

NFPA 50B

Standard for Liquefied Hydrogen Systems at Consumer Sites

1999 Edition



National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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NFPA 50B

Standard for

**Liquefied Hydrogen Systems
at Consumer Sites**

1999 Edition

This edition of NFPA 50B, *Standard for Liquefied Hydrogen Systems at Consumer Sites*, was prepared by the Technical Committee on Industrial and Medical Gases and acted on by the National Fire Protection Association, Inc., at its Fall Meeting held November 16–18, 1998, in Atlanta, GA. It was issued by the Standards Council on January 15, 1999, with an effective date of February 4, 1999, and supersedes all previous editions.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

This edition of NFPA 50B was approved as an American National Standard on February 4, 1999.

Origin and Development of NFPA 50B

Preparation of this standard was initiated and materially assisted by a committee of the Compressed Gas Association, Inc., which submitted a text to the NFPA Committee on Industrial and Medical Gases in 1966. The standard was tentatively adopted in 1967. The first edition was adopted in 1968. Subsequent editions were adopted in 1971, 1973, 1978, 1985, 1989, and 1994.

Technical Committee on Industrial and Medical Gases

Charles B. Henrici, *Chair*
River Forest Fire Dept., IL [E]
Rep. Int'l Assn. of Fire Chiefs

William H. Barlen, Airgas, CT [M]
Francis X. Bender, Hazards Research Corp., NJ [SE]
Carl A. Caves, U.S. Dept. of Energy, MD [U]
Rick Ginn, Wright Brothers, Inc., OH [M]
Rep. Nat'l Welding Supply Assn.
Douglas F. Nelson, HSB Industrial Risk Insurers, PA [I]
John T. Pavlovcak, Air Products & Chemicals, Inc., PA [IM]
Rep. Compressed Gas Assn., Inc.
William J. Satterfield, III, RODE & Assoc., LLC, CT [SE]

Samir Shibani, Intel Corp., AZ [U]
David N. Simon, Air Liquide America Corp., TX [IM]
Rep. Compressed Gas Assn., Inc.
Michael W. St. Clair, Ohio State University, OH [U]
Rep. NFPA Industrial Fire Protection Section
Gary F. Trojak, The Chlorine Inst., Inc., DC [M]
Randolph Viscomi, ARC Chemical, NY [IM]
Lionel Wolpert, BOC Gases, NJ [IM]
Rep. Compressed Gas Assn., Inc.
Robert A. Zeman, Underwriters Laboratories Inc., IL [RT]

Alternates

John Anicello, BOC Gases, CA [IM]
(Alt. to L. Wolpert)
Marshall Issen, Underwriters Laboratories Inc., IL [RT]
(Alt. to R. A. Zeman)
Michael E. Lyden, The Chlorine Inst., Inc., DC [M]
(Alt. to G. F. Trojak)

Anthony J. McErlean, Messer Group (MG Industries), PA [IM]
(Alt. to D. N. Simon)
Roger A. Smith, Compressed Gas Assn., Inc., VA [IM]
(Alt. to J. T. Pavlovcak)
William A. Thornberg, Industrial Risk Insurers, CT [I]
(Alt. to D. F. Nelson)

Nonvoting

Wendell Glasier, U.S. Dept. of Labor OSHA, DC [E]
(Alt. to J. E. Slattery)
Fred K. Kitson, F K Kitson Safety Assoc., VA [SE]

Joanne E. Slattery, U.S. Dept. of Labor OSHA, DC [E]

Carl Rivkin, NFPA Staff Liaison

This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of this document.

NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on the storage, transfer, and use of industrial gases. Included are the storage and handling of such gases in their gaseous or liquid phases; the installation of associated storage, piping, and distribution equipment; and operating practices. The Committee also has a technical responsibility for contributions in the same areas for medical gases and clean rooms.

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Appendix A.

Information on referenced publications can be found in Chapter 8 and Appendix C.

Information on the physical properties of liquefied hydrogen can be found in Appendix B.

