

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.

**8.11.11** Prior to using a perchloric acid hood for any purpose, the hood shall be water-washed and shall be tested according to 8.11.9 to ensure residual perchlorates are not present.

#### **8.12 Identification of Chemical Fume Hood Systems.**

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

**8.12.2** 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

#### **8.13 Inspection, Testing, and Maintenance.**

**8.13.1\*** 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 7.5.3*)
- (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

**8.13.2** Deficiencies in hood performance shall be corrected, or one of the following shall apply:

- (1) The activity within the hood shall be restricted to the capability of the hood.
- (2) The hood shall not be used.

**8.13.3** Chemical fume hood face velocity profile or hood exhaust air quantity shall be checked after any adjustment to the ventilation system balance.

#### **8.13.4 Detectors and Alarms.**

**8.13.4.1** Air system flow detectors, if installed, shall be inspected and tested annually.

**8.13.4.2** Where potentially corrosive or obstructive conditions exist, the inspection and test frequency shall be increased.

#### **8.13.5 Fans and Motors.**

**8.13.5.1\*** Air supply and exhaust fans, motors, and components shall be inspected at least annually.

**8.13.5.2** Where airflow detectors are not provided or airflow-rate tests are not made, fan belts shall be inspected quarterly; double sheaves and belts shall be permitted to be inspected semi-annually.

**8.13.5.3** Frayed or broken belts shall be replaced promptly.

**8.13.6** Fixed fire-extinguishing systems protecting filters shall be inspected quarterly for accumulation of deposits on nozzles and cleaned as necessary.

## **Chapter 9 Chemical Storage, Handling, and Waste Disposal**

### **9.1\* Ordering Procedures.**

**9.1.1** When a chemical is ordered, steps shall be taken to determine its hazards and to transmit that information to those who will receive, store, use, or dispose of the chemical.

**9.1.2** Restrictions imposed by governmental regulations and in-house rules shall be followed.

### **9.2 Handling and Storage.**

#### **9.2.1 Facilities.**

**9.2.1.1** Chemicals shall not be brought into a laboratory work area unless the design, construction, and fire protection of receiving and storage facilities are commensurate with the quantities and hazards of chemicals involved.

**9.2.1.2** Safe storage facilities shall be provided for materials that have unique physical or hazardous properties, such as temperature sensitivity, water reactivity, or explosibility. (*See A.9.1 for sources of additional information.*)

**9.2.1.3** Hazardous chemicals shall be stored and handled in such a manner as to limit a spill scenario to less than 20 L (5 gal).

#### **9.2.2 Handling.**

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

**9.2.2.2\*** Materials of construction for ducts, piping, and vessels shall be compatible with materials to be transferred or handled.

**9.2.2.3** Before a chemical material is used, the user shall determine that information and facilities are available for safe disposal of hazardous materials and waste products.

**9.2.2.4** Class I liquids shall not be transferred from one vessel to another in any exit access corridor.

**9.2.2.5** Pressurized liquid dispensing containers containing chemicals shall be in accordance with Section 10.4.

**9.2.2.6** Chemical quantities outside of storage shall be maintained at the lowest possible level necessary for the work performed.

**9.2.2.7** Handling and storage of chemicals shall conform to the manufacturers' recommendations and material safety data sheet (MSDS).

#### **9.2.3 Storage.**

**9.2.3.1\*** Chemical inventories in each laboratory unit shall be maintained within the maximum allowable quantities specified in the applicable fire prevention code or building code except as modified in Chapter 10 for buildings with more than three stories.

**9.2.3.1.1** Maximum allowable quantities shall be reduced by 50 percent for Class B laboratory units located above the third floor.

**9.2.3.1.2** Maximum allowable quantities shall be reduced by 25 percent for Class C and Class D laboratory units located on the fourth through sixth floors of a building.

**9.2.3.1.3** Maximum allowable quantities shall be reduced by 50 percent for Class C and Class D laboratory units located above the sixth floor.

