NFPA

45

FIRE PROTECTION FOR

LABORATORIES USING CHEMICALS 1975

NATIONAL FIRE PROTECTION ASSOCIATION, INC.
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Standard on

Fire Protection for Laboratories Using Chemicals

NFPA 45 — 1975

Origin and Development of NFPA 45

NFPA 45 has been developed by the Sectional Committee on Chemistry Laboratories. The standard was tentatively adopted at the 1974 NFPA Annual Meeting. Based on the comments received on the text of the tentative standard, it was amended by the Sectional Committee.

This edition of NFPA 45 was officially adopted at the 1975 Fall Meeting in Pittsburgh, PA on November 19, 1975. The text presented here contains those requirements that the Sectional Committee believes to be essential for protection of life and property in laboratories where hazardous chemicals are handled.

The Sectional Committee wishes to acknowledge that the completion of this standard NFPA 45 is due in large part to the able leadership and untiring efforts of the late Russell H. Scott who served as Chairman of the Sectional Committee on Chemistry Laboratories during the planning and drafting stages of the standard.

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Standard on

Fire Protection for Laboratories Using Chemicals

NFPA 45 — 1975

Foreword

This Standard on Fire Protection for Laboratories Using Chemicals was prepared during 1969–1974 by the Sectional Committee on Chemistry Laboratories. The NFPA assembled and chartered this Committee at the prompting of school, industrial, research and governmental authorities who felt an urgent need for standard guidance in the fire protection of laboratories.

The Standard is divided into ten chapters of requirements. Explanatory, advisory and reference material is in four appendices, which are not part of the Standard.

Appendix A contains explanatory material and recommended good practices. Each Appendix A item is printed at the bottom of the page on which the requirement it relates to is printed. The recommended good practices in Appendix A are those which the Committee feels are desirable supplements to the requirements in the Standard.

Appendices B, C and D are printed at the end of the Standard. Appendix B contains a method of calculating shock waves for explosions; Appendix C contains recommendations for equipment inspection, testing and maintenance; and Appendix D is a list of non-NFPA publications referenced in the Standard.

During the preparation of the Standard, the Committee gathered loss experience. The experience shows that automatic extinguishing systems and particularly sprinkler systems have been effective in minimizing laboratory losses from fire. Noncombustible construction has also been effective in limiting damage. The experience has also drawn attention to the need for 1) better training of laboratory personnel and students in basic fire prevention and conduct in fire emergencies; 2) increased attention to electrically safe systems and equipment; 3) safer storage and handling of flammable liquids and gases and other hazardous chemicals, and 4) better maintenance and inspection of laboratory equipment and ventilation systems. Overall, management commitment to fire loss prevention is essential if persons, property and laboratory operations are to be properly safeguarded against fire and explosion hazards.

Chapter 1 General

1-1 Purpose.

1-1.1 The standard prescribes basic requirements for the protection of life and property in laboratories where hazardous chemicals are handled, through prevention and control of fires and explosions involving hazardous chemicals. The unique nature of many laboratory operations may make more stringent requirements necessary.

1-1.2 The standard is designed to protect persons from the effects of toxic, corrosive, or otherwise hazardous chemicals to which they may be exposed as a result of a fire or explosion. Although it does not attempt to deal with health hazards that are not related to fires or explosions, many of the requirements to protect against fires and explosions, e.g., those for hood exhaust systems, will also serve to protect persons from exposure to nonfire health hazards of chemicals.

1-1.3 The standard has the objective of achieving a comprehensive laboratory fire protection program.

1-2 Scope.

1-2.1 This standard applies to laboratories in which hazardous chemicals are handled or stored.[1]

Exception No. 1. It does not apply to laboratories in buildings in which patient care is provided and that are covered by the Safety Standard for Laboratories in Health-Related Institutions, NFPA 56C — 1973.

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, manufacturing plants.

Exception No. 4. It does not apply to incidental testing facilities for in-process control located within the manufacturing areas.

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[1] For requirements for incidental testing facilities in industrial plants see Flammable and Combustible Liquids Code, NFPA 30 — 1973, Chapter V, Industrial Plants.

1-2.2* This standard contains requirements for conducting laboratory experiments and for handling and storage of hazardous chemicals.

Exception No. 1. It does not cover the special fire protection required when handling explosive materials.

Exception No. 2. It does not cover the special fire protection required when handling radioactive material.

Exception No. 3. It does not contain all-inclusive requirements for conducting laboratory experiments.

1-2.3 Laboratories, laboratory buildings, equipment and installations that do not comply strictly with this Standard shall be considered to be in compliance if it can be shown that equivalent protection has been provided or that no specific hazard will be created or continued through noncompliance.

1-3 **Definitions.** The following terms, for the purpose of this standard, will have the meanings given below.

Combustible Liquid. See Liquids.

Educational Occupancies. Buildings used for the gathering of six or more persons for purposes of instruction, such as schools, universities, colleges, and academies.

Explosive Material.* A chemical compound, mixture or device, the primary or common purpose of which is to function by explosion.

Flammable Gas. A gas that will burn in the normal concentration of oxygen in air.

Flammable Liquids. See Liquids.

Appendix A

Appendix A, which starts here and continues at the foot of other pages of the Standard as necessary, is not a part of the Standard and is included for information purposes only.

A1-2.2 For requirements for storage of explosive material see the Code for the Manufacture, Transportation, Storage and Use of Explosive Materials, NFPA 495 — 1973. For the handling of radioactive material, see Recommended Fire Protection Practice for Facilities Handling Radioactive Materials, NFPA 801 — 1975.

A1-3(a) For a more detailed definition of explosive material see Code for the Manufacture, Transportation, Storage and Use of Explosive Materials, NFPA 495 — 1973.

Flash Point.* The minimum temperature at which a liquid gives off vapor in sufficient concentration to form an ignitible mixture with air near the surface of the liquid within the vessel, as specified by appropriate test procedure and apparatus.

Hazardous Chemical.* A chemical with one or more of the following hazard ratings as defined in *Standard System for the Identification of Fire Hazards of Materials, NFPA 704 — 1975:* Health, 2, 3 or 4; Flammability, 2, 3 or 4; Reactivity, 2, 3 or 4.

Health.

Health 4. Materials which on very short exposure could cause death or major residual injury even though prompt medical treatment were given, including those which are too dangerous to be approached without specialized protective equipment. This degree should include:

Materials which can penetrate ordinary rubber protective clothing;

Materials which under normal conditions or under fire conditions give off gases which are extremely hazardous (i.e., toxic or corrosive) through inhalation or through contact with or absorption through the skin.

Health 3. Materials which on short exposure could cause serious temporary or residual injury even though prompt medical treatment were given, including those requiring protection from all bodily contact. This degree should include:

Materials giving off highly toxic combustion products;

Materials corrosive to living tissue or toxic by skin absorption.

Appendix A (continued)

A1-3(b) The flash point of a liquid having a viscosity less than 45 SUS at 100°F (37.8°C) and a flash point below 200°F (93.4°C), shall be determined in accordance with the Standard Method of Test for Flash Point by the Tag Closed Tester, ASTM D 56–70. (See reference D1 in Appendix D.)

The flash point of a liquid having a viscosity of 45 SUS or more at 100°F (37.8°C) or a flash point of 200°F (93.4°C) or higher shall be determined in accordance with the Standard Method of Test for Flash Point by the Pensky-Martens Closed Tester, ASTM D 93–72. (See reference D15 in Appendix D.)

A1-3(c) For hazard ratings of many chemicals see Hazardous Chemicals Data, NFPA 49 — 1975 and Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids, NFPA 325M — 1969.

Health 2. Materials which on intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given, including those requiring use of respiratory protective equipment with independent air supply. This degree should include:

Materials giving off basic toxic combustion products;

Materials giving off highly irritating combustion products;

Materials which either under normal conditions or under fire conditions give off toxic vapors lacking warning properties.

Flammability.

Flammability 4. Materials which will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature or which are readily dispersed in air, and which will burn readily. This degree should include:

Gases;

Cryogenic materials.

Any liquid or gaseous material which is a liquid while under pressure and having a flash point below 73°F (22.8°C) and having a boiling point below 100°F (37.8°C). (Class IA flammable liquids.)

Materials which on account of their physical form or environmental conditions can form explosive mixtures with air and which are readily dispersed in air, such as dusts of combustible solids and mists of flammable or combustible liquid droplets.

Flammability 3. Liquids and solids that can be ignited under almost all ambient temperature conditions. Materials in this degree produce hazardous atmospheres with air under almost all ambient temperatures or, though unaffected by ambient temperatures, are readily ignited under almost all conditions. This degree should include:

Liquids having a flash point below 73°F (22.8°C) and having a boiling point at or above 100°F (37.8°C) and those liquids having a flash point at or above 73°F (22.8°C) and below 100°F (37.8°C).

Solid materials in the form of coarse dusts which may burn rapidly but which generally do not form explosive atmospheres with air;

Solid materials in a fibrous or shredded form which may burn rapidly and create flash fire hazards, such as cotton, sisal and hemp;

Materials which burn with extreme rapidity, usually, by reason of self-contained oxygen (e.g., dry nitrocellulose and many organic peroxides);

Materials which ignite spontaneously when exposed to air.