Chapter 1 General Information

1-1 Scope.

1-1.1 Application. This standard covers the requirements for the installation of liquefied hydrogen systems on consumer premises where the liquid hydrogen supply to the consumer's premises originates outside the consumer's premises and is delivered by mobile equipment.

1-1.2* Nonapplication. This standard does not apply to the following:

- (a) Portable containers having a total liquefied hydrogen content of less than 39.7 gal (150 L)
- (b) Liquefied hydrogen manufacturing plants or other establishments operated by the hydrogen supplier or his or her agent for the sole purpose of storing liquefied hydrogen and refilling portable containers, trailers, mobile supply trucks, or tank cars

1-2 Retroactivity. An existing system that is not in strict compliance with the provisions of this standard is permitted to be continued in use where such use does not constitute a distinct hazard to life or adjoining property.

1-3 Definitions.

Approved.* Acceptable to the authority having jurisdiction.

Authority Having Jurisdiction.* The organization, office, or individual responsible for approving equipment, an installation, or a procedure.

Combustible Liquid. A liquid having a closed-cup flash point at or above 100°F (37.8°C) and are subdivided as follows:

- (a) Class II liquids include those having a flash point at or above 100°F (37.8°C) and below 140°F (60°C).
- (b) Class IIIA liquids include those having a flash point at or above 140°F (60°C) and below 200°F (93.4°C).
- (c) Class IIIB liquids include those having a flash point at or above 200°F (93.4°C).

Flammable Liquid (Class I).* Any liquid having a closed-cup flash point below 100°F (37.8°C) and having a vapor pressure not exceeding 40 psia (276 kPa) at 100°F (37.8°C).

Gallon. A standard U.S. gallon.

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

Limited-Combustible Material. A material, as defined in NFPA 220, *Standard on Types of Building Construction*, not complying with the definition of noncombustible material, that, in the form in which it is used, has a potential heat value not exceeding 3500 Btu/lb (8141 kJ/kg) and complies with one of the following paragraphs (a) or (b). Materials subject to an increase in combustibility or flame spread rating, beyond the limits herein established, through the effects of age, moisture, or other atmospheric condition are considered combustible.

(a) Materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of $\frac{1}{8}$ in. (3.2 mm) that has a flame spread rating not greater than 50.

- (b)*Materials, in the form and thickness used, other than as described in (a), having neither a flame spread rating greater than 25 nor evidence of continued progressive combustion and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread rating greater than 25 nor evidence of continued progressive combustion.

Liquefied Hydrogen System.* A system into which liquefied hydrogen is delivered and stored and from which it is discharged in the liquid or gaseous form to the consumer's piping. The system originates at the storage container fill connection and terminates at the point where hydrogen at service pressure first enters the supply line.

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

Noncombustible Material. A material, as defined in NFPA 220, *Standard on Types of Building Construction*, which, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. Materials reported as noncombustible, when tested in accordance with ASTM E 136, *Standard Method of Test for Behavior of Materials in a Vertical Tube Furnace at 750°C*, are considered noncombustible materials.

Outdoors. Location outside of any building or structure or locations under a roof, weather shelter, or canopy provided this area is not enclosed on more than two sides.

Portable Containers.* Liquefied hydrogen cylinders, portable tanks, tank cars, and tank trucks as defined by the U.S. Department of Transportation.

Separate Building. A detached, noncommunicating building used exclusively to house a hydrogen system.

Shall. Indicates a mandatory requirement.

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

Special Room. A separate enclosed area that is part of or attached to another building and is used exclusively for a hydrogen system.

Standard. A document, the main text of which contains only mandatory provisions using the word “shall” to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

Chapter 2 Design of Liquefied Hydrogen Systems

2-1 Containers.

2-1.1 Hydrogen containers shall comply with the following.

- (a) Storage containers shall be designed, constructed, and tested in accordance with appropriate requirements of the ASME *Boiler and Pressure Vessel Code*, Section VIII, “Rules for the Construction of Pressure Vessels.”
- (b) Portable containers shall be designed, constructed, and tested in accordance with 49 *CFR* 171–190.