**9.2.3.2\*** Incompatible materials shall be segregated to prevent accidental contact with one another.

**9.2.3.3** Class I flammable liquids and Class II combustible liquids that are not in use inside of laboratory units shall be stored in safety cans; in approved storage cabinets constructed in accordance with NFPA 30, *Flammable and Combustible Liquids Code*, and ANSI/UL 1275, *Standard for Flammable Liquid Cabinets*; or in an inside liquid storage area.

**9.2.3.4\*** Containers of materials that might become hazardous (i.e., time sensitive) during prolonged storage shall be dated when first opened, and properly managed.

**9.2.3.4.1\*** Proper management shall consist of the following elements:

- (1) Defining those materials present that are time sensitive
- (2) Defining each time-sensitive material's inspection frequency
- (3) Defining proper or approved inspection methodologies to determine the relative hazard of the time-sensitive material
- (4) Defining pass/fail criteria for inspection results

**9.2.3.4.2** Time-sensitive materials that pass inspection shall be permitted to be redated and retained for an additional defined inspection period.

**9.2.3.4.3** All other material shall be safely discarded.

**9.2.3.5\*** Storage cabinets used in laboratories shall not be required to be vented for fire protection purposes.

**9.2.3.6** Laboratory storage facilities shall be inspected to ensure compliance with the provisions of Chapter 9.

**9.2.3.7** Storage of chemicals in the fume hood shall be prohibited.

### 9.3 Waste Handling and Disposal.

**9.3.1** Waste chemicals shall be handled and stored according to the requirements in Section 9.2.

**9.3.2** Waste chemicals shall not be combined or mixed with other waste chemicals unless they have been evaluated for compatibility by a qualified person.

**9.3.3** Chemical waste containers shall be labeled with the hazards of the waste chemicals.

**9.3.4** Liquid waste containers stored in laboratory work areas shall not exceed 20 L (5 gal).

**9.3.5** Waste quantities shall be subject to the maximum container sizes and type in accordance with Table 10.1.2.

**9.3.6** Waste quantities shall be subject to the maximum allowable quantity for the laboratory unit.

## Chapter 10 Flammable and Combustible Liquids

### 10.1 Quantity Limitations.

**10.1.1** The density and total amount of flammable and combustible liquids in use in laboratory work areas and in the laboratory unit outside of flammable liquid storage rooms shall not exceed the quantities presented in Table 10.1.1(a) and Table 10.1.1(b) for the respective class of laboratory.

**10.1.2\*** Container types and maximum capacities for flammable and combustible liquids shall comply with Table 10.1.2 except as follows:

- (1) Glass containers as large as 4 L (1 gal) shall be permitted to be used if all the following conditions are present:
  - (a) Excessive corrosion or degradation of a metal or an approved plastic container would result.
  - (b) The glass container size allowed in Table 10.1.2 is not available.
  - (c) The glass containers are required for purity purposes.
- (2) Containers of not more than 227 L (60 gal) capacity shall be permitted in a separate area inside the building if the inside area meets the requirements of NFPA 30, *Flammable and Combustible Liquids Code*.
- (3) In educational and instructional laboratory work areas, containers for Class I or Class II liquids shall not exceed the following capacity:
  - (a) Safety cans of 8 L (2.1 gal)
  - (b) Other containers of 4 L (1 gal)

**10.2 Supply Piping.** Supply piping for flammable and combustible liquid supply systems shall comply with NFPA 30, *Flammable and Combustible Liquids Code*.

### 10.3 Liquid Dispensing.

**10.3.1\*** Dispensing of Class I liquids to or from containers less than or equal to 20 L (5 gal) in capacity shall be performed in one of the following locations:

- (1) In a chemical fume hood
- (2) In an area provided with ventilation adequate to prevent accumulations of flammable vapor/air mixtures from exceeding 25 percent of the lower flammable limit
- (3) Inside liquid storage areas specifically designed and protected for dispensing Class I flammable liquids that meet the requirements of NFPA 30, *Flammable and Combustible Liquids Code*

**10.3.2\*** Except for pressurized liquid dispensing containers meeting the requirements of Section 10.4, dispensing of Class I liquids to or from containers greater than 20 L (5 gal) shall be performed in one of the following locations:

- (1) In a separate area outside the building
- (2) Inside liquid storage areas specifically designed and protected for dispensing Class I flammable liquids that meet the requirements of NFPA 30, *Flammable and Combustible Liquids Code*

**10.3.3\*** Class I liquids shall not be transferred between conductive containers of greater than 4 L (1 gal) capacity unless the containers are electrically interconnected by direct bonding or by indirect bonding through a common grounding system.

