NFPA No.

50B

LIQUEFIED HYDROGEN SYSTEMS 1973

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NATIONAL FIRE PROTECTION ASSOCIATION
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Official NFPA Definitions

Adopted Jan. 23, 1964: Revised Dec. 9, 1969. Where variances to these definitions are found, efforts to eliminate such conflicts are in process.

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Standard for

Liquefied Hydrogen Systems at Consumer Sites

NFPA No. 50B — 1973

1973 Edition of No. 50B

This edition contain amendments recommended by the Committee on Industrial and Medical Gases which were adopted at the NFPA Annual Meeting on May 16, 1973. It supersedes the 1971 edition. Amendments, other than editorial, are indicated by vertical lines in the margin of the pages in which they appear.

Origin and Development of No. 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 and revised in 1971.

Committee on Industrial and Medical Gases

L. G. Matthews, *Chairman,*
Union Carbide Corporation, Linde Division, Safety Affairs Dept.,
Old Saw Mill River Rd., Tarrytown, NY 10591
(rep. Compressed Gas Association, Inc.)

W. L. Walls,† *Secretary,*
National Fire Protection Assn., 470 Atlantic Ave., Boston, MA 02210

J. A. Cedervall, Underwriters' Laboratories, Inc.

A. E. Cichelli, American Iron & Steel Institute

John J. Crowe, Compressed Gas Association, Inc.

W. H. Doyle, Factory Insurance Assn.

L. H. Flanders, Factory Mutual Research Corp.

Leo Foxwell, American Insurance Assn.

Charles B. Henrici, Fire Marshals Assn., of North America

W. B. Howard, Manufacturing Chemists' Assn.

Robert E. Lenhard, Compressed Gas Assn., Inc.

James Alexander Meyer,* NFPA Committee on Hospitals

R. E. Poethig, National LP-Gas Assn.

E. C. Sommer, American Petroleum Institute

A. A. Weintraub, U.S. Atomic Energy Commission

*Liaison Representative — Vote limited to items on medical gases.

Alternates.

W. H. Johnson, National LP-Gas Assn. (Alternate to R. E. Poethig)

Fred K. Kitson, Compressed Gas Assn., Inc. (Alternate to John J. Crowe)

A. C. Miller, Factory Mutual Research Corp., (Alternate to L. H. Flanders)

A. A. Mulliken, Jr., American Petroleum Institute (Alternate to E. C. Sommer)

Edwin A. Olsen, Compressed Gas Association, Inc. (Alternate to L. G. Matthews and Robert E. Lenhard)

Floyd E. Ouellette, Manufacturing Chemists' Assn. (Alternate to W. B. Howard)

R. I. Spencer, Factory Insurance Assn. (Alternate to W. H. Doyle)

†Nonvoting.

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.

Interpretation Procedure of the Committee on Industrial and Medical Gases

Those desiring an interpretation shall supply the Chairman with live identical copies of a statement in which shall appear specific reference to a single problem, paragraph, or section. Such a statement shall be on the business stationery of the inquirer and shall be duly signed.

When applications involve actual field situations they shall so state and all parties shall be named.

The Interpretations Committee will reserve the prerogative to refuse consideration of any application that refers specifically to proprietary items of equipment or devices. Generally inquiries should be confined to interpretation of the literal text or the intent thereof.

Requests for interpretations should be addressed to the National Fire Protection Association, 470 Atlantic Avenue, Boston, MA. 02210.

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Standard for

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1. INTRODUCTION

11. Liquefied hydrogen is transparent, odorless and is not corrosive or significantly reactive. The boiling point at atmospheric pressure is −423.2 F. It is only one-fourteenth as heavy as water. In converting liquefied hydrogen to gaseous hydrogen at standard conditions, it expands approximately 850 times.

12. Hydrogen burns in air with a pale blue, almost invisible flame. At atmospheric pressure the ignition temperature of hydrogen-air mixtures will not vary greatly from 1085 F. 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.

13. 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.

14. 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 on the consumer premises.

2. APPLICATION OF STANDARD

21. This Standard covers the general principles recommended for the installation of liquefied hydrogen systems on consumer premises where the liquid hydrogen supply to the consumer premises originates outside the consumer premises and is delivered by mobile equipment.

22. The system shall be classified according to the maximum total quantity of liquefied hydrogen including unconnected liquefied hydrogen reserves, as follows:

221. Less than 3,501 gallons, except as covered in 24.

222. From 3,501 to 15,000 gallons.

223. From 15,001 to 30,000 gallons.

23. The authority having jurisdiction may authorize the continued use of an existing system which is not in strict compliance with the provisions of this standard, when such continued use will not constitute a hazard to life or adjoining property.