2-1.2 Permanently installed containers shall be provided with substantial supports of noncombustible material securely anchored on firm foundations of noncombustible material. Steel supports in excess of 18 in. (46 cm) in height shall be protected with a protective coating having a 2-hour fire resistance rating.

2-1.3 Each container shall be marked as follows:

LIQUEFIED HYDROGEN — FLAMMABLE GAS

2-2 Pressure Relief Devices.

2-2.1 Stationary liquefied hydrogen containers shall be equipped with pressure relief devices sized in accordance with CGA S-1.3, *Pressure Relief Device Standards — Part 3 — Compressed Gas Storage Containers*.

2-2.2 Portable liquefied hydrogen containers complying with DOT *Specifications and Regulations* shall be equipped with pressure relief devices as required in DOT *Specifications and Regulations*. Pressure relief devices shall be sized in accordance with the requirements of CGA S-1.1, *Pressure Relief Device Standards — Part 1 — Cylinders for Compressed Gases*, and CGA S-1.2, *Pressure Relief Device Standards — Part 2 — Cargo and Portable Tanks for Compressed Gases*.

2-2.3 Pressure relief devices shall be arranged to discharge unobstructed to the outdoors and in such a manner as to prevent impingement of escaping liquid or gas upon the container, adjacent structures, or personnel. (See 3-1.5 for venting of pressure relief devices in special locations.)

2-2.4 Pressure relief devices or vent piping shall be designed or located so that moisture cannot collect and freeze in a manner that would interfere with proper operation of the device.

2-2.5 Pressure relief devices shall be provided in piping wherever liquefied hydrogen could be trapped between closures.

2-2.6 A sign shall be placed on the container near the pressure relief valve vent stack, on the vent stack that warns against spraying water on, or in the vent opening.

2-3 Piping, Tubing, and Fittings.

2-3.1* Piping, tubing, and fittings, and gasket and thread sealants shall be suitable for hydrogen service at the pressures and temperatures involved. Consideration shall be given to the thermal expansion and contraction of piping systems when exposed to temperature fluctuations of ambient to liquefied hydrogen temperatures.

2-3.2 Material specifications and thickness requirements for piping and tubing shall conform to ASME B31.3, *Chemical Process Piping*. Piping or tubing for operating temperatures below –20°F (–29°C) shall be fabricated from materials meeting the impact test requirements of Chapter III of ASME B31.3 when tested at the minimum operating temperature to which the piping can be subjected in service.

2-3.3 Joints in piping and tubing shall be made by welding or brazing or by use of flanged, threaded, socket, slip, or suitable compression fittings. Brazing materials shall have a melting point above 1000°F (538°C).

2-3.4 Means shall be provided to minimize exposure of personnel to piping operating at low temperatures and to prevent air condensate from contacting piping, structural members, and surfaces not suitable for cryogenic temperatures. Insulation shall be of noncombustible material and shall be designed to have a vaportight seal in the outer covering to prevent the condensation of air and subsequent oxygen enrichment within the insulation. The insulation material and outside shield also shall be of adequate design to prevent attrition of the insulation due to normal operating conditions.

2-3.5 Uninsulated piping and equipment that operate at liquefied hydrogen temperatures shall not be installed above asphalt surfaces or other combustible materials in order to prevent contact of liquid air with such materials. Drip pans shall be permitted to be installed under uninsulated piping and equipment to retain and vaporize condensed liquid air.

2-4 Equipment Assembly.

2-4.1 Valves, gauges, regulators, and other accessories shall be suitable for liquefied hydrogen service and for the pressures and temperatures involved.

2-4.2 Installation of liquefied hydrogen systems shall be supervised by personnel familiar with proper installation practices and with their construction and use.