**10.3.4** When dispensing Class I liquids involves nonconductive containers larger than 4 L (1 gal), which can be difficult to bond or ground, special dispensing procedures commensu-

**Table 10.1.1(a) Maximum Quantities of Flammable and Combustible Liquids in Laboratory Units Outside of Inside Liquid Storage Areas (Metric)**

Laboratory Unit Fire Hazard Class	Flammable and Combustible Liquid Class <sup>a</sup>	Quantities in Use <sup>a</sup>		Quantities in Use and Storage <sup>a</sup>	
		Maximum Quantity <sup>b</sup> per 9.3 m <sup>2</sup> of Laboratory Unit <sup>c</sup>	Maximum Quantity <sup>b</sup> per Laboratory Unit	Maximum Quantity <sup>b</sup> per 9.3 m <sup>2</sup> of Laboratory Unit <sup>c</sup>	Maximum Quantity <sup>b</sup> per Laboratory Unit
		L	L	L	L
A (high fire hazard)	I, II, and IIIA	38	1820	76	1820
		76	3028	150	6060
B <sup>d</sup> (moderate fire hazard)	I, II, and IIIA	20	1136	38	1820
		38	1515	76	3028
C <sup>e</sup> (low fire hazard)	I, II, and IIIA	7.5	570	15	1136
		15	757	30	1515
D <sup>e</sup> (minimal fire hazard)	I, II, and IIIA	4	284	7.5	570
		4	284	7.5	570

Note: For maximum container sizes, see Table 10.1.2.

<sup>a</sup>The maximum amount in use in open systems is limited to 10 percent of the quantities listed.

<sup>b</sup>See 4.2.2 for additional requirements for educational and instructional laboratories.

<sup>c</sup>The quantities per 9.3 m<sup>2</sup> do not imply the quantities must be within that 9.3 m<sup>2</sup> area; the quantities per 9.3 m<sup>2</sup> are for calculation purposes to determine the total quantity allowed per laboratory work area and the total amount overall in the laboratory unit.

<sup>d</sup>Reduce quantities by 50 percent for B laboratory units located above the 3rd floor.

<sup>e</sup>Reduce quantities by 25 percent for C and D laboratory units located on the 4th–6th floors of a building and reduce quantities by 50 percent for C and D laboratory units located above the 6th floor.

rate with the electrical characteristics of the liquid shall be developed and implemented.

#### 10.4 Pressurized Liquid Dispensing Containers (PLDC).

**10.4.1** Pressurized liquid dispensing containers used for flammable and combustible liquids shall be listed or labeled for their intended use by a nationally recognized testing laboratory.

**10.4.2** Nonmetallic containers larger than 4 L (1 gal) shall not be used.

**10.4.3\*** Relief devices shall discharge to a safe location, in accordance with the manufacturer's recommendation.

**10.4.4** The piping/hose between the container and the use point shall be rated for the pressure, compatible with the materials being transferred, and not subject to mechanical damage.

**10.4.5** Prior to pressurizing the system, all fittings and connections shall be secure and leak free.

**10.4.6\*** A readily accessible means to stop the flow of liquid from the container shall be provided.

**10.4.7** Containers shall be pressurized only with nitrogen or inert gas; air shall not be used.

**10.4.8** A means to prevent backflow into the gas supply system shall be provided.

#### 10.5 Equipment.

**10.5.1** Storage cabinets used for the storage of flammable and combustible liquids shall be constructed in accordance with NFPA 30, *Flammable and Combustible Liquids Code*.

**10.5.2** Flammable liquids stored in refrigerated equipment shall be stored in closed containers. (See 12.2.2.)

**10.5.3\*** Laboratory heating equipment such as ovens, furnaces, environmental chambers, and other heated enclosures shall not be used to heat, store, or test flammable or combustible liquids or aerosols containing flammable gases unless the equipment is designed or modified to prevent internal explosion.

