory exhaust systems.

N 7.5.10.2 Ductwork.

N **7.5.10.2.1** A duct conveying laboratory exhaust that passes through a fire barrier shall provide an alternative means of protection equal to or greater than the rating through which the duct passes by one of the following or in accordance with 7.5.10.2.2:

- (1) Wrapped or encased with listed or approved materials having a fire resistance rating equal to the fire barrier for 10 ft (3 m) of the duct on each side of the fire barrier including duct supports within this span [91:4.2.12(1)]
- (2) Constructed of materials and supports having a minimum fire resistance rating equal to the fire barrier [91:4.2.12(2)]
- (3) Enclosed with a shaft that is constructed of material having a fire resistance rating equal to the fire barrier for 10 ft (3 m) of the duct on each side of the fire barrier with no inlets to the duct within this distance, and the duct entry into and exit from the shaft is protected in accordance with 4.2.13 of NFPA 91 [91:4.2.12(3)]

N **7.5.10.2.2** If not protected in accordance with 7.5.10.2.1, when an exhaust duct enters an exhaust shaft, the penetration shall be protected by all of the following:

- (1) Branch ducts connect to enclosed exhaust risers meeting the requirements of 5.3.4.1 or 5.3.4.4 of NFPA 90A. [90A: 5.3.4.6.2(1)]
- (2) The airflow moves upward. [90A:5.3.4.6.2(2)]
- (3)* Steel subducts at least 560 mm (22 in.) in length are carried up inside the riser from each inlet. [90A: 5.3.4.6.2(3)]
- (4) The riser is appropriately sized to accommodate the flow restriction created by the subduct. [90A:5.3.4.6.2(4)]

7.5.11 Fire detection and alarm systems shall not be interlocked to automatically shut down laboratory exhaust fans.

7.5.12 Door operation for egress shall be maintained when the supply system shuts down and the lab exhaust system operates, creating a pressure differential.

7.6* 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 chemical fume hood.

7.6.1 If dirt, dust, or particulate generation in significant amounts is expected in a hood, then other measures such as separate dust filtration systems shall be required.

7.6.2 If significant amounts of condensable vapors are generated in the hood, then other measures such as condensing systems for condensate traps shall be provided.

7.7 Exhausters (Fans), Controls, Velocities, and Discharge.

7.7.1 Fans shall be selected to meet requirements for fire, explosion, and corrosion.

7.7.2 Fans conveying both corrosive and flammable or combustible materials shall be permitted to be lined with or constructed of corrosion-resistant materials having a flame spread index of 25 or less when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*.

7.7.3 Fans shall be located and arranged so as to afford ready access for repairs, cleaning, inspection, and maintenance.

7.7.4* Where flammable gases, flammable vapors, or combustible dusts are passed through the fans, the rotating element shall be of nonferrous or spark-resistant construction; alternatively, the casing shall be constructed of or lined with such material.

7.7.4.1 Where there is the possibility of solid material passing through the fan that would produce a spark, both the rotating element and the casing shall be constructed of such material.

7.7.4.2 Nonferrous or spark-resistant materials shall have a flame spread index of 25 or less when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*.

7.7.5 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.

7.7.6* Fans shall be marked with an arrow or other means to indicate direction of rotation and with the location of chemical fume hoods and exhaust systems served.

7.8 Chemical Fume Hood Requirements.

7.8.1 Chemical Fume Hood Interiors.

7.8.1.1* Materials of construction used for the interiors of new chemical fume hoods or for the modification of the interiors of existing chemical fume hoods shall have a flame spread index of 25 or less when tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or ANSI/UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*, unless the interior of the hood is provided with automatic fire protection in accordance with 7.10.2.

7.8.1.2 Chemical fume hoods shall meet the requirements of UL 1805, *Standard for Safety Laboratory Hoods and Cabinets*, or other approved standards.

7.8.1.3* Baffles shall be constructed so that they are unable to be adjusted to materially restrict the volume of air exhausted through the chemical fume hood.

7.8.1.4* Chemical fume hoods shall be provided with a means of preventing overflow of a spill of 2 L (0.5 gal) of liquid.

7.8.2* Chemical Fume Hood Sash Glazing. The sash, if provided, shall be glazed with material that will provide protection to the operator against the hazards associated with the use of the hood. (See also Annex C and the sash requirements of UL 1805, *Standard for Laboratory Hoods and Cabinets*.)

7.8.3* Chemical Fume Hood Sash Closure.

7.8.3.1 Chemical fume hood sashes shall be kept closed whenever possible.

7.8.3.2* Where a fume hood is unattended, its sash shall remain fully closed.

7.8.4* Electrical Devices.

7.8.4.1 In installations where services and controls are within the hood, additional electrical disconnects shall be located

within 15 m (50 ft) of the hood and shall be accessible and clearly marked.

7.8.4.2 If electrical receptacles are located external to the hood, no additional electrical disconnect shall be required. (See 5.5.1.)

7.8.5 Other Hood Services.

7.8.5.1 For new installations or modifications of existing installations, controls for chemical fume hood services (gas, air, water, etc.) shall be located external to the hood and within easy reach.

7.8.5.2 In existing installations where service controls are within the hood, additional shutoffs shall be located within 15 m (50 ft) of the hood and shall be accessible and clearly marked.

7.8.6 Auxiliary Air. For auxiliary air hoods, auxiliary air shall be introduced exterior to the hood face in such a manner that the airflow does not compromise the protection provided by the hood and so that an imbalance of auxiliary air to exhaust air will not pressurize the hood interior.

N 7.8.7 Hood Proper Function Alarm.