2-4.3 Storage containers, piping, valves, regulating equipment, and other accessories shall be readily accessible and shall be protected against physical damage and against tampering. A shutoff valve shall be located in liquid product withdrawal lines as close to the container as practical. On containers of over 2000-gal (7570-L) capacity, this shutoff valve shall be able to be operated by remote control with no connections, flanges, or other appurtenances (other than a welded manual shutoff valve) allowed in the piping between the shutoff valve and its connection to the inner container.

2-4.4 Cabinets or housings containing hydrogen control equipment shall be ventilated to prevent any accumulation of hydrogen gas.

2-5 Testing.

2-5.1 After installation, all field-erected piping shall be tested and proved hydrogen gas-tight at operating pressure and temperature.

2-5.2 Containers, if out of service in excess of 1 year, shall be inspected and tested as outlined in 2-5.1. The pressure relief devices shall be checked to determine if they are operable and properly set.

2-6 Liquefied Hydrogen Vaporizers.

2-6.1 The vaporizer shall be anchored and its connecting piping shall be sufficiently flexible to provide for the effect of expansion and contraction due to temperature changes.

2-6.2 The vaporizer and its piping shall be protected on the hydrogen and heating media sections with pressure relief devices.

2-6.3 Heat used in a liquefied hydrogen vaporizer shall be indirectly supplied utilizing media such as air, steam, water, or water solutions.

2-6.4 A low-temperature shutoff switch or valve shall be provided in the vaporizer discharge piping to prevent flow of liquefied hydrogen in the event of the loss of the heat source.

2-7 Electrical Systems. Electrical wiring and equipment shall be in accordance with Table 2-7 and Article 501 of NFPA 70, *National Electrical Code*®.

Exception No. 1: Where equipment approved for Class I, Group B atmospheres is not commercially available, the equipment used shall meet the following requirements:

- (a) *Purged or ventilated in accordance with NFPA 496, Standard for Purged and Pressurized Enclosures for Electrical Equipment*
- (b) *Intrinsically safe*
- (c) *Approved for Class I, Group C atmospheres*

Exception No. 2: Electrical equipment installed on mobile supply trucks or tank cars from which the storage container is filled.

Table 2-7 Electrical Area Classification

Location	Division	Extent of Classified Area
Points where connections are regularly made and disconnected	1	Within 3 ft (1 m) of connection
	2	Between 3 ft (1 m) and 25 ft (7.6 m) of connection

2-8 Bonding and Grounding. The liquefied hydrogen container and associated piping shall be electrically bonded and grounded.

Chapter 3 Location of Liquefied Hydrogen Systems

3-1 General Requirements.

3-1.1 The storage containers shall be located so that they are readily accessible to mobile supply equipment at ground level and to authorized personnel. Roadways or other means of access for emergency equipment, such as fire department apparatus, shall be provided.

3-1.2* Systems shall not be located beneath or where exposed by failure of the following:

- (a) Electric power lines
- (b) Piping containing all classes of flammable and combustible liquids
- (c) Piping containing other flammable gases
- (d) Piping containing oxidizing materials

3-1.3 Where a liquefied hydrogen container is installed on ground that is level with or lower than the adjacent storage of all classes of flammable and combustible liquid or liquid oxygen, suitable protective means shall be taken to prevent accumulation of liquids within 50 ft (15.2 m) of the liquefied hydrogen container. Protective means shall include diking, diversion curbs, or grading of the flammable and combustible liquid storage or liquid oxygen storage.

3-1.4 Storage sites shall be fenced and posted to prevent entrance by unauthorized personnel. Sites also shall be placarded as follows:

LIQUEFIED HYDROGEN
FLAMMABLE GAS
NO SMOKING — NO OPEN FLAMES

3-1.5 If liquefied hydrogen is located (as specified in Table 3-2.1) in a separate building, in a special room, or inside buildings where not in a special room or exposed to other occupancies, containers shall have the pressure relief devices vented unobstructed to the outdoors at a minimum elevation of 25 ft (7.6 m) above grade to a safe location as required in 2-2.3.

3-2 Specific Requirements.