Flammability 2. Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur. Materials in this degree would not under normal conditions form hazardous atmospheres with air, but under high ambient temperatures or under moderate heating may release vapor in sufficient quantities to produce hazardous atmospheres with air. This degree should include:

Liquids having a flash point above 100°F (37.8°C), but not exceeding 200°F (93.4°C);

Solids and semisolids which readily give off flammable vapors.

Reactivity.

Reactivity 4. Materials which in themselves are readily capable of detonation or of explosive decomposition or explosive reaction at normal temperatures and pressures. This degree should include materials which are sensitive to mechanical or localized thermal shock at normal temperatures and pressures.

Reactivity 3. Materials which in themselves are capable of detonation or of explosive decomposition or explosive reaction but which require a strong initiating source or which must be heated under confinement before initiation. This degree should include materials which are sensitive to thermal or mechanical shock at elevated temperatures and pressures or which react explosively with water without requiring heat or confinement.

Reactivity 2. Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. This degree should include materials which can undergo chemical change with rapid release of energy at normal temperatures and pressures or which can undergo violent chemical change at elevated temperatures and pressures. It should also include those materials which may react violently with water or which may form potentially explosive mixtures with water.

Instructional Laboratory Unit. A laboratory unit in an educational occupancy in which the person or persons conducting chemical experiments or tests are under the direct supervision of a faculty member or his assistant. Laboratory units used for graduate or post-graduate research shall not be considered instructional laboratory units.

Laboratory. A room or space for testing, analysis, research, instruction or similar activities which involves the use of chemical materials.

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

Laboratory Apparatus. Furniture, laboratory hoods, centrifuges, refrigerators, and commercial or made-on-site apparatus used in a laboratory.

Laboratory Equipment. See Laboratory Apparatus.

Laboratory Unit.* An enclosed space used for experiments or tests. Laboratory units may include offices, lavatories and other contiguous rooms maintained for or used by laboratory personnel and include corridors within the units. A laboratory unit may contain any number of separate laboratories.

Class A Laboratory Unit. A laboratory unit in which the quantities of flammable or flammable and combustible liquids exceed those for a Class B laboratory unit as shown in Table 2-1 but do not exceed those shown for a Class A laboratory unit.

Class B Laboratory Unit. A laboratory unit in which the quantities of flammable or flammable and combustible liquids exceed those for a Class C laboratory unit as shown in Table 2-1 but do not exceed those shown for a Class B laboratory unit.

Class C Laboratory Unit. A laboratory unit in which the quantities of flammable or flammable and combustible liquids do not exceed those shown for a Class C laboratory unit as shown in Table 2-1.

Laboratory Unit Separation. All walls, partitions, floors and ceilings, including openings in them, between a laboratory unit and adjoining areas in the building.

Liquids. Any material which has a fluidity greater than that of 300 penetration asphalt when tested in accordance with ASTM Test for Penetration of Bituminous Materials, D 5-71. When not otherwise identified, the term liquid shall include both flammable and combustible liquids. *(See Reference D26 in Appendix D.)*

Appendix A (continued)

A1-3(d) See Chapter 3 for requirements for enclosure of laboratory units.

Combustible Liquid shall mean a liquid having a flash point at or above 100°F (37.8°C).

Combustible Liquids shall be subdivided as follows:

Class II Liquids shall include those having flash points at or above 100°F (37.8°C) and below 140°F (60°C).

Class III Liquids shall include those with flashpoints at or above 140°F (60°C). Class III Liquids shall be subdivided in two subclasses: Class III A Liquids shall include those with flashpoints at or above 140°F (60°C) and below 200°F (93.4°C). Class III B Liquids shall include those with flashpoints at or above 200°F (93.4°C).

Flammable Liquid shall mean a liquid having a flash point below 100°F (37.8°C) and having a vapor pressure not exceeding 40 pounds per square inch (absolute) at 100°F (37.8°C) and shall be known as Class I liquid.

Class I liquids shall be subdivided as follows:

Class IA shall include those having flash points below 73°F (22.8°C) and having a boiling point below 100°F (37.8°C).

Class IB shall include those having flash points below 73°F (22.8°C) and having a boiling point at or above 100°F (37.8°C).

Class IC shall include those having flash points at or above 73°F (22.8°C) and below 100°F (37.8°C).

Nonlaboratory Area. Any space within a building not included in a laboratory unit. *(See definition of Laboratory Unit.)*

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

Potentially Explosive Reaction. Any chemical procedure that uses or forms reactive materials.

Reactive Material. A material that by itself is readily capable of detonation or of explosive decomposition or explosive reaction at normal or elevated temperatures and pressures. *(See also, in definition of Hazardous Material, the definitions of Reactivity 3 and Reactivity 4.)*

Safety Can. An approved container, of not more than five gallons capacity, having a spring-closing lid and spout cover and so designed that it will safely relieve internal pressure when subjected to fire exposure.

Storage Cabinet. A cabinet for the storage of flammable and combustible liquids that is constructed in accordance with the requirements for storage cabinets for flammable and combustible liquids in the *Flammable and Combustible Liquids Code, NFPA 30 — 1973.*

Storage Room. A room for the storage of flammable and combustible liquids that is cut off from surrounding areas and constructed and ventilated in accordance with the requirements for inside storage rooms for flammable and combustible liquids in the *Flammable and Combustible Liquids Code, NFPA 30 — 1973.*

Story. That portion of a building included between the upper surface of a floor and the upper surface of the floor or roof next above.

Street Floor. Street floor means any story or floor level accessible from the street or from outside the building at ground level with floor level at main entrance not more than three risers above or below ground level at these points, and so arranged and utilized to qualify as the main floor. When, due to differences in street levels, there are two or more stories accessible from the street, each is a street floor.

Unattended Laboratory Operation. No person present who is knowledgeable regarding the operation and emergency shutdown procedures.

1-4 Interface with Existing Standards and Codes.

1-4.1 Where areas of interface with existing NFPA and other consensus standards and codes occur, reference is made to the appropriate source in the text.

1-4.2 Where necessary, due to the special nature of laboratories, existing standards and codes are supplemented in this text so as to apply more specifically to buildings or portions of buildings devoted to laboratory usage.

1-4.3 Where a construction or protection requirement of a governmental agency having jurisdiction is more stringent than that in this standard, the more stringent requirement shall apply.

Chapter 2 Laboratory Unit Hazard Classification

2-1 General. This chapter classifies laboratory units on the basis of the amount of flammable and combustible liquids present and defines when a fire or explosion hazard exists.

2-1.1 Fire Hazard Classification.

2-1.1.1* Laboratory units shall be classified as Class A, B or C according to the quantities specified in Table 2-1.

2-1.1.2 Class A laboratory units shall not be used as instructional laboratory units and the maximum quantities of flammable and combustible liquids in Class B and Class C instructional laboratory units shall be 50 percent of that in Table 2-1.

Appendix A (continued)

***A2-1.1.1** Six conditions can affect the classification of a laboratory unit: 1, the quantity of Class I liquids per unit area; 2, the combined quantities of Classes I, II and IIIA liquids per unit area; 3, the area of the laboratory unit; 4, the quantity of Class I liquids in safety cans and storage cabinets; 5, the combined quantities of Classes I, II and IIIA liquids in safety cans and storage cabinets; and 6, the presence of automatic sprinkler protection or other approved automatic fire extinguishing system.

Example 1. A 5000 square foot unsprinklered laboratory unit containing 75 gallons of Class I liquids, 125 gallons of Class II liquids, and 75 gallons of Class IIIA liquids (excluding quantities in storage cabinets and safety cans). This is a Class A laboratory unit. Reason: Although neither the quantity of Class I liquids per 100 square feet (2.5 gallons) nor the combined quantity of Classes I, II and IIIA liquids per 100 square feet (5.5 gallons) exceeds the quantities per 100 square feet permitted for a Class B laboratory (5 and 10 gallons respectively) the total quantity of Classes I, II and IIIA liquids (275 gallons) exceeds that permitted in an unsprinklered Class B laboratory unit (200 gallons) but does not exceed that permitted in a Class A unit (400 gallons).

Example 2. The same laboratory unit as in Example 1 except that it is protected by sprinklers. This is a Class B laboratory unit. Reason: The total quantity of Classes I, II and IIIA liquids (275 gallons) exceeds that permitted in a sprinklered Class C laboratory unit (200 gallons) but does not exceed that permitted in a sprinklered Class B unit (400 gallons).

Example 3. The same laboratory unit as in Example 2 but with an additional 200 gallons of Class I, 400 gallons of Class II and 300 gallons of Class IIIA liquids in storage cabinets and safety cans. This is a Class A laboratory unit. Reason: The total quantity of liquids (1175 gallons) exceeds that permitted in a sprinklered Class B laboratory unit (800 gallons) but does not exceed that permitted in a Class A unit (1600 gallons).