24. This standard does not apply to portable containers having a total liquefied hydrogen content of less than 150 liters (39.63 gallons).

25. This standard does not apply to liquefied hydrogen manufacturing plants or other establishments operated by the hydrogen supplier or his agent for the sole purpose of storing liquefied hydrogen and refilling portable containers, trailers, mobile supply trucks or tank cars.

26. This standard does not apply to gaseous hydrogen systems. NFPA No. 50A, Gaseous Hydrogen Systems at Consumer Sites, provides information on this subject.

3. DEFINITIONS

31. A LIQUEFIED HYDROGEN SYSTEM is one into which liquefied hydrogen is delivered and stored and from which it is discharged in the liquid or gaseous form to consumer piping. The system may include stationary or portable containers, pressure regulators, safety relief devices, manifolds, interconnecting piping and controls as required. The system originates at the storage container fill connection and terminates at the point where hydrogen at service pressure first enters the supply line.

32. FLAMMABLE LIQUID shall mean any liquid having a flash point below 140 F and having a vapor pressure not exceeding 40 pounds per square inch absolute (psia) at 100 F. (Liquefied hydrogen is classed as a Flammable Compressed Gas by the U. S. Department of Transportation.

33. CF shall mean cubic feet of gas at 14.7 psia and 70 F.

34. GALLON shall mean standard U. S. gallon.

35. OUTDOOR LOCATION shall mean outside of any building or structure, and includes locations under a weather shelter or canopy provided such locations are not enclosed by more than two walls set at right angles and are provided with vent space between the walls and vented roof or canopy.

36. SEPARATE BUILDING shall mean a detached noncommunicating building used exclusively to house a liquefied hydrogen system.

37. SPECIAL ROOM shall mean a separate enclosed area which is part of or attached to another building and is used exclusively for a liquefied hydrogen system.

38. PORTABLE CONTAINERS shall mean liquefied hydrogen cylinders, portable tanks, tank cars and tank trucks as defined by the U. S. Dept. of Transportation (formerly Interstate Commerce Commission).[1]

4. DESIGN OF LIQUEFIED HYDROGEN SYSTEMS

41. Containers

411. 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 — Unfired Pressure Vessels (1965)[2] or applicable provisions of API Standard 620, Recommended Rules for Design & Construction of Large, Welded, Low-Pressure Storage Tanks, Second Edition (June 1963) and Appendix R (April 1965).[3]

(b) Portable containers shall be designed, constructed and tested in accordance with U. S. Dept. of Transportation Specifications and Regulations.[4]

42. Supports

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

43. Marking

431. Each container shall be legibly marked to indicate "LIQUEFIED HYDROGEN — FLAMMABLE GAS."

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[1] Regulations of the U. S. Dept. of Transportation outline specifications for transportation of explosives and dangerous articles (Federal Code of Regulations — Title 49 — Parts 171–190). Available from Government Printing Office, Washington, D. C., or from the Bureau of Explosives, 1920 L. St. N. W., Washington, D. C., 20036. In Canada, the regulations of the Canadian Transport Commission for Canada apply. Available from CTC, Union Station, Ottawa, Ontario.

[2] Available from American Society of Mechanical Engineers, 345 East 47th St., New York, N. Y. 10017.

[3] Available from American Petroleum Institute, 1801 K St. N.W., Washington, D. C., 20006.

[4] See Footnote 1.

44. Safety Relief Devices

441. (a) Stationary liquefied hydrogen containers shall be equipped with safety relief devices sized in accordance with CGA Pamphlet S-1, Part 3, Safety Relief Device Standards for Compressed Gas Storage Containers.[5]

(b) Portable liquefied hydrogen containers complying with the U. S. Dept. of Transportation Regulations shall be equipped with safety relief devices as required in the U. S. Dept. of Transportation Specifications and Regulations. Safety relief devices shall be sized in accordance with the requirements of CGA Pamphlet S-1, Safety Relief Device Standards, Part 1, Compressed Gas Cylinders and Part 2, Cargo and Portable Tank Containers.[5]

442. Safety 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 516 for venting of safety relief devices in special locations.

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

444. Safety relief devices shall be provided in piping wherever liquefied hydrogen could be trapped between closures.

45. Piping, Tubing and Fittings

451. Piping, tubing and fittings and gasket and thread sealants shall be suitable for hydrogen service at the pressures and temperatures involved.[6] Consideration shall be given to the thermal expansion and contraction of piping systems when exposed to temperature fluctuations of ambient to liquefied hydrogen temperatures.