3-2.1 The location of liquefied hydrogen storage, as determined by the maximum total quantity of liquefied hydrogen, shall be in the order of preference indicated by the Roman numerals in Table 3-2.1.

3-2.2* The minimum distance in feet from liquefied hydrogen systems of indicated storage capacity located either outdoors, in a separate building, or in a special room to any specified exposure shall be in accordance with Table 3-2.2.

Exception: The distances in numbers 1, 4, 6, 7, 8, and 11 in Table 3-2.2 shall be permitted to be reduced by two-thirds, but not to less than 5 ft (1.5 m), for insulated portions of the systems. For uninsulated portions of the system, the distances shall be permitted to be reduced by the use of protective structures having a minimum fire resistance rating of 2 hours. The protective structure or the insulated liquefied hydrogen tank shall interrupt the line of sight between uninsulated portions of the liquefied hydrogen storage system and the exposure.

3-2.3 Unloading connections on delivery equipment shall not be positioned closer to any of the exposures cited in Table 3-2.2 than the distances given for the storage system.

3-2.4 The minimum distance of container fill connections from parked vehicles shall be 25 ft (7.6 m).

3-3 Handling of Liquefied Hydrogen Inside Buildings Other Than Separate Buildings and Special Rooms. Portable liquefied hydrogen containers of 50-gal (189-L) or less capacity as permitted in Table 3-2.1 and in compliance with 3-1.5 where housed inside buildings not located in a special room and exposed to other occupancies shall comply with the following minimum requirements.

Table 3-2.1 Preferred Locations of Liquefied Hydrogen Systems

Nature of Location	Size of Hydrogen Storage			
	39.63 gal to 50 gal (150 L to 189.25 L)	51 gal to 300 gal (193.03 L to 1135.5 L)	301 gal to 600 gal (1139.29 L to 2271 L)	In Excess of 600 gal (2271 L)
Outdoors	I	I	I	I
In a separate building	II	II	II	Not permitted
In a special room	III	III	Not permitted	Not permitted
Inside buildings not in a special room or exposed to other occupancies	IV	Not permitted	Not permitted	Not permitted

Note: This table shall not apply to the storage in dewars of the type generally used in laboratories for experimental purposes.

- (a) Containers shall be located 20 ft (6.1 m) from all classes of flammable and combustible liquids and readily combustible materials such as excelsior or paper.
- (b) Containers shall be located 25 ft (7.6 m) from ordinary electrical equipment and other sources of ignition including process or analytical equipment. *(See Section 2-7.)*
- (c) Containers shall be located 50 ft (15 m) from intakes of ventilation and air-conditioning equipment or intakes of compressors.
- (d) Containers shall be located 50 ft (15 m) from storage of other flammable gases or storage of oxidizing gases.
- (e) Containers shall be protected against damage or injury due to falling objects or work activity in the area.
- (f) Containers shall be firmly secured and stored in an upright position.
- (g) Welding or cutting operations and smoking shall be prohibited while hydrogen is in the room.
- (h) Ventilation to the outdoors shall be provided. Pressure relief devices on the containers shall be vented directly outdoors or to a suitable hood. *(See 2-2.3 and 3-1.5.)*

Table 3-2.2 Minimum Distance from Liquefied Hydrogen Systems to Exposures

Type of Exposure	Total Liquefied Hydrogen Storage		
	39.63 gal to 3500 gal (ft)	3501 gal to 15,000 gal (ft)	15,001 gal to 75,000 gal (ft)
1. Building or structure			
(a) Wall(s) adjacent to system constructed of non-combustible or limited-combustible materials			
(1) Sprinklered building or structure or unsprinklered building or structure having noncombustible contents	5 ^a	5 ^a	5 ^a
(2) Unsprinklered building or structure with combustible contents			
Adjacent wall(s) with fire resistance rating less than 3 hours ^b	25	50	75
Adjacent wall(s) with fire resistance rating of 3 hours or greater ^b	5	5	5
(b) Wall(s) adjacent to system constructed of combustible materials			
(1) Sprinklered building or structure	50	50	50
(2) Unsprinklered building or structure	50	75	100
2. Wall openings			
(a) Openable	75	75	75
(b) Unopenable	25	50	50