N 7.8.7.1* A measuring device for indicating that the hood airflow remains within safe design limits shall be provided on each chemical fume hood.

7.8.7.2* The measuring device for hood airflow shall be a permanently installed device and shall provide continuous indication to the hood user of adequate airflow and alert inadequate hood airflow by a combination of an audible and visual alarm. Where an audible alarm could compromise the safety of the user or the research, alternative means of alarm shall be considered.

7.9 Chemical Fume Hood Location.

7.9.1* Chemical fume hoods shall be located in areas of minimum air turbulence.

7.9.2 Chemical fume hoods shall not be located adjacent to a single means of access to an exit or to high-traffic areas.

7.9.3* Work stations not directly related to the chemical fume hood activity shall not be located directly in front of chemical fume hood openings.

7.10 Chemical Fume Hood Fire Protection.

7.10.1* Automatic fire extinguishing systems shall be provided in chemical fume hoods in the following cases:

- (1) Existing hoods having interiors with a flame spread index greater than 25 in which flammable liquids are handled
- (2) If a hazard assessment determines that an automatic extinguishing system is required for the chemical fume hood, then the applicable automatic fire protection system standard shall be followed.

7.10.2 Automatic Fire Protection Systems.

N 7.10.2.1* Automatic fire protection systems, where provided, shall comply with NFPA 11, NFPA 12, NFPA 12A, NFPA 13, NFPA 15, NFPA 17, NFPA 17A, NFPA 69, NFPA 750, and NFPA 2001, as applicable.

7.10.2.2 The fire extinguishing system shall be designed to extinguish fires within the chemical fume hood under the anticipated conditions of use.

7.10.3 Chemical fume 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 or 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.

7.10.4* Chemical fume hoods shall be installed in a manner that prevents fire or smoke from a fire in the chemical fume hood from spreading into the voids above the ceiling.

7.11* Inert Atmosphere Glove Boxes.

7.11.1* Glove boxes shall be designed and operated in accordance with Section 4.1 of ANSI/AIHA Z9.5, *Laboratory Ventilation*.

7.11.2 Glove boxes that are vented shall be vented to the chemical exhaust system.

7.11.3 Glove boxes shall be operated at a positive pressure to keep air and water vapor out of the glove box.

7.11.4 Glove boxes shall be provided with pressure control to limit the pressure inside them.

7.11.5 Pressure relief shall be provided for glove boxes. Reliance on component failure, such as glove blowout, is not considered pressure relief.

7.12 Perchloric Acid Hoods.

7.12.1 Chemical Fume Hood Design.

N 7.12.1.1* Perchloric acid heated above ambient temperatures shall only be used in a chemical fume hood specifically designed for its use and identified as follows:

FOR PERCHLORIC ACID OPERATIONS

7.12.1.2* Perchloric acid shall be permitted to be used in a chemical fume hood that is not specifically designed for perchloric acid operations where the vapors are trapped and scrubbed before they are released into the hood.

7.12.2 Perchloric acid hoods and exhaust ductwork shall be constructed of materials that are acid resistant, nonreactive, and impervious to perchloric acid.

7.12.3 The exhaust fan shall be acid resistant and spark resistant.

7.12.4 The exhaust fan motor shall not be located within the ductwork.

7.12.5 Drive belts shall be conductive and shall not be located within the ductwork.

7.12.6 Ductwork for perchloric acid hoods and exhaust systems shall take the shortest and straightest path to the outside of the building and shall not be manifolded with other exhaust systems.

7.12.6.1 Horizontal runs shall be as short as possible, with no sharp turns or bends.

7.12.6.2 The ductwork shall provide a positive drainage slope back into the hood.

7.12.6.3 Ductwork shall consist of sealed sections.

7.12.6.4 Flexible connectors shall not be used.

7.12.7 Sealants, gaskets, and lubricants used with perchloric acid hoods, ductwork, and exhaust systems shall be acid resistant and nonreactive with perchloric acid.

7.12.8* A water spray system shall be provided for washing down the hood interior behind the baffle and the entire exhaust system.

7.12.8.1 The hood work surface shall be watertight with a minimum depression of 13 mm (½ in.) at the front and sides.

7.12.8.2 An integral trough shall be provided at the rear of the hood to collect washdown water.

7.12.9 The hood baffle shall be removable for inspection and cleaning.

7.12.10* If a chemical fume hood or exhaust system was used for perchloric acid heated above ambient temperature, tests shall be conducted for explosive perchlorates before any inspection, cleaning, maintenance, or any other work is done on any part of the exhaust system or hood interior.

7.12.11 Prior to using a perchloric acid hood for any purpose, the hood shall be water-washed and shall be tested according to 7.12.9 to ensure residual perchlorates are not present.

7.13 Identification of Chemical Fume Hood Systems.

7.13.1* Special-use chemical fume hoods and special-use local exhaust systems shall be identified to indicate their intended use.

7.13.2 A sign containing the following information from the last inspection shall be affixed to each hood, or a properly maintained log of all hoods providing the following information shall be maintained:

- (1) Inspection interval
- (2) Last inspection date
- (3) Average face velocity
- (4) Location of fan that serves hood
- (5) Inspector's name

7.14 Inspection, Testing, and Maintenance.

7.14.1* When installed or modified and at least annually thereafter, chemical fume hoods, chemical fume hood exhaust systems, and laboratory special exhaust systems shall be inspected and tested as applicable, as follows:

- (1) Visual inspection of the physical condition of the hood interior, sash, and ductwork (*see C.2.6.3*)
- (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

7.14.2 Deficiencies in hood performance shall result in immediate suspension of all activities inside the hood until the deficiencies are corrected.