**10.5.4** Baths handling flammable liquids or combustible liquids heated to their flash points shall be placed in a chemical fume hood or shall be vented to a safe location to control vapors.

**10.5.5** Electric motors shall be suitable for Class I, Division 2 locations when flammable and combustible liquids or flammable gas concentrations can produce hazardous concentrations of flammable mixtures.

*Exception: Electric motors shall be exempt from this requirement if they are located in chemical fume hoods or provided with special local ventilation that will prevent flammable concentrations of gases or vapors from reaching the motor.*

## Chapter 11 Compressed and Liquefied Gases

### 11.1 Compressed and Liquefied Gases in Cylinders.

**11.1.1** Cylinders shall be handled only by trained personnel. (See Annex E and Annex F.)

**11.1.2\*** Cylinders, except nominal 0.5 kg (1 lb) propane cylinders made for consumer use, that are not necessary for current laboratory requirements shall be stored outside the laboratory unit in accordance with NFPA 55, *Compressed Gases and Cryogenic Fluids Code*.

**11.1.3\*** Any compressed gas cylinder or container used at gauge pressures over 103 kPa (15 psi) shall be fabricated to the specifications of or authorized for use by the U.S. DOT, T.C., or Section VIII of the ASME *Boiler and Pressure Vessel Code*.

**11.1.3.1** The container shall be marked to show the authorization code and its working pressure at 21°C (70°F).

**11.1.3.2** Vessels whose physical size, operating pressure, or both, are outside the scope of the referenced code(s) shall be constructed in accordance with the philosophy and guidance of the ASME *Boiler and Pressure Vessel Code* and shall not require marking.

#### 11.1.4 Special Ventilation Requirements for Gas Cylinders.

**11.1.4.1** This section shall not apply to gases that have a health rating of 3, as rated in NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, if they are rated as such by virtue of it being a cryogenic, with no other health hazards.

**11.1.4.2** Lecture bottle-sized cylinders of the following gases located in laboratory units shall be kept in a continuously mechanically ventilated hood or other continuously mechanically ventilated enclosure:

- (1) All gases that have health hazard ratings of 3 or 4
- (2) All gases that have a health hazard rating of 2 without physiological warning properties
- (3) Pyrophoric gases

**11.1.4.3** Cylinders of all gases that are greater than lecture bottle size and have health hazard ratings of 3 or 4 and cylinders of gases that have a health hazard rating of 2 without physiological warning properties that are located in laboratory units shall meet both the following conditions:

- (1) Storage in approved continuously mechanically ventilated gas cabinets
- (2) Compliance with NFPA 55, *Compressed Gases and Cryogenic Fluids Code*

**11.1.4.4** Cylinders of pyrophoric gases that are greater than lecture bottle size that are located in laboratory units shall be kept in approved continuously mechanically ventilated, sprinklered gas cabinets.

#### 11.1.5 Cylinder Safety.

**11.1.5.1** Cylinders shall be secured from tipping over by holders designed for such service.

**11.1.5.2** Cylinders in the laboratory shall be equipped with a pressure regulator designed for the specific gas and marked for its maximum cylinder pressure.

**11.1.5.2.1** The regulator system shall be equipped with two gauges, either on the regulator or remote from the regulator,

installed so as to show both the cylinder pressure and the outlet pressure.

**11.1.5.2.2** Where the source cylinder is outside of the laboratory, a station regulator and gauge shall be installed at the point of use to show outlet pressure.