Example 4. An unsprinklered 1000 square foot laboratory unit containing the same quantities of liquids as in Example 1. A 1000 square foot laboratory unit with those quantities is not permitted. Reason: The combined quantity per 100 square feet of Classes I, II and IIIA liquids (27.5 gallons) exceeds that permitted in a Class A laboratory unit (20 gallons).

Table 2-1. Maximum Quantities of Flammable and Combustible Liquids in Laboratory Units[1] Outside of Approved Flammable Liquid Storage Rooms

Laboratory Unit Class	Flammable or Combustible Liquid Class	*Excluding* Quantities in Storage Cabinets and Safety Cans			*Including* Quantities in Storage Cabinets and Safety Cans		
		Maximum Quantity[2] Per 100 Square Feet of Laboratory Unit	Maximum Allowable Quantity[2] Per Laboratory Unit		Maximum Quantity[2] Per 100 Square Feet of Laboratory Unit	Maximum Allowable Quantity[2] Per Laboratory Unit	
			Unsprinklered	Sprinklered[5]		Unsprinklered	Sprinklered[5]
A	I	10 Gallons	300 Gallons	600 Gallons	20 Gallons	600 Gallons	1200 Gallons
	I, II and IIIA[4]	20 Gallons	400 Gallons	800 Gallons	40 Gallons	800 Gallons	1600 Gallons
B	I	5 Gallons	150 Gallons	300 Gallons	10 Gallons	300 Gallons	600 Gallons
	I, II and IIIA[4]	10 Gallons	200 Gallons	400 Gallons	20 Gallons	400 Gallons	800 Gallons
C	I	2 Gallons	75 Gallons	150 Gallons	4 Gallons	150 Gallons	300 Gallons
	I, II and IIIA[4]	4 Gallons	100 Gallons	200 Gallons	8 Gallons	200 Gallons	400 Gallons

[1] Class A Laboratory Units shall not be used as instructional laboratory units and the maximum quantities of flammable and combustible liquids in Class B and Class C Instructional Laboratory Units shall be 50% of those in Table 2-1.

[2] For maximum container sizes see Table 7-1.

[3] Regardless of the maximum allowable quantity, the maximum amount in a laboratory unit shall never exceed that calculated by using the maximum quantity per 100 square feet.

[4] The maximum quantities of Class I liquids shall not exceed the quantities specified for Class I liquids alone.

[5] In laboratory units where water creates a serious fire or personnel hazard, a nonwater extinguishing system may be substituted for sprinklers.

2-1.1.3 Maximum capacity of containers in laboratory units shall comply with Table 7-1 and paragraph 7-2.3.4.

2-1.1.4 Requirements for laboratory units in this standard shall apply to all laboratory units unless identified as applying to a laboratory unit of a specific hazard class.

2-1.1.5 For construction and fire protection requirements for laboratory units, see Chapters 3 and 4.

2-1.2 Explosion Hazard Classification.

2-1.2.1* A laboratory shall be considered to contain an explosion hazard if the explosion of the quantities or concentrations of materials in items (a) through (e) below could cause serious or fatal injuries to personnel *within* the laboratory in an explosion.

(a)* The storage of materials with a reactivity of 4.

(b)* The use or formation of materials with a reactivity of 3 or 4.

(c) Highly exothermic reactions, e.g., polymerizations, oxidations, nitrations, peroxidations, hydrogenations or organo-metallic reactions.

(d) The use or formation of materials whose structures indicate a potential hazard but whose properties have not been established, e.g., triple bonds, epoxy radicals, nitro and nitroso compounds and peroxides.

(e)* High pressure reactions.

2-1.2.2 If the explosion hazard in a laboratory could cause major property damage or serious injury *outside* the laboratory, the *laboratory unit* of which it is a part shall be considered to contain an explosion hazard.

Appendix A (continued)

A2-1.2.1 An explosion overpressure of 6 psi is sufficient to shatter an unreinforced concrete or cinder-block wall 8 in. to 12 in. thick, shatter transite or gypsum board, buckle steel or aluminum paneling or buckle 2 in. by 6 in. wood beams. A formula and graph for estimating the peak reflected pressure is included in Appendix B. The source is "Structures to Resist the Effects of Accidental Explosions," *(See reference D2 in Appendix D.)*

WARNING: Persons in the immediate vicinity of an explosion in a laboratory unit may be injured or killed even though the explosion does not cause major damage.

2-1.2.3 For explosion hazard protection, see Chapter 5.

Appendix A (continued)

A2-1.2.1(a) & (b) For reactivity ratings of many chemicals see Hazardous Chemicals Data, NFPA 49 — 1975 and Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids, NFPA 325M — 1969.

A2-1.2.1e Items a through h below contain recommendations for classifying reactions in vessels as high pressure and low pressure and contain recommendations for protecting against explosion hazards of reactions conducted at above atmospheric pressures.

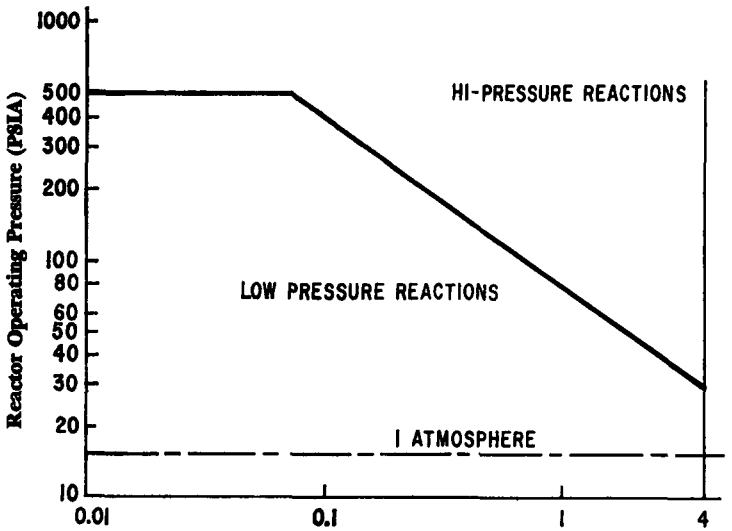

Figure A2-1.2.1e

a. Reaction below the curve in Figure A2-1.2.1e should be classified as low pressure reactions.

b. Reactions above the curve in Figure A2-1.2.1e should be classified as high pressure reactions.

c. High pressure experimental reactions should be conducted behind substantial fixed barricades able to withstand lateral forces of at least 1 psi static loading without fragmenting. The barricades should be firmly supported at the top and bottom to take those loads. At least one wall should be explosion venting. *(See Chapter 5 and see the Guide for Explosion Venting, NFPA 68 — 1974.)*

d. Experimental reactions that are known to involve materials inherently unstable, such as reactions with acetylenic compounds and certain oxidations such as halogenations and nitrations, should be barricaded even if, because of the pressures and volumes, they fall below the curve in Figure A2-1.2.1e. *(See items a, b and c under 2-1.2.1.)*

Appendix A (continued)

e. Routine reactions where pressures and temperatures are expected between certain predetermined limits based on long experience or routine work need not be conducted behind barricades if the vessels comply with items f and g below.

f. Vessels should be built of suitable materials of construction and have an adequate safety factor.

g. All vessels should be provided with pressure relief in the form of a safety relief valve or a rupture disc. *(See 9-2.6.)*

h. Low pressure reactions, if it is deemed necessary to do so, should be conducted in hoods or behind portable barricades.

A2-1.2.2 If an explosion hazard can be contained in the explosion hazard laboratory by means of protection as outlined in Chapter 5, Explosion Hazard Protection, the laboratory unit of which it is a part need not be protected.

Chapter 3 Laboratory Construction and Design

3-1* Laboratory Unit Enclosure.

3-1.1 The required construction of laboratory units depends on the laboratory unit fire hazard classification, the area and the protection to be provided.

3-1.2 The construction requirements are the minimum permitted and do not exclude the use of construction with greater fire resistance.

3-1.2.1 Laboratory units shall be separated from non-laboratory spaces by construction equal to or greater than the fire-resistance requirements shown in Table 3-1.

3-1.2.2 Laboratory units shall be separated from other laboratory units of equal or lesser hazard class by construction meeting or exceeding the fire-resistance requirements shown in Table 3-1.

3-1.2.3 Laboratory units shall be separated from other laboratory units of a higher hazard class by construction meeting or exceeding the separation requirements for the higher hazard class shown in Table 3-1.

3-2 Maximum Area of Laboratory Units.

3-2.1* The maximum area of a laboratory unit shall be determined by the fire hazard classification, the construction of the building, and the fire protection provided as shown in Table 3-1.

3-3 Means of Egress Requirements.

3-3.1 Means of Egress in Laboratory Buildings.

3-3.1.1 Means of egress requirements for a laboratory building shall comply with the exit requirements specified for the occupancy of the building in the *Code for Safety to Life from Fire in Buildings and Structures, NFPA 101 — 1973.* Laboratory

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Appendix A (continued)

A3-1 Consideration should be given to providing proper drainage for flammable liquids and water used for fire extinguishment.