(continues)

Table 3-2.2 Minimum Distance from Liquefied Hydrogen Systems to Exposures (continued)

Type of Exposure	Total Liquefied Hydrogen Storage		
	39.63 gal to 3500 gal (ft)	3501 gal to 15,000 gal (ft)	15,001 gal to 75,000 gal (ft)
3. Air compressor intakes or inlets for air-conditioning or ventilating equipment	75	75	75
4. All classes of flammable and combustible liquids (above ground and vent or fill openings if below ground) (see 3-1.3) ^c	50	75	100
5. Between stationary liquefied hydrogen containers	5	5	5
6. Flammable gas storage other than hydrogen	50	75	75
7. Liquid oxygen storage and other oxidizers (see 3-1.3)	75	75	75
8. Combustible solids	50	75	100
9. Open flames and welding	50	50	50
10. Places of public assembly	75	75	75
11. Public ways, railroads, and property lines	25	50	75
12. Inlet to underground sewers	5	5	5

For SI units: 1 ft = 0.305 m; 1 gal = 3.785 L.

^aPortions of wall less than 10 ft (3 m) (measured horizontally) from any part of a system shall have a fire resistance rating of at least 1/2 hour.

^bExclusive of windows and doors.

^cDistances can be reduced to 15 ft (4.6 m) for Class IIIB combustible liquids.

Chapter 4 Design Considerations at Specific Locations

4-1 Outdoor Locations.

4-1.1 Roadways and yard surfaces located below liquefied hydrogen piping as well as areas under the fill connections and delivery vehicle's uninsulated hydrogen piping from which liquid air can drip shall be constructed of noncombustible materials. For the purposes of this standard, asphaltic and bitumastic paving shall be considered combustible. If expansion joints are used, fillers also shall be of noncombustible materials.

4-1.2 If walls, roofs, weather shelters, or canopies are provided, they shall be constructed of noncombustible or limited-combustible materials.

4-1.3 Electrical wiring and equipment shall comply with Section 2-7.

4-1.4 Lighting shall be provided for nighttime transfer operation.

4-2 Separate Buildings.

4-2.1 Separate buildings containing more than 300 gal (1136 L) of liquefied hydrogen shall be constructed of noncombustible or limited-combustible materials on a substantial frame. Walls and roofs shall be lightly fastened. All venting elements shall be designed to relieve at a maximum pressure of 25 lb/ft² (1.2 kPa). Doors shall be located in such a manner that they are readily accessible to personnel in an emergency.

Exception: Window glazing shall be permitted to be of plastic.

4-2.1.1 Separate buildings containing 300 gal (1136 L) or less of liquefied hydrogen shall be constructed in accordance with 4-2.1.

Exception: Explosion venting shall be permitted to be in accordance with 4-3.3.

4-2.2 Ventilation to the outdoors shall be provided. Inlet openings shall be located near the floor level in exterior walls only. Outlet openings shall be located at the high point of the room in exterior walls or roof. Both the inlet and outlet vent openings shall have a minimum total area of 1 ft²/1000 ft³ (1 m²/300 m³) of room volume. Discharge from outlet openings shall be directed or conducted to a safe location.

4-2.3 There shall be no sources of ignition.

4-2.4 Electrical wiring and equipment shall comply with Section 2-7.

Exception: All electrical wiring and equipment in the separate building shall be Class I, Division 2, Group B.

4-2.5 Heating, if provided, shall be by indirect means such as steam or hot water.

Exception: Electrical heating shall be in accordance with 4-2.4.

4-3 Special Rooms.

4-3.1 Floors, walls, and ceilings shall be constructed of noncombustible or limited-combustible materials. Interior walls or partitions shall have a fire resistance rating of at least 2 hours, shall be continuous from floor to ceiling, and shall be securely anchored. At least one wall shall be an exterior wall. Openings to other parts of the building shall not be permitted. Windows and doors shall be in exterior walls, and doors shall be located in such a manner that they are accessible in an emergency.