**11.1.5.3** Cylinders shall have a manual shutoff valve. A quick connect shall not be used in place of a shutoff valve.

#### 11.1.6 Cylinders in Use.

**11.1.6.1** Cylinders, when in use, shall be connected to gas delivery systems designed by a qualified person.

**11.1.6.2** Cylinders shall be attached to an instrument for use by means of a regulator.

**11.1.6.3** A compressed gas cylinder shall be considered to be "in use" if it is in compliance with one of the following:

- (1) Connected through a regulator to deliver gas to a laboratory operation
- (2) Connected to a manifold being used to deliver gas to a laboratory operation
- (3) A single cylinder secured alongside the cylinder described in 11.1.6.3(1) as the reserve cylinder for the cylinder described in 11.1.6.3(1)

**11.1.6.4** Cylinders not "in use" shall not be stored in the laboratory unit.

**11.1.6.5** The quantity of compressed and liquefied gases in Class A, Class B, and Class C laboratory units shall be in accordance with the amounts listed in Table 6.3.1 of NFPA 55, *Compressed Gases and Cryogenic Fluids Code*.

**11.1.6.6** The number of lecture bottle cylinders in Class A, Class B, and Class C laboratory units shall be limited to 25.

**11.1.6.7** The quantity of compressed and liquefied gases in Class D laboratory units shall be limited to 50 percent of the amounts listed in Table 6.3.1 of NFPA 55, *Compressed Gases and Cryogenic Fluids Code*,

**11.1.6.8** In instructional laboratory work areas, the quantity of compressed and liquefied gases shall be limited to 10 percent of the amounts listed in Table 6.3.1 of NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, or 10 lecture bottle-sized cylinders.

**11.1.6.9** In educational laboratory work areas, the quantity of compressed and liquefied gases shall be limited as follows:

- (1) The maximum quantity of flammable gas shall not exceed 2.8 m<sup>3</sup> (100 ft<sup>3</sup>).
- (2) The maximum quantity of oxidizing gas shall not exceed 2.8 m<sup>3</sup> (100 ft<sup>3</sup>).
- (3) A maximum of two 0.5 kg (1 lb) liquefied flammable gas cylinders shall be permitted.
- (4) Health hazard 3 and 4 gases shall not be permitted

### 11.2 Storage and Piping Systems.

**11.2.1\*** The method of storage and piping systems for compressed and liquefied gases shall comply with the applicable requirements of NFPA standards, including the following:

- (1) NFPA 51, *Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes*
- (2) NFPA 54, *National Fuel Gas Code*
- (3) NFPA 55, *Compressed Gases and Cryogenic Fluids Code*
- (4) NFPA 58, *Liquefied Petroleum Gas Code*

**11.2.2** Systems for other compressed gases and for cryogenic materials shall comply with the manufacturer's design and specifications.

**11.2.3\*** Each point of use shall have an accessible manual shutoff valve.

**11.2.3.1** The manual shutoff valve at the point of use shall be located away from the potential hazards and be located within 1.8 m (6 ft) of the point of use.

**11.2.3.2** Where the cylinder valve is located within immediate reach, a separate point-of-use shutoff valve shall not be required.

**11.2.3.3** Line regulators that have their source away from the point of use shall have a manual shutoff valve.

**11.2.3.4** An emergency gas shutoff device in an accessible location at the exit shall be provided in addition to the manual point-of-use valve in each educational and instructional laboratory space that has a piped gas-dispensing valve.

**11.2.4** Each and every portion of a piping system shall have uninterruptible pressure relief.

**11.2.4.1** Any part of the system that can be isolated from the rest of the system shall have adequate pressure relief.

**11.2.4.2** Piping shall be designed for a pressure greater than the maximum system pressure that can be developed under abnormal conditions.

**11.2.4.3** A pressure relief system shall be designed to provide a discharge rate sufficient to avoid further pressure increase and shall vent to a safe location.

**11.2.5\*** Permanent piping shall be identified at the supply point and at each discharge point with the name of the material being transported.

**11.2.6\*** Piping systems, including regulators, shall not be used for gases other than those for which they are designed and identified unless a thorough review of the design specifications, materials of construction, and service compatibility is made and other appropriate modifications have been made.

### **11.3 Outdoor Installation of Compressed Gas Cylinders for Servicing Laboratory Work Areas (Located Outside of Laboratory Work Areas).**

**11.3.1** Compressed gas cylinders installed or stored outside of laboratory buildings shall be installed and operated in accordance with the requirements in NFPA 55, *Compressed Gases and Cryogenic Fluids Code*.