A3-2.1 The types of construction in Table 3-1 are defined in *Standard Types of Building Construction, NFPA* 220 — 1975.

Table 3-1. Construction and Fire Protection Requirements for Laboratory Units[1]

Laboratory Unit Class	Area of Laboratory Unit	Nonsprinklered Laboratory Units				Sprinklered Laboratory Units[2]	
		In Fire-resistive, Protected Noncombustible or Noncombustible Buildings		In Heavy Timber, Ordinary or Wood Frame Buildings		Any Building or Laboratory Construction	
		Separation from Nonlaboratory Areas[3]	Separation from Laboratory Units of Equal or Lower Hazard Class[3]	Separation from Nonlaboratory Areas[3]	Separation from Laboratory Units of Equal or Lower Hazard Class[3]	Separation from Nonlaboratory Areas[3]	Separation from Laboratory Units of Equal or Lower Hazard Class[3]
A	Under 1000 Sq. Ft.	1 Hour	1 Hour	2 Hours	1 Hour	1 Hour	Noncombustible[4]
	1001–2000 Sq. Ft.	1 Hour	1 Hour	Not Permitted		1 Hour	Noncombustible[4]
	2001–5000 Sq. Ft.	2 Hour	1 Hour	Not Permitted		1 Hour	Noncombustible[4]
	5001–10,000 Sq. Ft.	Not Permitted		Not Permitted		1 Hour	1 Hour
	10,001 or more Sq. Ft.	Not Permitted		Not Permitted		Not Permitted	
B	Under 20,000 Sq. Ft.	1 Hour	Noncombustible[4]	1 Hour	1 Hour	Noncomb.[4, 5]	Noncombustible[4]
	20,001 or more Sq. Ft.	Not Permitted		Not Permitted		Not Permitted	
C	Under 10,000 Sq. Ft.	1 Hour	Noncombustible[4]	1 Hour	Noncombustible[4]	Noncomb.[4, 5]	No Requirement
	10,001 or more Sq. Ft.	1 Hour	Noncombustible[4]	1 Hour	1 Hour	Noncomb.[4, 5]	Noncombustible[4]

[1] Where a laboratory unit contains an explosion hazard, appropriate explosion protection shall be provided for adjoining laboratory units and nonlaboratory areas as specified in Chapter 5.

[2] In laboratory units where water creates a serious fire or personnel hazard, a nonwater extinguishing system may be substituted for sprinklers.

[3] For a discussion of fire resistance of building materials, including the resistance of wall, partition, floor and ceiling construction see "Fire Protection Handbook," Boston, NFPA, 1969, Thirteenth Edition, pages 8-86 — 8-124. For information on the fire resistance, installation, and maintenance requirements of Fire Doors, see NFPA 80–*Standard for Fire Doors and Windows*.

[4] May be ½-hour fire resistance rated combustible construction in lieu of noncombustible construction separation.

[5] In educational occupancies laboratory units shall be separated from nonlaboratory areas by construction having not less than one-hour fire-resistance.

buildings shall comply with the exit requirements for general purpose industrial buildings except that such buildings as educational institutions shall comply with the exit requirements for educational occupancies.

3-3.2 Additional Exit Access.

3-3.2.1* A second means of access to an exit shall be provided from a laboratory if any of the following conditions exist:

(a) A hood in a laboratory within a Class A or Class B laboratory unit is located adjacent to the door.

(b) A laboratory within a Class A unit exceeds 500 square feet.

(c) A laboratory within a Class B or Class C unit exceeds 1,000 square feet.

3-3.2.2 The doors of all Class A and Class B laboratories and laboratory units shall swing in the direction of egress.

3-3.3 Furniture and Equipment.

3-3.3.1 Furniture and laboratory equipment in laboratories shall be so arranged that means of access to an exit may be reached easily from any point.

3-3.4 Electrical Systems.

3-3.4.1 All electrical installations including wiring and appurtenances, apparatus, lighting, signal systems, alarm systems, remote control installations, communication systems and emergency power systems or parts thereof, shall be in conformance with the provisions of the *National Electrical Code, NFPA 70 — 1975.*

3-3.4.2 Laboratories shall be considered as unclassified electrically, with respect to the *National Electrical Code, NFPA 70 — 1975 Article 500.*

Exception. Under some conditions of extraordinary hazard, it may be necessary to classify a laboratory or a part thereof as a hazardous location, for the purpose of designating suitable electrical installations. (See 9-2.3.1 and 9-2.5.1 for examples).

Appendix A (continued)

A3-3.2.1 A door to an adjoining laboratory is considered to be a second access to an exit.

Chapter 4 Fire Protection

4-1 General.

4-1.1 All laboratory units shall have fire protection appropriate to the fire hazard as follows:

(a) Portable fire extinguishers *(see Section 4-4).*

(b) An alarm system *(see Section 4-5).*

(c) An evacuation and emergency plan *(see Section 4-6).*

4-1.2 In addition to the fire protection specified in 4-1.1, laboratory units under some conditions shall be provided with (a) automatic extinguishing systems *(see Section 4-2),* and (b) inside standpipe and hose systems *(see Section 4-3).*

4-2 Automatic Fire Extinguishing Systems.

4-2.1* General.

4-2.1.1 An automatic fire extinguishing system may be required in a laboratory unit, depending upon the construction of the building, the hazard class of the laboratory unit, the construction of its enclosure, and its area. Table 3-1 in Chapter 3, which shows the interrelationship of hazard class, automatic protection, construction, and area, shall be followed.

4-2.2 Automatic Sprinkler Systems.

4-2.2.1 Automatic sprinklers for Class A laboratory units shall be designed for extra hazard occupancies or shall be hydraulically calculated for Ordinary Hazard Group 3, as specified in the *Standard for the Installation of Sprinkler Systems, NFPA 13 — 1975.*

Appendix A (continued)

A4-2.1 The automatic fire extinguishing system should be an automatic sprinkler system. If extinguishment or control may be more effectively accomplished by a type of automatic extinguishing system that does not use water, it may be advisable to install another type of extinguishing system in lieu of sprinklers.

4-2.2.2. Automatic sprinklers for Class B laboratory units shall be designed for ordinary hazard occupancies or shall be hydraulically calculated for Ordinary Hazard Group 2, as specified in the *Standard for the Installation of Sprinkler Systems, NFPA 13 — 1975.*

4-2.2.3 Automatic sprinklers for Class C laboratory units shall be designed for ordinary hazard occupancies or shall be hydraulically calculated for Ordinary Hazard Group 1, as specified in the *Standard for the Installation of Sprinkler Systems, NFPA 13 — 1975.*

4-2.2.4 Automatic sprinkler systems shall be inspected regularly, cared for properly and maintained in service. *(See Recommended Practice for the Care and Maintenance of Sprinkler Systems, NFPA 13A — 1971.)*

4-2.3 Other Automatic Extinguishing Systems.

4-2.3.1 Nonwater automatic extinguishing systems or special hazard extinguishing systems when required, shall be designed, installed and maintained in accordance with the appropriate standards:

(a) *Standard on Carbon Dioxide Extinguishing Systems, NFPA 12 — 1973.*

(b) *Standard on Halogenated Fire Extinguishing Agent Systems — Halon 1301, NFPA 12A — 1973.*

(c) *Standard on Halogenated Fire Extinguishing Agent Systems — Halon 1211, NFPA 12B — 1973.*

(d) *Standard for Dry Chemical Extinguishing Systems, NFPA 17 — 1975.*

(e) *Standard for Foam Extinguishing Systems, NFPA 11 — 1975.*

(f) *Standard for High Expansion Foam Systems, NFPA 11A — 1970.*

(g) *Standard for Water Spray Fixed Systems for Fire Protection, NFPA 15 — 1973.*

(h) *Standard on Explosion Prevention Systems, NFPA 69 — 1973.*

4-2.4 The discharge of an automatic fire extinguishing system shall activate an audible alarm system on the premises.

4-3 Standpipe and Hose Systems.

4-3.1* In all unsprinklered laboratory buildings with two or more stories above or below the street floor, a standpipe with 2½-inch hose connections shall be provided for use by the fire brigade or fire department.

4-3.2 Standpipes shall be installed in conformance with the requirements in the *Standard for the Installation of Standpipe and Hose Systems, NFPA 14 — 1974.*

4-3.3 Hose shall be of an approved type and shall be tested and cared for in accordance with the *Standard for Care of Fire Hose, NFPA 198 — 1972.*

4-3.4 Standpipes and hose systems shall be inspected and maintained in accordance with the *Standard for the Installation of Standpipe and Hose Systems, NFPA 14 — 1974.*

4-4 Portable Fire Extinguishers.

4-4.1 Portable fire extinguishers shall be installed, located, and maintained in accordance with the *Standard for the Installation of Portable Fire Extinguishers, NFPA 10 — 1975.* Class A laboratory units shall be graded as extra hazard, and Class B and C laboratory units as ordinary hazard.

4-5 Alarm Systems.

4-5.1 A manual fire alarm system shall be installed in a laboratory building if a fire may not of itself provide adequate warning to building occupants.