Exception: Window glazing shall be permitted to be of plastic.

4-3.2 Ventilation shall be as provided in 4-2.2.

4-3.3 Explosion venting shall be provided in exterior walls or roof only. Vents shall be designed to relieve at a maximum internal pressure of 25 lb/ft² (1.2 kPa) and shall consist of any one or any combination of the following:

- (a) Walls of light material
- (b) Lightly fastened hatch covers
- (c) Lightly fastened, outward-opening, swinging doors in exterior walls
- (d) Lightly fastened walls or roofs

4-3.3.1 Where applicable, snow loads shall be considered.

4-3.3.2 The venting area shall be equal to not less than 1 ft²/30 ft³ (1 m²/9 m³) of room volume.

4-3.4 There shall be no sources of ignition.

4-3.5 Electrical wiring and equipment shall comply with Section 2-7, except that all electrical wiring and equipment in the special room shall be Class I, Division 2, Group B.

4-3.6 Heating, if provided, shall be by steam, hot water, or other indirect means.

Exception: Electrical heating shall be in accordance with 4-3.5.

Chapter 5 Operation

5-1 Operating Instructions. For installations that require any operation of equipment by the user, instructions shall be maintained at operating locations.

5-2 Qualification of Personnel. A qualified person shall be in attendance at all times while the mobile hydrogen supply unit is being unloaded.

5-3 Securing Equipment. Each mobile liquefied hydrogen supply unit used as part of a hydrogen system shall be secured to prevent movement.

5-4 Grounding. The mobile liquefied hydrogen supply unit shall be grounded.

Chapter 6 Maintenance

6-1 Inspection. Each liquefied hydrogen system installed on consumer premises shall be inspected annually and maintained by a qualified representative of the equipment owner.

6-2 Clearance to Combustibles. Weeds or similar combustibles shall not be permitted within 25 ft (7.6 m) of any liquefied hydrogen equipment.

Chapter 7 Fire Protection

7-1* Cautionary Information. Personnel shall be cautioned that hydrogen flames are practically invisible.

Chapter 8 Referenced Publications

8-1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory docu-

ment is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix C.

8-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 70, *National Electrical Code*®, 1999 edition.

NFPA 220, *Standard on Types of Building Construction*, 1995 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, 1998 edition.

8-1.2 Other Publications.

8-1.2.1 ASME Publications. American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

ASME B31.3, *Process Piping*, 1996.

ASME *Boiler and Pressure Vessel Code*, Section VIII, "Rules for the Construction of Pressure Vessels," 1995.

8-1.2.2 ASTM Publication. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM E 136-96a, *Standard Method of Test for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 1988.

8-1.2.3 CGA Publications. Compressed Gas Association, 1725 Jefferson Davis Highway, Arlington, VA 22202-4100.

S-1.1, *Pressure Relief Device Standards — Part 1 — Cylinders for Compressed Gases*, 1980.

S-1.2, *Pressure Relief Device Standards — Part 2 — Cargo and Portable Tanks for Compressed Gases*, 1980.

S-1.3, *Pressure Relief Device Standards — Part 3 — Compressed Gas Storage Containers*, 1980.

8-1.2.4 U.S. Government Publication. U.S. Government Printing Office, Washington, DC 20402.

Title 49, *Code of Federal Regulations*, Parts 171–190, U.S. Department of Transportation *Specifications and Regulations*.

Appendix A Explanatory Material

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

A-1-1.2 For information on gaseous hydrogen systems, see NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites*.

A-1-3 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-1-3 Authority Having Jurisdiction. The phrase “authority having jurisdiction” 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-1-3 Flammable Liquid (Class I). Liquefied hydrogen is classed as a flammable compressed gas by the U.S. Department of Transportation.

A-1-3(b) Limited-Combustible Material. See NFPA 259, *Standard Test Method for Potential Heat of Building Materials*.