452. Hydrogen piping and tubing shall conform to American National Standard Code for Pressure Piping, Petroleum Refinery Piping, ANSI B31.3 (1973).[7] For temperatures of –20 F to –320 F American National Standard Code for Pressure Piping, Refrigeration Piping Systems, ANSI B31.5 (1967)[7] may be used.

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[5] Available from Compressed Gas Association, Inc., 500 Fifth Avenue, New York, New York 10036.

[6] Some materials suitable for liquefied hydrogen temperature are austenitic chromium-nickel alloys, certain copper alloys, and aluminum which retain ductility and do not become brittle at the temperature of liquefied hydrogen.

[7] Available from American National Standards Institute, 1430 Broadway, New York, New York 10018.

453. Joints in piping and tubing shall preferably be made by welding or brazing; flanged, threaded, socket or suitable compression fittings may be used.

454. 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. Only those insulating materials which are rated nonburning in accordance with ASTM Procedure D-1692-68[8] may be used. Other protective means may be used to protect personnel. The insulation shall be designed to have a vapor-tight seal in the outer covering to prevent the condensation of air and subsequent oxygen enrichment within the insulation. The insulation material and outside shield shall also be of adequate design to prevent attrition of the insulation due to normal operating conditions.

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

46. Equipment Assembly

461. Valves, gages, regulators and other accessories shall be suitable for liquefied hydrogen service and for the pressures and temperatures involved.

462. Installation of liquefied hydrogen systems shall be supervised by personnel familiar with proper practices and with reference to their construction and use.

463. 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 2,000 gallons capacity, this shutoff valve shall be of the remote control type 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.

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

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[8] Available from the American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103.

47. Testing

471. After installation, all field erected piping shall be tested and proved hydrogen gastight at operating pressure and temperature.

472. Containers if out of service in excess of one year shall be inspected and tested as outlined in 471. The safety relief devices shall be checked to determine if they are operable and properly set.

48. Liquefied Hydrogen Vaporizers

481. 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.

482. The vaporizer and its piping shall be adequately protected on the hydrogen and heating media sections with safety relief devices.

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

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

49. Electrical Systems

491. Electrical wiring and equipment located within 3 feet of a point where connections are regularly made and disconnected, shall be in accordance with Article 501 of the National Electrical Code, NFPA No. 70, for Class I, Group B, Division 1 locations.

492. Except as provided in 491, electrical wiring and equipment located within 25 feet of a point where connections are regularly made and disconnected or within 25 feet of a liquid hydrogen storage container, shall be in accordance with Article 501 of the National Electrical Code, NFPA No. 70, for Class I, Group B, Division 2 locations. When equipment approved for Class I, Group B atmospheres it not commercially available, the equipment may be (1) purged or ventilated in accordance with NFPA No. 496, Standard for Purged Enclosures for Electrical Equipment in Hazardous Locations, or (2) intrinsically safe, or (3) approved for Class I, Group C atmospheres. This requirement does not apply to electrical equipment which is installed on mobile supply trucks or tank cars from which the storage container is filled.

410. Bonding and Grounding

4101. The liquefied hydrogen container and associated piping shall be electrically bonded and grounded.

5. LOCATION OF LIQUEFIED HYDROGEN STORAGE

51. General Requirements

511. The storage containers shall be located so that they are readily accessible to mobile supply equipment at ground level and to authorized personnel.

512. The containers shall not be exposed by electric power lines, flammable liquid lines, flammable gas lines, or lines carrying oxidizing materials.

513. When locating liquefied hydrogen storage containers near aboveground flammable liquid storage or liquid oxygen storage, it is advisable to locate the liquefied hydrogen container on ground higher than flammable liquid storage or liquid oxygen storage.

514. Where it is necessary to locate the liquefied hydrogen container on ground that is level with or lower than adjacent flammable liquid storage or liquid oxygen storage, suitable protective means shall be taken (such as by diking, diversion curbs, or grading), with respect to the adjacent flammable liquid storage or liquid oxygen storage, to prevent accumulation of liquids within 50 feet of the liquefied hydrogen container.

515. Storage sites shall be fenced and posted to prevent entrance by unauthorized personnel. Sites shall also be placarded as follows: "LIQUEFIED HYDROGEN — FLAMMABLE GAS — NO SMOKING — NO OPEN FLAMES."

516. If liquefied hydrogen is located (as specified in Table 1) in a separate building, in a special room, or inside buildings when not in a special room and exposed to other occupancies, containers shall have the safety relief devices vented unobstructed to the outdoors at a minimum elevation of 25 feet above grade to a safe location as required in 442.