4-5.2 Fire alarm systems and fire detection systems, where required, shall be installed and maintained in accordance with one of the following:

(a) *Standard for the Installation, Maintenance and Use of Central Station Signaling Systems, NFPA 71 — 1974.*

Appendix A (continued)

A4-3.1 In all laboratory buildings 1½-inch hose connections with hose and combination straight stream and fog nozzle should be provided for use by occupants. Waterflow from the standpipe system should activate a fire alarm.

(b) *Standard for the Installation, Maintenance and Use of Local Protective Signaling Systems for Watchman, Fire Alarm and Supervisory Service, NFPA 72A — 1975.*

(c) *Standard for the Installation, Maintenance and Use of Auxiliary Protective Signaling Systems for Fire Alarm Service, NFPA 72B — 1975.*

(d) *Standard for the Installation, Maintenance and Use of Remote Station Protective Signaling Systems, NFPA 72C — 1975.*

(e) *Standard for the Installation, Maintenance and Use of Proprietary Protective Signaling Systems for Watchman, Fire Alarms and Supervisory Service, NFPA 72D — 1975.*

(f) *Standard for the Installation, Maintenance and Use of Automatic Fire Detection Systems, NFPA 72E — 1974.*

4-5.2.1 Signal transmission for alarms designed to activate signals at more than one location shall be verified at each location during each inspection of the alarm system.

4-5.3 The fire alarm system, where required, shall be so designed that all personnel endangered by the fire condition or a contingent condition will be alerted.

4-5.4 The fire alarm system shall alert a local fire brigade or public fire department.

4-6 Fire Loss Prevention.

4-6.1 Emergency Procedures.

4-6.1.1* Procedures for laboratory emergencies shall be developed. Such procedures shall include alarm actuation, evacuation and equipment shutdown procedures, and provisions for fire-fighting action including specific detailed plans for fire control operations by an emergency control organization or a public fire department. (For additional information on fire loss prevention organization, see *Recommendations for Organizations of Industrial Loss Prevention, NFPA 6 — 1974.)*

Appendix A (continued)

A4-6.1.1 Emergency telephones are of value when they are connected directly to an emergency office and when they are located within the laboratory building so that they can be readily used by laboratory personnel and also when they are available at an exterior location for use by evacuees or passersby. An emergency telephone system should be inter-connected with a mass notification system such as a public address system.

a. *Evacuation procedures.* The management of each laboratory or laboratory building covered by this standard should be responsible for promulgating and distributing an appropriate evacuation plan for the facility. The plan

4-6.1.2* Emergency procedures for extinguishing clothing fires shall be established.

Appendix A (continued)

should be written with accompanying diagrams and distributed to each supervisor and posted in appropriate locations for all employees to read and study. In addition to fires and explosions, the evacuation plan should also consider other hazardous events such as spills, leaks or releases of flammable, toxic or radioactive materials and acts of nature, such as tornadoes, hurricanes and floods.

The evacuation plan should cover, but not be limited to describing:

(1) Under what conditions evacuation will be necessary.

(2) Method of alarm transmission.

(3) Action to be taken on receipt of alarm in addition to evacuation (i.e., turn off flames, other ignition sources).

(4) Exit routes: Primary and alternate routes to horizontal and vertical exits leading to the exterior of the building or safe refuge zones as may be permitted if total evacuation of the facility is not required and the alarm system is appropriately zoned.

(5) Instructions necessary to prevent evacuees from hampering fire fighters, or emergency organization from proceeding with essential duties (i.e., move away from the building to a pre-designated area).

(6) Accountability to determine if everyone has left the facility: Wardens or supervisors instructed on sound of the alarm to check all occupied spaces in their assigned area to ensure that everyone has heard the alarm and is evacuating. Personnel from particular groups, departments, floors or areas to gather in a predesignated area outside of the building or in the safe refuge zone. Special procedures established for evacuation of handicapped persons. Floor or area fire warden or group supervisor to have responsibility to account for everyone. (Normal sign-in-sign-out procedures may be helpful if they also include visitors and guests.)

(7) Methods to notify personnel when it is safe to re-enter the facility. (Dependence on duly authorized persons, such as wardens, to pass this word will prevent someone from entering the facility prematurely.)

b. Laboratories should hold fire exit drills at least once a year to test the evacuation procedure by familiarizing occupants with exits, particularly emergency exits not normally used, and their safe and efficient use.

NOTE: For required frequency of fire exit drills in educational occupancies, see "Code for Safety to Life from Fire in Buildings and Structures," NFPA 101 — 1973. *Fire exit drills* differ from *fire drills* in that the latter are held for the purpose of fire fighting practice by the fire brigade or other emergency organizations. Since a conflict exists between evacuation and fire fighting, management should appoint different persons to be responsible for each procedure, as one cannot effectively direct fire fighting operations and evacuation simultaneously.

c. Fire alarm systems, where available, should be used in the conduct of fire exit drills. No one should be excused from participating in a drill as it may fail its intended purpose in a real fire.

A4-6.1.2 Laboratory personnel should be thoroughly indoctrinated on procedures to follow in cases of clothing fires. The single, most important instruction in such cases, one which should be stressed until it becomes second nature to all personnel, is to immediately drop to the floor and roll. They also should

Chapter 5 Explosion Hazard Protection

5-1 General.

5-1.1 When a laboratory or laboratory unit is considered to contain an explosion hazard as defined in 2-1.2.1 and 2-1.2.2, appropriate protection shall be provided to protect the occupants of the laboratory, laboratory unit, of adjoining laboratory units and of nonlaboratory areas.

5-1.2 Protection shall be provided by one or more of the following:

(a) Providing special preventive or protective measures for the reactions, equipment or materials themselves, e.g., explosion suppression, high speed fire detection with deluge sprinklers or explosion-resistant enclosures. (See 4-2.3.1.)

(b) Using remote control to minimize personnel exposure.

(c) Carrying out experiments in a detached or isolated building, or outdoors.

(d) Providing explosion-resistant walls or barricades for the hazardous laboratory.

(e) Limiting amounts of flammable or reactive chemicals exposed by experiments.

(f) Providing explosion venting in outside walls sufficient to maintain the integrity of the walls separating the hazardous laboratory unit from adjoining areas.

5-2 Explosion-Resistant Construction.

5-2.1 When explosion-resistant construction is used, adequately designed explosion resistance shall be achieved by one of the following:

(a) Reinforced concrete walls.

(b) Rodded and filled concrete block walls.

(c) Steel walls.

(d) Steel plate walls with energy-absorbing lining.

(e) Barricades such as those used for explosives operations constructed of reinforced concrete, sand-filled wood sandwich, wood-lined steel plate, earth or rock berm.

4-6.2 Fire Prevention Procedures.

4-6.2.1 Fire prevention procedures shall be established. The following critical areas require special considerations: handling and storage of flammable and combustible liquids or gases; handling and storage of hazardous materials; open flame and spark-producing work permit system; arrangement and use of portable electric cords; and smoking area controls.

4-6.3* Maintenance Procedures. Maintenance procedures shall be established. Such procedures shall include the inspection, testing and maintenance of:

(a) Utilities — steam, gas, electrical

(b) Air supply and exhaust systems

(c) Fire protection equipment

(d) Detectors and alarms

(e) Pressure and temperature relief valves

(f) Waste disposal system

(g) Fire doors

Appendix A (continued)

recognize that, in the event of another person's clothing igniting, they should immediately knock that person to the floor and roll that person around to smother the flames. Too often a person will panic if his clothing ignites and run, resulting in painful, often fatal, burn injuries.

Laboratory personnel should recognize that safety showers or fire blankets are of secondary importance. They should only be used when immediately at hand. They should further recognize that rolling on the floor does not merely smother the fire. It aids in keeping flames out of the face, especially the eyes. Also, inhalation of smoke and heat is greatly reduced.

A4-6.3 Successful prevention or extinguishment of fires and protection of personnel from injury due to fire or contingent conditions requires an adequate maintenance program. Appendix C outlines additional advisable equipment inspection, testing and maintenance programs for a laboratory beyond those required by this Standard.

5-3* Explosion Venting.

5-3.1 When explosion venting is used, explosion venting shall be designed and located so that:

(a) Fragments will not strike other occupied buildings or areas or

(b) Blast mats, energy-absorbing barrier walls or earth or rock berms will interrupt the flight of fragments.

5-4 Unauthorized Access.

5-4.1 Appropriate doors, gates, fences or other barriers properly posted shall be provided to prevent or restrict access to explosion hazard laboratories and to the space between the explosion venting means and the fragment barrier.

Appendix A (continued)

A5-3 Guidance on venting explosions of flammable vapors, gases and dusts is contained in the *Guide for Explosion Venting, NFPA 68 — 1974.* Information on explosion-resistant construction is available in several publications (see references D2, D3, D17, D18, D19, D20, D21 and D22 in Appendix D.)

Chapter 6 Ventilating Systems

6-1 General.

6-1.1 Basic Standards.