A-1-3 Liquefied Hydrogen System. The system includes stationary or portable containers, including unconnected reserves, pressure regulators, pressure relief devices, manifolds, interconnecting piping, and controls as required.

A-1-3 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 should utilize the system employed by the listing organization to identify a listed product.

A-1-3 Portable Containers. Regulations of the U.S. Department of Transportation outline specifications for transportation of explosives and dangerous articles (*see 49 CFR 171–190*). In Canada, the regulations of Transport Canada, *Transportation of Dangerous Goods Regulations*, apply.

A-2-3.1 Some materials suitable for liquefied hydrogen temperature include austenitic chromium-nickel alloys, certain copper alloys, and aluminum, which retain ductility and do not become brittle at the temperature of liquefied hydrogen.

A-3-1.2 When locating liquefied hydrogen storage containers near all classes of aboveground flammable and combustible liquid storage or liquid oxygen storage, it is advisable to locate the liquefied hydrogen container on ground higher than all classes of flammable and combustible liquid storage or liquid oxygen storage.

A-3-2.2 Separation distances to exposures in Table 3-2.2 should be measured in a direct line of sight or horizontally in the shortest path along the outside of buildings. The 5-ft (1.5-m) distance in Table 3-2.2 facilitates maintenance and enhances ventilation.

A-7-1 Hydrogen fires are not normally extinguished until the supply of hydrogen has been shut off because of the danger of reignition or explosion. In the event of fire, large quantities of water have been sprayed on adjacent equipment to cool the equipment and prevent involvement in the fire. Combination fog and solid stream nozzles have been preferred to permit widest adaptability in fire control. Small hydrogen fires have been extinguished by dry chemical extinguishers or with carbon dioxide, nitrogen, and steam. Reignition can occur if a

metal surface adjacent to the flame is not cooled with water or other means.

The fire protection provided shall be determined by an analysis of local conditions of hazard within the plant, exposure to other properties, water supplies, the probable effectiveness of plant fire brigades, and the time of response and probable effectiveness of fire departments.

Appendix B Physical Properties of Liquefied Hydrogen

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

B-1 Physical Properties. Liquefied hydrogen is transparent, odorless, and not corrosive or significantly reactive. The boiling point at atmospheric pressure is -423°F (-253°C). It is only $1/14$ as heavy as water. In converting liquefied hydrogen to gaseous hydrogen at standard conditions, it expands approximately 850 times.

B-1.1 Hydrogen burns air with a pale blue, almost invisible flame. At atmospheric pressure the ignition temperature of hydrogen-air mixtures has been reported by the U.S. Bureau of Mines to be as low as 932°F (500°C). The flammable limits of hydrogen-air mixtures depend upon pressure, temperature, and water-vapor content. At atmospheric pressure the flammable range is approximately 4 percent to 74 percent by volume of hydrogen in air.

B-1.2 Hydrogen is nontoxic, but can cause anoxia (asphyxiation) when it displaces the normal 21 percent oxygen in a confined area without adequate ventilation. Because hydrogen is colorless, odorless, and tasteless, its presence cannot be detected by the human senses.

B-2 Fire Prevention. Since the control of the hydrogen system can remain with the supplier, compliance with this standard will minimize the possibility of a consumer fire involving the liquefied hydrogen system, as well as the possibility of a liquefied hydrogen fire involving the consumer's premises.

Appendix C Referenced Publications

C-1 The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not considered part of the requirements of this standard unless also listed in Chapter 8. The edition indicated here for each reference is the current edition as of the date of the NFPA issuance of this standard.

C-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites*, 1999 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, 1998 edition.

C-1.2 TC Publication. Transport Canada, Department of Transport, 330 Sparks Street, Ottawa, Ontario K1A 0N5.
Transportation of Dangerous Goods Regulations.

C-1.3 U.S. Government Publication. U.S. Government Printing Office, Washington, DC 20402.

Title 49, *Code of Federal Regulations*, Parts 171–190, U.S. Department of Transportation *Specifications and Regulations*.

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