**11.3.2** Compressed gas delivery systems shall be designed in accordance with NFPA 55, *Compressed Gases and Cryogenic Fluids Code*.

### **11.4 Cryogenic Fluids.**

**11.4.1** All system components used for cryogenic fluids shall be selected and designed for such service.

**11.4.1.1** Design pressure for vessels and piping shall be not less than 150 percent of maximum pressure relief.

**11.4.1.2\*** Systems or apparatus handling a cryogenic fluid that can cause freezing or liquefaction of the surrounding atmosphere shall be designed to prevent contact of the condensed air with organic materials.

**11.4.1.3** Systems or apparatus handling liquid oxygen shall be designed to prevent contact of the oxygen with organic materials.

**11.4.2** Pressure relief of vessels and piping handling cryogenic fluids shall comply with the applicable requirements of Section 11.2.

**11.4.3** The space in which cryogenic systems are located shall be ventilated commensurate with the properties of the specific cryogenic fluid in use.

## **Chapter 12 Laboratory Operations and Apparatus**

### **12.1 Operations.**

**12.1.1\* Hazards of Chemicals and Chemical Reactions.** Experiments and tests conducted in educational and instructional laboratory units shall be under the direct supervision of an instructor.

**12.1.1.1** Before laboratory tests or chemical reactions are begun, evaluations shall be made for hazards that can be encountered or generated during the course of the work.

**12.1.1.2** Evaluations shall include the hazards associated with the properties and the reactivity of the materials used and any intermediate and end products that can be formed, hazards associated with the operation of the equipment at the operating conditions, and hazards associated with the proposed reactions — for example, oxidation and polymerization. (*See also 12.1.1.4.*)

**12.1.1.3** Regular reviews of laboratory operations and procedures shall be conducted with special attention given to any change in materials, operations, or personnel.

**12.1.1.4\*** Where reactions are being performed to synthesize materials, the hazard characteristics of which have not yet been determined by test, precautions shall be employed to control the highest possible hazard based on a known hazard of similar material.

**12.1.1.5** Where use of a new material might present a severe explosion potential, initial experiments or tests shall be conducted in an enclosure that is designed to protect people and property from potential explosion damage. (*See Chapter 7.*)

**12.1.1.6** Unattended or automatic laboratory operations involving hazardous chemicals shall be provided with regular surveillance for abnormal conditions. (*See 12.1.2.4 and 12.2.4.1.*)

### **12.1.2 Heating Operations.**

**12.1.2.1** All heating of flammable or combustible liquids shall be conducted so as to minimize fire hazards.

**12.1.2.2** Provisions shall be made to contain liquid that might be accidentally released from glass apparatus containing more than 0.25 L (8.4 oz) of flammable liquid or combustible liquid heated to its flash point.

**12.1.2.3** Supplementary fire-extinguishing equipment shall be provided, if necessary.

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

**12.1.2.5** Strong oxidizing materials, such as perchloric acid, shall not be heated by gas flames or oil baths.

### **12.1.3 Distillation Operations.**

**12.1.3.1** Distillations shall be conducted in equipment designed and fabricated for this use and shall be assembled with

consideration being given to fire hazards from vent gases and possible equipment breakage or failure.

**12.1.3.2** Care shall be taken to avoid the presence of unstable components (e.g., peroxides) in the still pot and to avoid overheating still contents.

**12.1.3.3** Glass equipment used for distillations shall be inspected for cracks, scratches, and other defects prior to each use.

**12.1.3.4** Faulty glass equipment shall be discarded or repaired.

**12.1.4\* Other Separation Operations.** Filtrations, extractions, sublimations, adsorptions, evaporations, centrifuging operations, and other separation techniques that involve flammable or combustible materials shall be protected from ignition sources and shall be provided with ventilation that prevents the accumulation of an ignitable concentration of vapors in the work area.

#### **12.1.5 Mixing and Grinding Operations.**

**12.1.5.1** Mixing, grinding, stirring, and agitating operations involving flammable and combustible materials shall require the same precautions against fire as set forth in 12.1.4.