6-1.1.1 Except as supplemented by the requirements of this chapter, duct systems for laboratory heating and ventilating, including warm air heating systems, general ventilating systems, air cooling systems, and laboratory exhaust and hood exhaust systems, shall comply with the *Standard for the Installation of Air Conditioning and Ventilating Systems, NFPA 90A — 1975,* and with the *Standard for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying, NFPA 91 — 1973,* as these systems particularly relate to laboratory installations.

6-2 Supply Systems.

6-2.1 Outside Air Source.

6-2.1.1 The location of fresh air intakes shall be chosen to avoid drawing in flammable or toxic materials of byproducts of combustion coming either from the laboratory building itself or other structures and devices.

6.2.2 Air Distribution.

6.2.2.1* Laboratories in which flammable materials are stored or used shall be maintained air negative to the corridors or adjacent non-laboratory spaces during laboratory operations.

Exception No. 1: Where operational activities such as those requiring clean rooms preclude a negative pressure in relation to surrounding spaces, special precautions shall be taken to prevent escape of the atmosphere in the laboratory to the surrounding spaces.

Exception No. 2: Laboratories in which not more than one liter of flammable liquids or not more than 30 standard cubic feet of flammable compressed gases are used are excluded from this requirement.

6-2.2.2. Care shall be exercised in the placement of air supply diffusion devices to avoid air currents that would adversely affect the capture velocity of laboratory hoods.

Appendix A (continued)

A6-2.2.1 Provision should be made so that recirculation of environmental air may be immediately interrupted in the event of a spill or release of dangerous quantities of toxic or flammable materials.

6-3 Exhaust System.

6-3.1 Exhaust Air Discharge.

6-3.1.1 Air exhausted from laboratory hoods shall not be recirculated.

6-3.1.2 Air exhausted from laboratory spaces or apparatus to the outside shall not pass unducted through other spaces.

6-3.1.3* Air containing flammable or toxic material shall be discharged in ductwork systems maintained at a negative pressure in relation to the pressure in the surrounding space within the building.

Exception: The pressure in the ductwork system need not be negative in relation to the air pressure of the surrounding space if special precautions are taken to prevent discharge of materials through the walls of the ducts. Portions of the ductwork systems which are under positive pressure shall be seamless, braised, welded or soldered construction to prevent escape of materials through the walls of the ducts.

6-3.1.4* Laboratory hood face velocities shall be sufficient to assure a capture velocity into the hood for the operating conditions.

Appendix A (continued)

A6-3.1.3 The intent of 6-3.1.3 is to require permanent installations which will positively prevent escape of materials to any space within the building. Installations which are only partially effective or which are subject to deterioration are not included within this intent.

A6-3.1.4 The American Industrial Hygiene Association and the American Conference of Governmental Industrial Hygienists have published guides on recommended minimum air velocities at the working face of laboratory hoods. (See references D4 and D5 in Appendix D.)

The following recommendations have been based on those guides:

1. For materials of extreme toxicity or hazard, such as tetraethyllead, berylium compounds, metal carbonyls and volatile carcinogens, the recommendations for average velocity at the hood opening range from 125 to 150 feet per minute with minimums at any one point of 100 to 125 feet per minute.

2. An average velocity of 100 fpm (minimum at any one point, 80 fpm) is recommended generally for all laboratory hoods except those mentioned in 1. above and 3. below.

3. For those operations where the hazard is not high, that is, where materials of low toxicity such as acetone, ethanol, and straight-chain hydrocarbons are used, and for operations creating nuisance dusts and fumes, the recommendations for average face velocity range from 75 to 80 fpm and for a minimum velocity at any one point from 50 to 60 fpm.

6-3.1.5 Local or spot exhaust systems, e.g., snorkels (elephant trunks), shall have sufficiently high velocities to capture the particular materials being emitted.

6-3.2 Duct Construction for Hoods and Other Local Exhaust Systems.

6-3.2.1 Laboratory hood ducts shall be constructed of noncombustible materials.

Exception No. 1: Combustible ducts may be used if enclosed in a shaft of noncombustible construction where they pass through non-laboratory areas or through laboratory units other than the unit which they serve.

Exception No. 2: Combustible ducts may be used if all areas through which they pass are protected with an approved fire extinguishing system as described in Chapter 4.

6-3.2.2 Combustible ducts or duct linings, when used in new installations or as replacements, shall have a flame spread of 25 or less when tested in accordance with *Test for Surface Flammability of Material Using a Radiant Heat Energy Source, ASTM E162-67, (see reference D6 in Appendix D)* or *Method of Test of Surface Burning Characteristics of Building Materials, NFPA 255 — 1972.* Test specimens shall be of the minimum thickness used in the construction of the duct. Where results obtained by tests conducted by different test methods vary, those obtained by *NFPA 255* shall prevail. (For construction of perchloric acid fume hoods and ducts see Section 9-2.9.)

6-3.2.3 Ducts shall be of adequate strength and rigidity to meet the conditions of service and installation requirements, and shall be properly protected where subject to mechanical injury.

6-3.2.4 Vibration isolation connectors shall comply with the requirements for ducts in 6-3.2.1.

6-3.2.5 Flexible connectors containing pockets in which conveyed materials may collect shall not be used in any concealed space, or where strong oxidizing materials, e.g., perchloric acid, are used.

6-3.2.6 Controls and dampers, where required for balancing of the exhaust system, shall be of a type that in the event of failure due to fire or corrosion, fails open (will open) to assure continuous draft.

6-3.2.7* Hand holes if 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.

6-3.2.8 Fire detectors and alarm devices shall not automatically shut off exhausters (fans) except as required when actuating halon or carbon dioxide fire extinguishing systems.

6-3.3 Duct Velocities for Hoods and Other Local Exhaust Systems.

6-3.3.1* Laboratory air exhaust systems shall be maintained at velocities sufficiently high to minimize deposition of materials being emitted into the hood chamber, or otherwise pulled into the exhaust system.

6-3.4 Exhausters (Fans).

6-3.4.1 Fans shall be selected with due consideration to the fire, explosion and corrosion problems.

6-3.4.2 Fans for conveying both corrosive materials and flammable or combustible materials may be lined with or constructed of corrosion-resistant materials having a flame spread of 25 or less when tested in accordance with *Test for Surface Flammability of Materials Using a Radiant Heat Source, ASTM-E162-67 (See reference D6 in Appendix D)* or *Method of Test of Surface Burning Characteristics of Building Materials, NFPA 255 — 1972.* Test specimens shall be of the minimum thickness used in the construction of the fan. Where results obtained by tests conducted by different test methods vary, those obtained by *NFPA 255* shall prevail.

6-3.4.3 Fans shall be so located and arranged as to afford ready access for repairing, cleaning, inspection, and lubricating.

6-3.4.4 When flammable dusts or vapors are passed through the fans, the rotating element shall be nonferrous or nonsparking material, or the casing shall consist of or be lined

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Appendix A (continued)

A6-3.2.7 Automatic fire dampers should be omitted from laboratory local exhaust systems.

A6-3.3.1 See Industrial Ventilation: A Manual of Recommended Practices, Twelfth Edition, American Conference of Governmental Industrial Hygienists. (See reference D5 in Appendix D.)

with such material. Where there is a possibility of solid foreign material passing through the fan that would produce a spark, both the rotating element and the casting shall be constructed of nonferrous or nonsparking material. Nonferrous or nonsparking materials shall meet the flame spread test requirement for fans in 6-3.4.2.

6-3.5 Power and Control.

6-3.5.1 Motors and their controls shall be located outside of the location in which flammable or combustible vapors or dusts are being generated and removed unless of the type approved for the particular conditions or hazard.

6-4 Inspection and Maintenance of Ventilation Equipment.

6-4.1 Detectors and Alarms.

6-4.1.1 Air system flow detectors, when installed, shall be inspected at least annually. Where potentially corrosive or obstructive conditions exist, the inspection frequency shall be increased appropriately. Velocity and pressure-sensing detectors shall be tested at each inspection. Low-flow or no-flow alarms of the visible (lights) or audible (e.g., horns, bells) type shall be tested for correct operation at least at each inspection. Signal transmission for alarms designed to activate signals at more than one location shall be verified at each location during each inspection.

6-4.2 Filters.

6-4.2.1 Fixed fire extinguishing systems provided for the protection of filters shall be inspected quarterly for accumulation of combustible material deposits on nozzles and cleaned as required. *(See Appendix C for recommendations for additional inspection and testing maintenance.)*

6-4.3 Fans and Motors.

6-4.3.1 Air supply and exhaust fans and motor components shall be inspected at least annually. *(See Appendix C for recommendations for additional inspection and testing maintenance.)*

6-4.3.2 When air flow detectors are not provided or measured air flow tests are not made quarterly, fan belts shall be inspected quarterly. Frayed or broken belts shall be replaced promptly. Where double sheaves and belts are employed, the inspection frequency may be semi-annually.

Chapter 7 Chemical Storage, Handling and Waste Disposal

7-1 Ordering.

7-1.1 Procedures.

7-1.1.1* When a chemical is ordered, steps shall be taken to determine the hazards and to transmit that information to those who will receive, store, use or dispose of the chemical. Restrictions imposed by governmental regulations and in-house rules shall be followed.