52. Specific Requirements

521. The location of liquefied hydrogen storage, as determined by the maximum total quantity of liquefied hydrogen, shall be in the order of preference as indicated by Roman numerals in the following Table 1:

TABLE 1

Maximum Total Quantity of Liquefied Hydrogen Storage Permitted

Nature of Location	Size of Hydrogen Storage (Capacity in Gallons)			
	39.63 (150 liters) to 50	51 to 300	301 to 600	In excess of 600
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 and exposed to other occupancies	IV	Not Permitted	Not Permitted	Not Permitted

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

522. The minimum distance in feet from liquefied hydrogen systems of indicated storage capacity located outdoors, in a separate building, or in a special room to any specified exposure shall be in accordance with Table 2.

TABLE 2

Minimum Distance (feet) from Liquefied Hydrogen Systems to Exposures

Type of Exposure	Liquefied Hydrogen Storage (Capacity in Gallons)		
	39.63 (150 liters) to 3,500	3,501 to 15,000	15,001 to 30,000
1. Fire-resistive Building and Fire Walls*	5	5	5
2. Noncombustible Building*	25	50	75
3. Other Buildings*	50	75	100
4. Wall Openings, Air Compressor Intakes, Inlets for Air-conditioning or Ventilating Equipment	75	75	75
5. Flammable Liquids (Aboveground and Vent or Fill Openings if Below Ground) (See 513 & 514)	50	75	100
6. Between Stationary Liquefied Hydrogen Containers	5	5	5
7. Flammable Gas Storage	50	75	100
8. Liquid Oxygen Storage and other Oxidizers (See 513 & 514)	100	100	100
9. Combustible Solids	50	75	100
10. Open Flames, Smoking and Welding	50	50	50
11. Concentrations of People†	75	75	75
12. Public Ways, Railroads, and Property Lines	25	50	75

*Refer to NFPA No. 220, "Standard Types of Building Construction," for definitions of construction types.

†In congested areas such as offices, lunchrooms, locker rooms, time clock areas and places of public assembly.

NOTE 1: The distances in Nos. 2, 3, 5, 7, 8, 9 and 12, in Table 2, may be reduced where protective structures, such as fire walls equal to height of top of the container, to safeguard the liquefied hydrogen storage system, are located between the liquefied hydrogen storage installation and the exposure. (See 35)

NOTE 2: Where protective structures are provided, ventilation and confinement of product shall be considered. The 5-foot distance in Nos. 1 and 6 facilitates maintenance and enhances ventilation.

53. Handling of Liquefied Hydrogen Inside Buildings Other than Separate Buildings and Special Rooms

531. Portable liquefied hydrogen containers of 50 gallons or less capacity as permitted in Table 1 and in compliance with 516 when housed inside buildings not located in a special room and exposed to other occupancies shall comply with the following minimum requirements:

(a) Be located 20 feet from flammable liquids and readily combustible materials such as excelsior or paper.

(b) Be located 25 feet from ordinary electrical equipment, and other sources of ignition including process or analytical equipment (see 491).

(c) Be located 25 feet from concentrations of people.

(d) Be located 50 feet from intakes of ventilation and air-conditioning equipment or intakes of compressors.

(e) Be located 50 feet from storage of other flammable gases or storage of oxidizing gases.

(f) Containers shall be protected against damage or injury due to falling objects or work activity in the area.

(g) Containers shall be firmly secured and stored in an upright position.

(h) Welding or cutting operations, and smoking shall be prohibited while hydrogen is in the room.

(i) The area shall be adequately ventilated. Safety relief devices on the containers shall be vented directly outdoors or to a suitable hood. See 442 and 516.

6. DESIGN CONSIDERATIONS AT SPECIFIC LOCATIONS

61. Outdoor Locations

611. Roadways and yard surfaces located below liquefied hydrogen piping, from which liquid air may drip, shall be constructed of noncombustible materials.

612. If protective walls are provided, they shall be constructed of noncombustible materials and in accordance with the provisions of 35 as applicable.

613. Electrical wiring and equipment shall comply with 491 and 492.

614. Adequate lighting shall be provided for nighttime transfer operation.

62. Separate Buildings

621. Separate buildings shall be of light, noncombustible construction on a substantial frame. Walls and roofs shall be lightly fastened and designed to relieve at a maximum internal pressure of 25 pounds per square foot. Windows shall be of shatterproof glass or plastic in metal frames. Doors shall be located in such a manner that they will be readily accessible to personnel in an emergency.

622. Adequate 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 one square foot per 1,000 cubic feet of room volume. Discharge from outlet openings shall be directed or conducted to a safe location.

623. There shall be no sources of ignition.

624. Electrical wiring and equipment shall comply with 491 and 492 except that the provisions of 492 shall apply to all electrical wiring and equipment in the separate building.

625. Heating, if provided, shall be by steam, hot water, or other indirect means.