**12.1.5.2** Precautions shall be taken to avoid local overheating during grinding and mixing of solids.

**12.1.5.3** Care shall be taken to avoid fire or explosion hazards from flammable or combustible materials.

#### **12.1.6 Other Operations.**

**12.1.6.1** Other laboratory operations, such as reactions at temperatures and pressures either above or below ambient conditions, shall be conducted in a manner that minimizes hazards.

**12.1.6.2** Shielding shall be used whenever there is a reasonable probability of explosion or vigorous chemical reaction and associated hazards during charging, sampling, venting, and discharge of products. (See *Chapter 7 and 12.2.5.*)

**12.1.6.3** Glass apparatus containing gas or vapors under vacuum or above ambient pressure shall be shielded, wrapped with tape, or otherwise protected from shattering (such as engineering controls or by apparatus design) during use.

**12.1.6.4\*** Quantities of reactants shall be limited and procedures shall be developed to control or isolate vigorous or exothermic reactions.

**12.1.6.5** Flammable gases or vapors evolved during drying operations shall be condensed, trapped, or vented to avoid ignition.

**12.1.6.6** Spraying of flammable or combustible paint and varnishes shall comply with the requirements of NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials.*

### **12.2 Apparatus.**

#### **12.2.1 General.**

**12.2.1.1** Apparatus shall be installed in compliance with applicable requirements of NFPA standards, including NFPA 70, *National Electrical Code.*

**12.2.1.2** Operating controls shall be accessible under normal and emergency conditions.

#### **12.2.2 Refrigeration and Cooling Equipment.**

**12.2.2.1\*** Each refrigerator, freezer, or cooler shall be prominently marked to indicate whether it meets the requirements for safe storage of flammable liquids.

**12.2.2.2\*** Refrigerators, freezers, and other cooling equipment used to store or cool flammable liquids shall be listed as special purpose units for use in laboratories or equipment listed for Class I, Division 1 locations, as described in Article 501 of NFPA 70, *National Electrical Code.*

**12.2.2.2.1\*** Domestic refrigerators, freezers, and other cooling equipment shall be permitted to store or cool flammable liquids if modified as follows:

- (1) Any electrical equipment located within the outer shell, within the storage compartment, on the door, or on the door frame shall meet the requirements for Class I, Division 1 locations, as described in Article 501 of NFPA 70, *National Electrical Code.*
- (2) Electrical equipment mounted on the outside of the storage compartment shall be installed in one of the following ways:
  - (a) To meet the requirements for Class I, Division 2 locations
  - (b) To be located above the storage compartment
  - (c) To be located on the outside surface of the equipment where exposure to hazardous concentrations of vapors will be minimal

**12.2.2.3** Refrigerators, freezers, and cooling equipment located in a laboratory work area designated as a Class I location, as specified in the Exception to 5.6.2, shall be approved for Class I, Division 1 or 2 locations and shall be installed in accordance with Article 501 of NFPA 70, *National Electrical Code.*

#### **12.2.3 Heating Equipment.**

**12.2.3.1** All unattended electrical heating equipment shall be equipped with a manual reset over-temperature shutoff switch, in addition to normal temperature controls, if overheating could result in a fire or explosion.

**12.2.3.2** Heating equipment with circulation fans or water cooling shall be equipped with an interlock arranged to disconnect current to the heating elements if the fan fails or the water supply is interrupted.

**12.2.3.3** Burners, induction heaters, ovens, furnaces, and other heat-producing equipment shall be located a safe distance from areas where temperature-sensitive and flammable materials and compressed gases are handled.

**12.2.3.4** Oven and furnace installations shall comply with NFPA 86, *Standard for Ovens and Furnaces.*

#### **12.2.4 Heated Constant Temperature Baths.**

**12.2.4.1** Electrically heated constant temperature baths shall be equipped with over-temperature shutoff switches in addition to normal temperature controls, if overheating could result in a fire or an explosion.

**12.2.4.2** Bath containers shall be of noncombustible materials.

#### **12.2.5 Pressure Equipment.**

**12.2.5.1\*** Equipment used at pressures above 103 kPa gauge (15 psi) shall be designed and constructed by qualified individuals for use at the expected temperature, pressure, and other operating conditions affecting safety.