7-2 Handling and Storage.

7-2.1 Facilities.

7-2.1.1 Hazardous chemicals shall not be brought into the laboratory complex unless design, construction and fire protection of receiving and storage facilities are commensurate with quantities and hazards of chemicals involved.

7-2.1.2* Safe storage facilities shall be provided for materials having unique physical or hazardous properties such as temperature-sensitive, water-reactive, and explosive materials.

7-2.2 Handling.

7-2.2.1 Receiving, transporting, unpacking, and dispensing of chemicals and other hazardous materials shall be carried out by trained personnel in such locations and manner as to minimize hazards from flammable, reactive or toxic materials.

Appendix A (continued)

A7-1.1.1 Before a hazardous chemical is ordered, controls should be established to assure that adequate facilities and procedures are available for receiving, storing, using, and disposing of the material. Information sources are *Hazardous Chemicals Data NFPA 49 — 1975, Manual of Hazardous Chemical Reactions, NFPA 491M — 1975, Flash Point Index of Trade Name Liquids, NFPA 325A — 1972 and Fire-Hazard Properties of Flammable Liquids, Gases and Volatile Solids, NFPA 325M — 1969.* See also the Chemical Safety Data Sheets and the Laboratory Waste Disposal Manual, published by the Manufacturing Chemists' Association. (See references D12 and D14 in Appendix D.)

A7-2.1.2 Guidance on unique physical or hazardous properties will be found in *Hazardous Chemicals Data, NFPA 49 — 1975,* the *Manual of Hazardous Chemical Reactions, NFPA 491M — 1975, and Code for the Manufacture, Transportation, Storage, and Use of Explosive Materials, NFPA 495 — 1973.*

Table 7-1. Maximum Allowable Size of Containers

Container Type	Flammable Liquids			Combustible Liquids	
	Class IA[1]	Class IB[2]	Class 1C[3]	Class II[4]	Class IIIA[5]
Glass	1 pt.[6]	1 qt.[6]	1 gal.	1 gal.	5 gal.
Metal (other than DOT Drums) or approved plastic	1 gal.	5 gal.[7]	5 gal.[7]	5 gal.[7]	5 gal.[7]
Safety Cans	2 gal.	5 gal.[7]	5 gal.[7]	5 gal.[7]	5 gal.[7]
Metal Drums (DOT Spec.)	5 gal.[7]	5 gal.[7]	5 gal.[7]	60 gal.[7]	60 gal.[7]

[1] Class IA liquids are those having flash points below 73°F (22.8°C) and boiling points below 100°F (37.8°C).

[2] Class IB liquids are those having flash points below 73°F (22.8°C) and boiling points at or above 100°F. (37.8°C).

[3] Class IC liquids are those having flash points at or above 73°F (22.8°C) and below 100°F (37.8°C).

[4] Class II liquids are those having flash points at or above 100°F (37.8°C) and below 140°F (60°C).

[5] Class IIIA liquids are those having flash points at or above 140° F (60° C) and below 200° F (93.4° C).

[6] Sizes as large as 1 gallon may be used if needed and if the required liquid purity would be adversely affected by storage in metal or if the liquid would cause excessive corrosion of the metal container.

[7] In instructional laboratories, no container for Class I or Class II liquids shall exceed a capacity of 1 gallon, except that safety cans may be of 2 gallons capacity.

[8] See Exception to 7-2.3.4.

7-2.2.2 Grounding and bonding procedures, outlined in *Recommended Practice on Static Electricity, NFPA 77 — 1972,* shall be followed.

7-2.2.3 Before the initial use of a chemical material, the user shall be made thoroughly familiar with its hazards. He shall follow such handling procedures as are appropriate.

7-2.2.4 Before a chemical material is used, the user shall determine that information and facilities are available to provide safe disposal of hazardous materials and waste products.

7-2.3* Storage.

7-2.3.1 Hazardous chemical inventories in a laboratory's storage facility shall be within the prescribed capacities of the facility for the various kinds of chemicals.

7-2.3.2 The quantities of hazardous chemicals within each laboratory unit shall not exceed the permitted quantities in Chapter 2 and Table 2-1.

7-2.3.3 Hazardous chemicals in the open in laboratories shall be kept to a minimum necessary for the work being done.

7-2.3.4* Container types and maximum capacities shall comply with Table 7-1, except that Class 1A and Class 1B flammable liquids may be stored in glass containers of not more than one-gallon capacity if the required liquid purity would be affected by storage in metal containers or if the liquid would cause excessive corrosion of the metal container.

Exception: Drums of up to and including 60 gallons capacity are permitted in approved storage rooms.

7-2.3.5* Incompatible materials shall be segregated to prevent accidental contact with one another.

Appendix A (continued)

A7-2.3 Flammable and combustible liquids that are not in use should be stored in safety cans, storage cabinets, or storage rooms.

A7-2.3.4 Class IA and Class IB flammable liquids in glass containers larger than the 1-pint and 1-quart sizes permitted in Table 7-1 should be stored in metal pails, or other suitable containers of sufficient size to hold the liquids in the glass container. Table 7-1 is taken from Table IV-I in the *Flammable and Combustible Liquids Code, NFPA 30 — 1973.*

A7-2.3.5 For guidance, see *Hazardous Chemicals Data, NFPA 49 — 1975* and *The Manual of Hazardous Chemical Reactions, NFPA 491M — 1975.*

7-2.3.6 Laboratory storage facilities shall be inspected to ensure compliance with the provisions of this Chapter.

7-3* Collection and Disposal of Chemical Waste.

7-3.1 General.

7-3.1.1 The handling, storage and transportation of chemical waste shall be subject to the provisions in this standard for the handling, storage, and transportation of chemicals.

7-3.2 Collection.

7-3.2.1 Special consideration shall be given to the classification of chemical waste at the time of collection so as to avoid chemical incompatibilities.

7-3.3* Disposal.

7-3.3.1 Disposal of chemical waste material shall be in accordance with good safety practices and applicable governmental regulations.

7-3.3.2 Persons or agencies employed to remove chemical waste from the premises shall be apprised of the basic character and hazards of the waste.

Appendix A (continued)

A7-3 Drain line traps from laboratory benches, hood floors, mechanical equipment rooms, etc., should have water added at regular intervals to assure that traps will not be the source of flammable or toxic vapor release. Where self-priming traps are provided, an annual inspection for proper operation should be made. Additions such as mineral oil are sometimes used to reduce evaporation of water from traps.

A7-3.3 The Laboratory Waste Disposal Manual, published by the Manufacturing Chemists' Association, (see reference D14 in Appendix D) contains recommendations for the safe disposal of some 1200 chemicals. The guidance of a technically qualified person is recommended for disposal of hazardous chemicals.

Chapter 8 Compressed or Liquefied Gases

8-1 Storage and Piping Systems.

8-1.1* Method of storage and piping systems for compressed gases and liquefied gases shall comply with the requirements of the applicable NFPA, CGA and ANSI standards where they exist.

8-1.2 Systems for other gases and for cryogenic materials shall comply with the manufacturer's design and specifications.

8-1.3 Relief Valves and Shutoffs.

8-1.3.1 Manual shutoff valves shall be provided at all points of supply and points of use.

NOTE. Some facilities also have shutoff valves in an accessible location outside of the space in which the gas is being used.

Exception: If the containers supplying the piping system are equipped with shutoff valves a separate valve on the piping system is not required.

8-1.4 Identification of Piping.

8-1.4.1* Piping shall be identified as to its contents.

8-1.4.2 Permanent piping shall be marked at both the supply and discharge ends with the name of the material to be piped.

Appendix A (continued)

A8-1.1 Applicable Standards of the National Fire Protection Association include: *Standard for Bulk Oxygen Systems at Consumer Sites, NFPA 50 — 1974, Standard for Gaseous Hydrogen Systems at Consumer Sites, NFPA 50A — 1973, Standard for Liquefied Hydrogen Systems at Consumer Sites, NFPA 50B — 1973, National Fuel Gas Code, NFPA 54 — 1974, Standard for the Storage and Handling of Liquefied Petroleum Gases, NFPA 58 — 1974.*

Applicable Standards of the American National Standards Institute include B31.1.0 — 1967, Power Piping with Addenda, B31.1.0a — 1971 (Second Edition), B31.1.0b — 1971, B31.1.0c — 1972, and B31.1.0d — 1972 (see reference D7 in Appendix D.); B31.2 — 1968, Fuel Gas Piping (see reference D8 in Appendix D.); B31.3 — 1966, Petroleum Refinery Piping (see reference D9 in Appendix D.).

Applicable Standards of the Compressed Gas Association including P-1, Safe Handling of Compressed Gases (see reference D11 in Appendix D.).

8-1.4.3 Piping systems, including regulators, shall not be used for gases other than those for which they are designed and identified.

8-2 Compressed or Liquefied Gas Cylinders.

8-2.1* The following requirements apply to compressed or liquefied gas cylinders containing hazardous chemicals or oxygen.

Table 8-2 Size and Quantity Limitations for Compressed or Liquefield Gas Cylinders in Laboratories

	Flammable Gases and Oxygen		Liquefied Flammable Gases		Gases with Health Hazard Rating of 3, or 4
	NS[2]	AS[2]	NS[2]	AS[2]	
Maximum Size Cylinder (Approximate Dimensions in inches)	10 by 50		9 by 30		5 by 15
Maximum No. Cylinders Per 500 square feet or Less[1]	3	6	2	3	3[3]

[1] In Instructional Laboratories, the total number of cylinders shall be reduced to 3 maximum-size cylinders or 10 2″ x 12″ cylinders (or equivalent volume) except that up to 25 2″ x 12″ cylinders (or the equivalent volume) shall be permitted.

[2] NS = Nonsprinklered Area, AS = Sprinklered Area.

[3] Cylinders of gases with health hazard rating 2 and with no warning property, and cylinders of all gases with health hazard rating 3 or 4 shall be kept in a continuously mechanically ventilated hood or other continuously mechanically ventilated enclosure. There shall be no more than two cylinders of gases with health hazard rating 3 or 4 per hood or other enclosure.

8-2.2 Cylinders shall be handled and stored as specified in *NFPA Standards 50, 50A, 50B and 58 as identified in 8-1.1,* and as specified in Section 3 of CGA pamphelt P-1, Safe Handling of Compressed Gases. *(See reference D11 in Appendix D.)*

8-2.3* The size and quantity of gas cylinders in laboratories shall be limited in accordance with Table 8-2. Cylinders which are not necessary for current laboratory requirements shall be

Appendix A (continued)

A8-1.4.1 The marking should be in conformance with ANSI Standard A13.1 — 1956, Standard Scheme for the Identification of Piping Systems (see reference D10 in Appendix D) or it should be in conformance with some other recognized scheme.

stored in a safely arranged location outside the laboratory. Gases which are corrosive to the cylinders or cylinder valves or which may become unstable, while stored within the cylinder, shall have a maximum retention period of six months, unless otherwise specified by the supplier.

8-2.3.1 Cylinders of all gases having Health Hazard rating of 3 or 4 and cylinders of gases having a Health Hazard rating of 2 with no physiological warning properties shall be kept in a continuously mechanically ventilated hood or other continuously mechanically ventilated enclosure. There shall be no more than three cylinders of gases with Health Hazard rating of 3 or 4 per hood or other enclosure.

8-2.4 All cylinders shall be secured in place to prevent falling.

Appendix A (continued)

A8-2.3 A six month maximum retention period, unless otherwise specified by the supplier, is recommended for:

(1) Acid and Alkaline gases which may corrode cylinders or cylinder valves (such as, Hydrogen Chloride, Hydrogen Bromide).

(2) Gases subject to explosive decomposition. *(See NFPA 49-1975, Hazardous Chemicals Data.)*

(3) Gases subject to polymerization. *(See NFPA 49-1975, Hazardous Chemicals Data.)*

Cylinders of gases should not be kept beyond the maximum recommended retention time specified by the supplier. They should be returned to their suppliers when the expiration of the maximum recommended retention period has been reached. Cylinders not in active use should be removed from laboratories to a storage facility as described in CGA P-1, Safe Handling of Compressed Gases. (See reference D11 in Appendix D.) In the absence of such recommended retention periods, the following should be used: 36 month retention period for liquefied flammable gases, flammable gases, and oxygen; 6 months for gases having health hazard ratings of 3 or 4

Chapter 9 Laboratory Operations and Apparatus

9-1 Operations.

9-1.1 Hazards of Reactions and Chemicals.

9-1.1.1* Before laboratory reactions or tests are begun, an evaluation shall be made for hazards that may be encountered or generated during the course of the work. This evaluation shall include hazards associated with the properties and reactivity of the materials used, hazards associated with the operation of the equipment at the operating conditions, and hazards associated with the nature of the proposed reaction (e.g., oxidation, polymerization).

9-1.1.2 Periodic reviews of laboratory operations and procedures shall be conducted with special attention given to any change in materials, operations or personnel.

9-1.1.3* Where reactions are being performed to synthesize materials whose hazard characteristics have not yet been determined by test, precautions shall be employed to control the highest hazard possible based on a known hazard of similar material. Where the new material may present a severe explosion potential, initial experiments or tests shall be conducted in a suitable enclosure using minimal quantities and with appropriate protection for the operator. *(See Chapter 5.)*

9-1.1.4 Unattended operations and automatic laboratory equipment shall be provided with periodic surveillance for abnormal operation. *(See also 9-1.2.3.)*

9-1.1.5 Open flame or open filament heating of flammable liquids and similarly hazardous procedures shall be attended and shall be conducted with adequate ventilating air exhausting to the outside.

Appendix A (continued)

A9-1.1.1 Suitable sources are *Hazardous Chemicals Data, NFPA 49 — 1975, Manual of Hazardous Chemical Reactions, NFPA 491M — 1975, Flash Point Index of Trade Name Liquids, NFPA 325A — 1972, Fire Hazard Properties of Flammable Liquids, Gases and Volatile Solids, NFPA 325M — 1969,* and Chemical Safety Data Sheets, published by the Manufacturing Chemicals' Association. *(See reference D12 in Appendix D.)*

A9-1.1.3 When produced, the new material should be subject to a hazard analysis as appropriate to the reasonably anticipated hazard characteristics of the material. Such tests may include, but are not limited to: differential thermal analysis, drop weight shock sensitivity, autoignition temperature, flash point, thermal stability under confinement, heat of combustion, and other appropriate tests.

9-1.2 Heating Operations.

9-1.2.1 All heating of flammable or combustible liquids shall be conducted so as to minimize fire hazards.

9-1.2.2 Provision shall be made to contain spilled liquid by providing metal catch pans or other heat-resistant noncombustible receptacles of suitable size for glass apparatus containing 250 cubic centimeters of flammable liquid or 250 cubic centimeters of combustible liquid if heated to its flash point. Suitable supplementary fire extinguishing equipment shall be available if necessary.

9-1.2.3 Unattended operations shall be provided with override control and automatic shutdown to prevent system failure that can result in fire or explosion.

9-1.2.4 Strong oxidizing materials, such as perchloric acid, shall not be heated by gas flames or oil baths.

9-1.3 Distillation Operations.

9-1.3.1 Distillations shall be conducted in suitable equipment properly assembled with consideration being given to fire hazards from vent gases and possible equipment breakage or failure. Care shall be taken to avoid the presence of unstable components in the still pot (e.g., peroxides) and to avoid overheating still contents. Metal catch pans or other heat-resistant noncombustible receptacles of a suitable size shall be utilized beneath pots and receivers with volumes above 250 cubic centimeters in glass apparatus.

9-1.3.2 Glass equipment for distillations, and particularly vacuum distillations, shall be inspected for cracks, scratches, or other defects prior to each use. Faulty glass equipment shall be discarded.

9-1.3.3 Glass vacuum equipment shall be shielded or wrapped with suitable tape during use.

9-1.4 Other Separation Operations.

9-1.4.1 Filtrations, extractions, sublimations, adsorptions, evaporations, and other separation techniques, including centrifuging, that involve flammable or combustible materials shall be protected from ignition sources and shall be furnished with suitable ventilation.

9-1.5 Mixing and Grinding Operations.

9-1.5.1* Mixing, grinding, stirring and agitation operations involving flammable and combustible materials shall require the same precautions against fire as in Section 9-1.4.1. Precautions shall be taken to avoid local overheating which may occur during grinding and mixing of solids. Care shall be taken to avoid fire or explosion hazards from dusts and flammable solvents.

9-1.6 Other Operations.

9-1.6.1 Other laboratory operations, such as reactions at temperatures and pressures above or below ambient conditions shall be conducted in such manner that hazards will be minimized. Shielding shall be utilized whenever there is a reasonable probability of explosion or vigorous decomposition and associated hazards, during charging, reaction sampling, venting and discharge of products. *(See also Chapter 5 and 9-2.6.3.)*

9-1.6.2 Quantities shall be limited and procedures developed to control or isolate vigorous or exothermic reactions.

NOTE: Approaches include chilling, quenching, cutoff of reactant supply, venting, dumping, "short-stopping" or inhibiting.

9-1.6.3 During drying operations in which flammable or combustible vapors are involved, suitable procedures shall be followed to condense, trap or vent such vapors and to avoid ignition sources.

9-1.6.4 Spraying of flammable or combustible paint and varnishes shall conform with the requirements of the *Standard for Spray Application Using Flammable and Combustible Materials, NFPA 33 — 1973.*

9-1.6.5 Flammable liquids stored in refrigeration equipment shall be in closed containers. *(See also 9-2.3.)*

9-2 Apparatus.

9-2.1 General.

9-2.1.1 Apparatus shall be installed in conformance with applicable requirements of NFPA standards, including the *National Electrical Code, NFPA 70 — 1975.*

Appendix A (continued)

A9-1.5.1 The NFPA has published 14 standards for the control of hazards of combustible dusts.