**12.2.5.2** Pressure equipment shall be fitted with a pressure relief device, such as a rupture disc or a relief valve. The pressure relief device shall be vented to a safe location.

**12.2.5.3** Equipment operated at pressures above 103 kPa gauge (15 psi), such as autoclaves, steam sterilizers, reactors, and calorimeters, shall be operated and maintained according to manufacturers' instructions, the design limitations of the equipment, and applicable codes and regulations.

**12.2.5.3.1** Such equipment shall be inspected on a regular basis.

**12.2.5.3.2** Any significant change in the condition of the equipment, such as corrosion, cracks, distortion, scale formation, or general chemical attack, or any weakening of the closure, or any inability of the equipment to maintain pressure, shall be documented and removed from service immediately and shall not be returned to service until approved by a qualified person.

**12.2.5.4** Any pressure equipment that has been found to be degraded shall be derated or discarded, whichever is appropriate.

### 12.2.6 Analytical Instruments.

**12.2.6.1** Analytical instruments, such as infrared, ultraviolet, atomic absorption, x-ray, mass spectrometers, chromatographs, and thermal analyzers, shall be installed in accordance with the manufacturers' instructions and applicable standards and codes.

**12.2.6.2** Analytical instruments shall be operated in accordance with manufacturers' instructions or approved recommended operating procedures.

**12.2.6.3** Hazards to personnel from high voltage, vapors or fumes, radiation, flames, flashbacks, and explosions shall be minimized.

## Chapter 13 Hazard Identification

### 13.1 Identification of Entrances.

**13.1.1\*** Entrances to laboratory units, laboratory work areas, storage areas, and associated facilities shall be identified by signs to warn emergency response personnel of unusual or severe hazards that are not directly related to the fire hazard of contents.

**13.1.2** The hazards shall be communicated in the plans for fire fighting. (See 6.6.3.1.)

**13.2\* Exhaust Systems.** Exhaust systems used for the removal of hazardous materials shall be identified to warn personnel of the possible hazards.

### 13.3 Labeling of Containers.

**13.3.1** Content identification, including precautionary information, shall be provided directly on all original and subsequent containers of hazardous chemicals, except those being used in ongoing experiments.

**13.3.2** Containers of materials that become hazardous during prolonged storage shall be dated when first opened, to facilitate hazard control. (See 9.2.3.4 and A.9.2.3.4.)

**13.4 Identification Systems.** Graphic systems used to identify hazards shall comply with ANSI Z535.1, *Safety Color Code*; ANSI Z535.2, *Environmental and Facility Safety Signs*; ANSI Z535.3, *Criteria for Safety Symbols*; and ANSI Z535.4, *Product Safety Signs and Labels*, or other approved graphic systems.

## Annex A Explanatory Material

*Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.*

**A.1.1.2(1)** Either condition of 1.1.2(1) meeting the minimum quantity will bring the lab within the scope of NFPA 45. A school lab with a low pressure natural gas system supplying Bunsen burners (with less than the minimum quantities of combustible or flammable liquids and less than the minimum quantities of other flammable gases) is an example of a lab outside the scope of NFPA 45.

**A.1.1.2(2)** The hazards of pilot plants are primarily based on the process, the chemistry, and the equipment, not the laboratory environment.

**A.1.1.2(7)** NFPA 801, *Standard for Fire Protection for Facilities Handling Radioactive Materials*, provides direction for controlling hazards associated with radioactive materials. NFPA 801 should be used only for issues related to radioactive materials in a laboratory. All other nonradioactive, laboratory issues are covered by NFPA 45.

**A.1.3** See Figure A.1.3 for determining the applicability of NFPA 45 to a lab setting. Existing laboratories using chemicals that are not in compliance with this standard should be permitted to be continued being used if they provide protection to life and adjoining property that is equivalent to that in this standard.

**A.3.2.1 Approved.** The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

**A.3.2.2 Authority Having Jurisdiction (AHJ).** The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

**A.3.2.4 Listed.** The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction