



DEPARTMENT OF LICENSING AND REGULATORY AFFAIRS

DIRECTOR'S OFFICE

GENERAL INDUSTRY SAFETY STANDARDS

Filed with the Secretary of State on January 1, 1975, (as amended April 30, 1982) (as amended July 28, 2000)
(as amended January 22, 2010)

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(By authority conferred on the director of the department of energy, labor, and economic growth by sections 16 and 21 of 1974 PA 154, and Executive Reorganization Order Nos. 1996-2, 2003-1, and 2008-20, MCL 408.1016, 408.1021, 445.2001, 445.2011, and 445.2025)

R 408.16902 of the Michigan Administrative Code is amended as follows:

PART 69. COMPRESSED GASES: ACETYLENE, HYDROGEN, OXYGEN, AND NITROUS OXIDE

TABLE OF CONTENTS

R 408.16901 Rescinded.....	1	1910.103 - HYDROGEN.....	2
R 408.16902 Adoption of standards by reference.....	1	1910.104 - OXYGEN.....	8
1910.101 - COMPRESSED GASES.....	1	1910.105 - NITROUS OXIDE.....	10
1910.102 - ACETYLENE.....	1		

R 408.16901 Rescinded.

R 408.16902 Adoption of standards by reference.

Rule 6902. (1) The following federal occupational safety and health administration's regulations promulgated by the United States department of labor are adopted by reference in this rule:

- (a) The provisions of 29 C.F.R. §1910.101, "Compressed Gases, general requirements." as amended on March 7, 1996.
- (b) The provisions of 29 C.F.R. §1910.102, "Acetylene," as amended on November 9, 2009.
- (c) The provisions of 29 C.F.R. §1910.103, "Hydrogen," as amended on December 14, 2007. The specifications for electrical equipment are contained and referenced in the following:
 - (i) General Industry Safety Standard Part 39 "Design Safety Standards For Electrical Systems," R 408.13901 to 1910.399.
 - (ii) General Industry Safety Standard Part 40 "Electrical Safety-related Work Practices," R 408.14001 to R 408.14009.
- (d) The provisions of 29 C.F.R. §1910.104, "Oxygen," as amended on March 7, 1996.
- (e) The provisions of 29 C.F.R. §1910.105, "Nitrous Oxide," as amended on March 7, 1996.

(2) The OSHA adopted regulations are available from the United States Department of Labor, Occupational Safety and Health Administration, 315 West Allegan, Room 315, Lansing, Michigan, 48917, or via the internet at website www.osha.gov, at no charge as of the time of adoption of these rules.

(3) The MIOSHA referenced standards are available from the Michigan Department of Energy, Labor, and Economic Growth, MIOSHA Standards Section, 7150 Harris Drive, P.O. Box 30643, Lansing, Michigan, 48909-8143, or via the internet at website: www.michigan.gov/mioshastandards, at no charge as of the time of adoption of these rules. For quantities greater than 5, the cost, as of the time of adoption of these rules, is 4 cents per page.

1910.101 Compressed Gases (General Requirements).

(a) "Inspection of compressed gas cylinders." Each employer shall determine that compressed gas cylinders under his control are in a safe condition to the extent that this can be determined by visual inspection. Visual and other inspections shall be conducted as prescribed in the Hazardous Materials Regulations of the Department of Transportation (49 CFR parts 171-179 and 14 CFR part 103). Where those regulations are not applicable, visual and other inspections shall be conducted in accordance with Compressed Gas Association Pamphlets C-6-1968 and C-8-1962, which is incorporated by reference as specified in Sec. 1910.6.

(b) "Compressed gases." The in-plant handling, storage, and utilization of all compressed gases in cylinders, portable tanks, rail tankcars, or motor vehicle cargo tanks shall be in accordance with Compressed Gas Association Pamphlet P-1-1965, which is incorporated by reference as specified in Sec. 1910.6.

(c) "Safety relief devices for compressed gas containers." Compressed gas cylinders, portable tanks, and cargo tanks shall have pressure relief devices installed and maintained in accordance with Compressed Gas Association Pamphlets S-1.1-1963 and 1965 addenda and S-1.2-1963, which is incorporated by reference as specified in Sec. 1910.6.

1910.102 Acetylene.

(a) **Cylinders.** Employers must ensure that the in-plant transfer, handling, storage, and use of acetylene in cylinders comply with the provisions of CGA Pamphlet G-1-2003 ("Acetylene") (Compressed Gas Association, Inc., 11th ed., 2003).

(b) Piped systems.

(1) Employers must comply with Chapter 9 ("Acetylene Piping") of NFPA 51A-2006 ("Standard for Acetylene Charging Plants") (National Fire Protection Association, 2006 ed., 2006).

(2) When employers can demonstrate that the facilities, equipment, structures, or installations used to generate acetylene or to charge (fill) acetylene cylinders were installed

prior to February 16, 2006, these employers may comply with the provisions of Chapter 7 ("Acetylene Piping") of NFPA 51A-2001 ("Standard for Acetylene Charging Plants") (National Fire Protection Association, 2001 ed., 2001).

(3) The provisions of § 1910.102(b)(2) also apply when the facilities, equipment, structures, or installations used to generate acetylene or to charge (fill) acetylene cylinders were approved for construction or installation prior to February 16, 2006, but constructed and installed on or after that date.

(4) For additional information on acetylene piping systems, see CGA G-1.2-2006, Part 3 ("Acetylene piping") (Compressed Gas Association, Inc., 3rd ed., 2006).

(c) Generators and filling cylinders.

(1) Employers must ensure that facilities, equipment, structures, or installations used to generate acetylene or to charge (fill) acetylene cylinders comply with the provisions of NFPA 51A-2006 ("Standard for Acetylene Charging Plants") (National Fire Protection Association, 2006 ed., 2006).

(2) When employers can demonstrate that the facilities, equipment, structures, or installations used to generate acetylene or to charge (fill) of acetylene cylinders were constructed or installed prior to February 16, 2006, these employers may comply with the provisions of NFPA 51A-2001 ("Standard for Acetylene Charging Plants") (National Fire Protection Association, 2001 ed., 2001).

(3) The provisions of § 1910.102(c)(2) also apply when the facilities, equipment, structures, or installations were approved for construction or installation prior to February 16, 2006, but constructed and installed on or after that date.

1910.103 Hydrogen.

(a) General.

(1) Definitions. As used in this section;

(i) **Gaseous hydrogen system** is one in which the hydrogen is delivered, stored and discharged in the gaseous form to consumer's piping. The system includes stationary or movable containers, pressure regulators, safety relief devices, manifolds, interconnecting piping and controls. The system terminates at the point where hydrogen at service pressure first enters the consumer's distribution piping.

(ii) **Approved** - Means, unless otherwise indicated, listed or approved by a nationally recognized testing laboratory. Refer to 1910.7 for definition of nationally recognized testing laboratory.

(iii) **Listed** - See "approved".

(iv) **ASME** - American Society of Mechanical Engineers.

(v) **DOT Specifications**- Regulations of the Department of Transportation published in 49 CFR Chapter I.

(vi) **DOT regulations** - See 1910.103 (a)(1)(v).

(2) Scope.

(i) Gaseous hydrogen systems.

(a) Paragraph (b) of this section applies to the installation of gaseous hydrogen systems on consumer premises where the hydrogen supply to the consumer premises originates outside the consumer premises and is delivered by mobile equipment.

(b) Paragraph (b) of this section does not apply to gaseous hydrogen systems having a total hydrogen content of less than 400 cubic feet, nor to hydrogen manufacturing plants or other establishments operated by the hydrogen supplier or his agent for the purpose of storing hydrogen and refilling portable containers, trailers, mobile supply trucks, or tank cars.

(ii) Liquefied hydrogen systems.

(a) Paragraph (c) of this section applies to the installation of liquefied hydrogen systems on consumer premises.

(b) Paragraph (c) of this section does not apply to liquefied hydrogen portable containers of less than 150 liters (39.63 gallons) capacity; nor 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.

(b) Gaseous hydrogen systems.

(1) Design.

(i) Containers.

(a) Hydrogen containers shall comply with one of the following:

(1) Designed, constructed, and tested in accordance with appropriate requirements of ASME Boiler and Pressure Vessel Code, Section VIII - Unfired Pressure Vessels - 1968, which is incorporated by reference as specified in Sec. 1910.6.

(2) Designed, constructed, tested and maintained in accordance with U.S. Department of Transportation Specifications and Regulations.

(b) Permanently installed containers shall be provided with substantial noncombustible supports on firm noncombustible foundations.

(c) Each portable container shall be legibly marked with the name "Hydrogen" in accordance with the marking requirements set forth in § 1910.253(b)(1)(ii). Each manifolded hydrogen supply unit shall be legibly marked with the name "Hydrogen" or a legend such as "This unit contains hydrogen."

(ii) Safety relief devices.

(a) Hydrogen containers shall be equipped with safety relief devices as required by the ASME Boiler and Pressure Vessel Code, Section VIII Unfired Pressure Vessels, 1968 or the DOT Specifications and Regulations under which the container is fabricated.

(b) Safety relief devices shall be arranged to discharge upward and unobstructed to the open air in such a manner as to prevent any impingement of escaping gas upon the container, adjacent structure or personnel. This requirement does not apply to DOT Specification containers having an internal volume of 2 cubic feet or less.

(c) 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.

(iii) Piping, tubing, and fittings.

(a) Piping, tubing, and fittings shall be suitable for hydrogen service and for the pressures and temperatures involved. Cast iron pipe and fittings shall not be used.

(b) Piping and tubing shall conform to Section 2 - "Industrial Gas and Air Piping" - Code for Pressure Piping, ANSI B31.1-1967 with addenda B31.1-1969, which is incorporated by reference as specified in Sec. 1910.6.

(c) Joints in piping and tubing may be made by welding or brazing or by use of flanged, threaded, socket, or compression fittings. Gaskets and thread sealants shall be suitable for hydrogen service.

(iv) Equipment assembly.

- (a) Valves, gauges, regulators, and other accessories shall be suitable for hydrogen service.
- (b) Installation of hydrogen systems shall be supervised by personnel familiar with proper practices with reference to their construction and use.
- (c) Storage containers, piping, valves, regulating equipment, and other accessories shall be readily accessible, and shall be protected against physical damage and against tampering.
- (d) Cabinets or housings containing hydrogen control or operating equipment shall be adequately ventilated.
- (e) Each mobile hydrogen supply unit used as part of a hydrogen system shall be adequately secured to prevent movement.
- (f) Mobile hydrogen supply units shall be electrically bonded to the system before discharging hydrogen.
- (v) **Marking.**
The hydrogen storage location shall be permanently placarded as follows:

**"HYDROGEN - FLAMMABLE GAS
NO SMOKING - NO OPEN FLAMES"**

or equivalent.

- (vi) **Testing.** After installations, all piping, tubing, and fittings shall be tested and proved hydrogen gas tight at maximum operating pressure.
- (2) **Location.**
- (i) **General.**
 - (a) The system shall be located so that it is readily accessible to delivery equipment and to authorized personnel.
 - (b) Systems shall be located above ground.
 - (c) Systems shall not be located beneath electric power lines.
 - (d) Systems shall not be located close to flammable liquid piping or piping of other flammable gases.

- (e) Systems near aboveground flammable liquid storage shall be located on ground higher than the flammable liquid storage except when dikes, diversion curbs, grading, or separating solid walls are used to prevent accumulation of flammable liquids under the system.
- (ii) **Specific requirements.**
- (a) The location of a system, as determined by the maximum total contained volume of hydrogen, shall be in the order of preference as indicated by Roman numerals in Table H-1.
- (b) The minimum distance in feet from a hydrogen system of indicated capacity located outdoors, in separate buildings or in special rooms to any specified outdoor exposure shall be in accordance with Table H-2.
- (c) The distances in Table H-2 Items 1 and 3 to 10 inclusive do not apply where protective structures such as adequate fire walls are located between the system and the exposure.
- (d) Hydrogen systems of less than 3,000 CF when located inside buildings and exposed to other occupancies shall be situated in the building so that the system will be as follows:
 - (1) In an adequately ventilated area as in paragraph (b)(3)(ii)(b) of this section.
 - (2) Twenty feet from stored flammable materials or oxidizing gases.
 - (3) Twenty-five feet from open flames, ordinary electrical equipment or other sources of ignition.
 - (4) Twenty-five feet from concentrations of people.
 - (5) Fifty feet from intakes of ventilation or air-conditioning equipment and air compressors.
 - (6) Fifty feet from other flammable gas storage.
 - (7) Protected against damage or injury due to falling objects or working activity in the area.
 - (8) More than one system of 3,000 CF or less may be installed in the same room, provided the systems are separated by at least 50 feet. Each such system shall meet all of the requirements of this paragraph.

TABLE H-1

Nature of Location	Size of Hydrogen System		
	Less than 3,000 CF	3,000 CF to 15,000 CF	In excess of 15,000 CF
Outdoors	I	IDI	-
In a separate building	II	II	II
In a special room	III	III	Not Permitted
Inside buildings not in a special room and exposed to other occupancies	IV	Not Permitted	Not Permitted

TABLE H-2

Type of Outdoor Exposure			Size of Hydrogen System		
			Less than 3,000 CF	3,000 CF to 15,000 CF	In excess of 15,000 CF
1.	Building or structure	Wood frame construction ¹	10	25	50
		Heavy timber, noncombustible or ordinary construction ¹	0	10	25 ²
		Fire-restive construction ¹	0	0	0
2.	Wall openings	Not above any part of a system	10	10	10
		Above any part of a system	25	25	25
3.	Flammable liquids above ground	0 to 1,000 gallons	10	25	25
		In excess of 1,000 gallons	25	50	50
4.	Flammable liquids below ground 0 to 1,000 gallons	Tank	10	10	10
		Vent or fill opening of tank	25	25	25
5.	Flammable liquids below ground in excess of 1,000 gallons	Tank	20	20	20
		Vent or fill opening of tank	25	25	25
6.	Flammable gas storage, either high pressure or low pressure	0 to 15,000 CF capacity	10	25	25
		In excess of 15,000 CF capacity	25	50	50
7.	Oxygen storage	12,000 CF or less ⁴ More than 12,000 CF ⁵	-	-	-
8.	Fast burning solids such as ordinary lumber, excelsior or paper		50	50	50
9.	Slow burning solids such as heavy timber or coal		25	25	25
10.	Open flames and other sources of ignition		25	25	25
11.	Air compressor intakes or inlets to ventilating or air-conditioning equipment		50	50	50
12.	Concentration of people ³		25	50	50

¹Refer to NFPA No. 220 Standard Types of Building Construction for definitions of various types of construction. (1969 Ed.)

²But not less than one-half the height of adjacent side wall of the structure.

³In congested areas such as offices, lunchrooms, locker rooms, time-clock areas.

⁴Refer to NFPA No 51, gas systems for welding and cutting (1969).

⁵Refer to NFPA No 566, bulk oxygen systems at consumer sites (1969).

(3) Design consideration at specific locations**(i) Outdoor locations.**

- (a) Where protective walls or roofs are provided, they shall be constructed of noncombustible materials.
- (b) Where the enclosing sides adjoin each other, the area shall be properly ventilated.
- (c) Electrical equipment within 15 feet shall be in accordance with subpart S of this part.

(ii) Separate buildings.

- (a) Separate buildings shall be built of at least noncombustible construction. Windows and doors shall be located so as to be readily accessible in case of emergency. Windows shall be of glass or plastic in metal frames.
- (b) Adequate ventilation to the outdoors shall be provided. Inlet openings shall be located near

the floor in exterior walls only. Outlet openings shall be located at the high point of the room in exterior walls or roof. Inlet and outlet openings shall each have minimum total area of one (1) square foot per 1,000 cubic feet of room volume. Discharge from outlet openings shall be directed or conducted to a safe location.

- (c) Explosion venting shall be provided in exterior walls or roof only. The venting area shall be equal to not less than 1 square foot per 30 cubic feet of room volume and may consist of any one or any combination of the following: Walls of light, noncombustible material, preferably single thickness, single strength glass; lightly fastened hatch covers; lightly fastened swinging doors in exterior walls opening outward; lightly fastened

walls or roof designed to relieve at a maximum pressure of 25 pounds per square foot.

- (d) There shall be no sources of ignition from open flames, electrical equipment, or heating equipment.
- (e) Electrical equipment shall be in accordance with subpart S of this part for Class I, Division 2 locations.
- (f) Heating, if provided, shall be by steam, hot water, or other indirect means.
- (iii) **Special rooms.**
 - (a) Floor, walls, and ceiling shall have a fire-resistance rating of at least 2 hours. Walls or partitions 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 shall be located so as to be readily accessible in case of emergency. Windows shall be of glass or plastic in metal frames.
 - (b) Ventilation shall be as provided in paragraph (b)(3)(ii)(b) of this section.
 - (c) Explosion venting shall be as provided in paragraph (b)(3)(ii)(c) of this section.
 - (d) There shall be no sources of ignition from open flames, electrical equipment, or heating equipment.
 - (e) Electrical equipment shall be in accordance with the requirements of subpart S of this part for Class I, Division 2 locations.
 - (f) Heating, if provided, shall be by steam, hot water, or indirect means.

(4) **Operating instructions.** For installations which require any operation of equipment by the user, legible instructions shall be maintained at operating locations.

(5) **Maintenance.** The equipment and functioning of each charged gaseous hydrogen system shall be maintained in a safe operating condition in accordance with the requirements of this section. The area within 15 feet of any hydrogen container shall be kept free of dry vegetation and combustible material.

(c) **Liquefied hydrogen systems.**

(1) **Design**

(i) **Containers.**

- (a) Hydrogen containers shall comply with the following: 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 (1968) or applicable provisions of API Standard 620, Recommended Rules for Design and Construction of Large, Welded, Low-Pressure Storage Tanks, Second Edition (June 1963) and appendix R (April 1965), which is incorporated by reference as specified in Sec. 1910.6.
- (b) Portable containers shall be designed, constructed and tested in accordance with DOT Specifications and Regulations.
- (ii) **Supports.** 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 a protective coating having a 2-hour fire-resistance rating.

- (iii) **Marking.** Each container shall be legibly marked to indicate

"LIQUEFIED HYDROGEN - FLAMMABLE GAS"

(iv) **Safety relief devices.**

- (a)(1) 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, which is incorporated by reference as specified in Sec. 1910.6.
- (2) Portable liquefied hydrogen containers complying with the U.S. Department of Transportation Regulations shall be equipped with safety relief devices as required in the U.S. Department 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.
 - (b) 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 paragraph (c)(2)(i)(f) of this section for venting of safety relief devices in special locations.
 - (c) 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.
 - (d) Safety relief devices shall be provided in piping wherever liquefied hydrogen could be trapped between closures.
 - (v) **Piping, tubing, and fittings.**
 - (a) 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.
 - (b) Gaseous hydrogen piping and tubing (above -20 deg. F.) shall conform to the applicable sections of Pressure Piping Section 2 - Industrial Gas and Air Piping, ANSI B31.1-1967 with addenda B31.1-1969. Design of liquefied hydrogen or cold (-20 deg. F. or below) gas piping shall use Petroleum Refinery Piping ANSI B31.3-1966 or Refrigeration Piping ANSI B31.5-1966 with addenda B31.5a-1968 as a guide, which is incorporated by reference as specified in Sec. 1910.6.
 - (c) Joints in piping and tubing shall preferably be made by welding or brazing; flanged, threaded, socket, or suitable compression fittings may be used.
 - (d) 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 Procedures D1692-68, which is incorporated by reference as specified in Sec. 1910.6, 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.

- (e) 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.
- (vi) **Equipment assembly.**
 - (a) Valves, gauges, regulators, and other accessories shall be suitable for liquefied hydrogen service and for the pressures and temperatures involved.
 - (b) Installation of liquefied hydrogen systems shall be supervised by personnel familiar with proper practices and with reference to their construction and use.
 - (c) 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.
 - (d) Cabinets or housings containing hydrogen control equipment shall be ventilated to prevent any accumulation of hydrogen gas.
- (vii) **Testing.**
 - (a) After installation, all field-erected piping shall be tested and proved hydrogen gas-tight at operating pressure and temperature.
 - (b) Containers if out of service in excess of 1 year shall be inspected and tested as outlined in (a) of this subdivision. The safety relief devices shall be checked to determine if they are operable and properly set.
- (viii) **Liquefied hydrogen vaporizers.**
 - (a) 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.
 - (b) The vaporizer and its piping shall be adequately protected on the hydrogen and heating media sections with safety relief devices.
 - (c) Heat used in a liquefied hydrogen vaporizer shall be indirectly supplied utilizing media such as air, steam, water, or water solutions.
 - (d) 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.
- (ix) **Electrical systems.**
 - (a) Electrical wiring and equipment located within 3 feet of a point where connections are regularly made and disconnected, shall be in accordance with subpart S of this part, for Class I, Group B, Division 1 locations.
 - (b) Except as provided in (a) of this subdivision, 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 subpart S of this part, for Class I, Group B, Division 2 locations. When equipment approved for class I, group B atmospheres is not commercially available, the equipment may be -

- (1) Purged or ventilated in accordance with NFPA No. 496-1967, Standard for Purged Enclosures for Electrical Equipment in Hazardous Locations,
 - (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.
 - (x) **Bonding and grounding.** The liquefied hydrogen container and associated piping shall be electrically bonded and grounded.
- (2) **Location of liquefied hydrogen storage**
- (i) **General requirements.**
 - (a) The storage containers shall be located so that they are readily accessible to mobile supply equipment at ground level and to authorized personnel.
 - (b) The containers shall not be exposed by electric power lines, flammable liquid lines, flammable gas lines, or lines carrying oxidizing materials.
 - (c) When locating liquefied hydrogen storage containers near above-ground 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.
 - (d) 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, 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.
 - (e) 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".**
 - (f) If liquefied hydrogen is located in (as specified in Table H-3) 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 paragraph (c)(1)(iv)(b) of this section.
 - (ii) **Specific requirements.**
 - (a) 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 H-3.
 - (b) 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 H-4.

TABLE H-3 - 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	Do
Inside buildings not in a special room and exposed to other occupancies	IV	Not Permitted	Do	Do

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

TABLE H-4 - MINIMUM DISTANCE (FEET) FROM LIQUEFIED HYDROGEN SYSTEMS TO EXPOSURE ^{1,2}

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 ³	5	5	5
2. Noncombustible buildings ³	25	50	75
3. Other buildings ³	50	75	100
4. Wall openings, air-compressor intakes, inlets for air-conditioning or ventilating equipment	75	75	75
5. Flammable liquids (above ground and vent or fill openings if below ground) (see 513 and 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 and 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

¹The distance in Nos. 2, 3, 5, 7, 9, and 12 in Table H-4 may be reduced where protective structures, such as firewalls 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.

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

³Refer to Standard Types of Building Construction, NFPA No. 220-1969 for definitions of various types of construction. In congested areas such as offices, lunchrooms, locker rooms, time-clock areas.

(iii) Handling of liquefied hydrogen inside buildings other than separate buildings and special rooms. Portable liquefied hydrogen containers of 50 gallons or less capacity as permitted in Table H-3 and in compliance with subdivision (i) (f) of this subparagraph 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.

(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 paragraphs (c)(1)(iv)(b) and (c)(2)(i)(f) of this section.
- (3) Design considerations at specific locations.**
- (i) Outdoor locations.**
 - (a) 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.
 - (b) Roadways and yard surfaces located below liquefied hydrogen piping, from which liquid air may drip, shall be constructed of noncombustible materials.
 - (c) If protective walls are provided, they shall be constructed of noncombustible materials and in accordance with the provisions of paragraphs (c)(3)(i)(a) of this section as applicable.
 - (d) Electrical wiring and equipment shall comply with paragraph (c)(1)(ix)(a) and (b) of this section.
 - (e) Adequate lighting shall be provided for nighttime transfer operation.
 - (ii) Separate buildings.**
 - (a) 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.
 - (b) 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 1 square foot per 1,000 cubic feet of room volume. Discharge from outlet openings shall be directed or conducted to a safe location.
 - (c) There shall be no sources of ignition.
 - (d) Electrical wiring and equipment shall comply with paragraphs (c)(1)(ix)(a) and (b) of this section except that the provisions of paragraph (c)(1)(ix)(b) of this section shall apply to all electrical wiring and equipment in the separate building.
 - (e) Heating, if provided, shall be by steam, hot water, or other indirect means.
 - (iii) Special rooms.**
 - (a) Floors, walls, and ceilings shall have a fire resistance rating of at least 2 hours. Walls or partitions 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 will be accessible in an emergency. Windows shall be of shatterproof glass or plastic in metal frames.
- (b) Ventilation shall be as provided in paragraph (c)(3)(ii)(b) of this section.
 - (c) Explosion venting shall be provided in exterior walls or roof only. The venting area shall be equal to not less than 1 square foot per 30 cubic feet of room volume and may consist of any one or any combination of the following: Walls of light noncombustible material; lightly fastened hatch covers; lightly fastened swinging doors opening outward in exterior walls; lightly fastened walls or roofs designed to relieve at a maximum pressure of 25 pounds per square foot.
 - (d) There shall be no sources of ignition.
 - (e) Electrical wiring and equipment shall comply with paragraphs (c)(1)(ix)(a) and (b) of this section except that the provision of paragraph (c)(1)(ix)(b) of this section shall apply to all electrical wiring and equipment in the special room.
 - (f) Heating, if provided, shall be steam, hot water, or by other indirect means.
- (4) Operating instructions.**
- (i) **Written instructions.** For installation which require any operation of equipment by the user, legible instructions shall be maintained at operating locations.
 - (ii) **Attendant.** A qualified person shall be in attendance at all times while the mobile hydrogen supply unit is being unloaded.
 - (iii) **Security.** Each mobile liquefied hydrogen supply unit used as part of a hydrogen system shall be adequately secured to prevent movement.
 - (iv) **Grounding.** The mobile liquefied hydrogen supply unit shall be grounded for static electricity.
- (5) Maintenance.** The equipment and functioning of each charged liquefied hydrogen system shall be maintained in a safe operating condition in accordance with the requirements of this section. Weeds or similar combustibles shall not be permitted within 25 feet of any liquefied hydrogen equipment.
- 1910.104 Oxygen.**
- (a) "Scope."** This section applies to the installation of bulk oxygen systems on industrial and institutional consumer premises. This section does not apply to oxygen manufacturing plants or other establishments operated by the oxygen supplier or his agent for the purpose of storing oxygen and refilling portable containers, trailers, mobile supply trucks, or tank cars, nor to systems having capacities less than those stated in paragraph (b) (1) of this section.
 - (b) "Bulk oxygen systems"**
 - (1) "Definition."** As used in this section: A bulk oxygen system is an assembly of equipment, such as oxygen storage containers, pressure regulators, safety devices, vaporizers, manifolds, and interconnecting piping, which has storage capacity of more than 13,000 cubic feet of oxygen, Normal Temperature and Pressure (NTP), connected in service or ready for service, or more than 25,000 cubic feet of oxygen (NTP) including unconnected reserves on hand at the site. The bulk oxygen system terminates at the point where oxygen at service pressure first enters the supply line. The oxygen containers may be stationary or movable, and the oxygen may be stored as gas or liquid.
 - (2) "Location"**
 - (i) **"General."** Bulk oxygen storage systems shall be located above ground out of doors, or shall be installed in a building of noncombustible construction, adequately vented, and used for that purpose exclusively. The location selected

shall be such that containers and associated equipment shall not be exposed by electric power lines, flammable or combustible liquid lines, or flammable gas lines.

- (ii) **"Accessibility."** The system shall be located so that it is readily accessible to mobile supply equipment at ground level and to authorized personnel.
 - (iii) **"Leakage."** Where oxygen is stored as a liquid, noncombustible surfacing shall be provided in an area in which any leakage of liquid oxygen might fall during operation of the system and filling of a storage container. For purposes of this paragraph, asphaltic or bituminous paving is considered to be combustible.
 - (iv) **"Elevation."** When locating bulk oxygen systems near above-ground flammable or combustible liquid storage which may be either indoors or outdoors, it is advisable to locate the system on ground higher than the flammable or combustible liquid storage.
 - (v) **"Dikes."** Where it is necessary to locate a bulk oxygen system on ground lower than adjacent flammable or combustible liquid storage suitable means shall be taken (such as by diking, diversion curbs, or grading) with respect to the adjacent flammable or combustible liquid storage to prevent accumulation of liquids under the bulk oxygen system.
- (3) **"Distance between systems and exposures"**
- (i) **"General."** The minimum distance from any bulk oxygen storage container to exposures, measured in the most direct line except as indicated in paragraphs (b)(3) (vi) and (viii) of this section, shall be as indicated in paragraphs (b)(3) (ii) to (xviii) of this section inclusive.
 - (ii) **"Combustible structures."** Fifty feet from any combustible structures.
 - (iii) **"Fire resistive structures."** Twenty-five feet from any structures with fire-resistive exterior walls or sprinklered buildings of other construction, but not less than one-half the height of adjacent side wall of the structure.
 - (iv) **"Openings."** At least 10 feet from any opening in adjacent walls of fire resistive structures. Spacing from such structures shall be adequate to permit maintenance, but shall not be less than 1 foot.
 - (v) **"Flammable liquid storage above-ground."**

Distance (feet)	Capacity (gallons)
50	0 to 1000
90	1001 or more

(vi) **"Flammable liquid storage below-ground."**

Distance measured horizontally from oxygen storage container to flammable liquid tank (feet)	Distance from oxygen storage container to filling and vent connections or openings to flammable liquid tank (feet)	Capacity gallons
15	50	0 to 1000
30	50	1001 or more

(vii) **"Combustible liquid storage above-ground."**

Distance (feet)	Capacity (gallons)
25	0 To 1000
50	1001 or more

(viii) **"Combustible liquid storage below ground."**

Distance measured horizontally from oxygen storage container to combustible liquid tank (feet)	Distance from oxygen storage container to filling and vent connections or openings to combustible liquid tank (feet)
15	40

(ix) **"Flammable gas storage." (Such as compressed flammable gases, liquefied flammable gases and flammable gases in low pressure gas holders):**

Distance (feet)	Capacity (cu. ft. NTP)
50	Less than 5000
90	5000 or more

- (x) **"Highly combustible materials."** Fifty feet from solid materials which burn rapidly, such as excelsior or paper.
- (xi) **"Slow-burning materials."** Twenty-five feet from solid materials which burn slowly, such as coal and heavy timber.
- (xii) **"Ventilation."** Seventy-five feet in one direction and 35 feet in approximately 90 deg. direction from confining walls (not including firewalls less than 20 feet high) to provide adequate ventilation in courtyards and similar confining areas.
- (xiii) **"Congested areas."** Twenty-five feet from congested areas such as offices, lunchrooms, locker rooms, time clock areas, and similar locations where people may congregate.
- (xiv)-(xvii) **[Reserved]**
- (xviii) **"Exceptions."** The distances in paragraphs (b)(3) (ii), (iii), (v) to (xi) inclusive, of this section do not apply where protective structures such as firewalls of adequate height to safeguard the oxygen storage systems are located between the bulk oxygen storage installation and the exposure. In such cases, the bulk oxygen storage installation may be a minimum distance of 1 foot from the firewall.

(4) **"Storage containers"**

- (i) **"Foundations and supports."** Permanently installed containers shall be provided with substantial noncombustible supports on firm noncombustible foundations.
- (ii) **"Construction - liquid."** Liquid oxygen storage containers shall be fabricated from materials meeting the impact test requirements of paragraph UG-84 of ASME Boiler and Pressure Vessel Code, Section VIII - Unfired Pressure Vessels - 1968, which is incorporated by reference as specified in Sec. 1910.6. Containers operating at pressures above 15 pounds per square inch gage (p.s.i.g.) shall be designed, constructed, and tested in accordance with appropriate requirements of ASME Boiler and Pressure Vessel Code, Section VII - Unfired Pressure Vessels - 1968. Insulation surrounding the liquid oxygen container shall be noncombustible.
- (iii) **"Construction - gaseous."** High-pressure gaseous oxygen containers shall comply with one of the following:

- (a) Designed, constructed, and tested in accordance with appropriate requirements of ASME Boiler and Pressure Vessel Code, Section VIII - Unfired Pressure Vessels - 1968.
 - (b) Designed, constructed, tested, and maintained in accordance with DOT Specifications and Regulations.
- (5) **"Piping, tubing, and fittings"**
- (i) **"Selection."** Piping, tubing, and fittings shall be suitable for oxygen service and for the pressures and temperatures involved.
 - (ii) **"Specification."** Piping and tubing shall conform to Section 2 - Gas and Air Piping Systems of Code for Pressure Piping, ANSI, B31.1-1967 with addenda B31.10a-1969, which is incorporated by reference as specified in Sec. 1910.6.
 - (iii) **"Fabrication."** Piping or tubing for operating temperatures below 20 deg. F. shall be fabricated from materials meeting the impact test requirements of paragraph UG-84 of ASME Boiler and Pressure Vessel Code, Section VIII - Unfired Pressure Vessels - 1968, when tested at the minimum operating temperature to which the piping may be subjected in service.
- (6) **"Safety relief devices"**
- (i) **"General."** Bulk oxygen storage containers, regardless of design pressure shall be equipped with safety relief devices as required by the ASME code or the DOT specifications and regulations.
 - (ii) **"DOT containers."** Bulk oxygen storage containers designed and constructed in accordance with DOT specification shall be equipped with safety relief devices as required thereby.
 - (iii) **"ASME containers."** Bulk oxygen storage containers designed and constructed in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII-Unfired Pressure Vessel-1968 shall be equipped with safety relief devices meeting the provisions of the Compressed Gas Association Pamphlet "Safety Relief Device Standards for Compressed Gas Storage Containers," S-1, Part 3, which is incorporated by reference as specified in Sec. 1910.6.
 - (iv) **"Insulation."** Insulation casings on liquid oxygen containers shall be equipped with suitable safety relief devices.
 - (v) **"Reliability."** All safety relief devices shall be so designed or located that moisture cannot collect and freeze in a manner which would interfere with proper operation of the device.
- (7) **"Liquid oxygen vaporizers"**
- (i) **"Mounts and couplings."** The vaporizer shall be anchored and its connecting piping be sufficiently flexible to provide for the effect of expansion and contraction due to temperature changes.
 - (ii) **"Relief devices."** The vaporizer and its piping shall be adequately protected on the oxygen and heating medium sections with safety relief devices.
 - (iii) **"Heating."** Heat used in an oxygen vaporizer shall be indirectly supplied only through media such as steam, air, water, or water solutions which do not react with oxygen.
 - (iv) **"Grounding."** If electric heaters are used to provide the primary source of heat, the vaporizing system shall be electrically grounded.

(8) **"Equipment assembly and installation"**

- (i) **"Cleaning."** Equipment making up a bulk oxygen system shall be cleaned in order to remove oil, grease or other readily oxidizable materials before placing the system in service.
- (ii) **"Joints."** Joints in piping and tubing may be made by welding or by use of flanged, threaded, slip, or compression fittings. Gaskets or thread sealants shall be suitable for oxygen service.
- (iii) **"Accessories."** Valves, gages, regulators, and other accessories shall be suitable for oxygen service.
- (iv) **"Installation."** Installation of bulk oxygen systems shall be supervised by personnel familiar with proper practices with reference to their construction and use.
- (v) **"Testing."** After installation all field erected piping shall be tested and proved gas tight at maximum operating pressure. Any medium used for testing shall be oil free and nonflammable.
- (vi) **"Security."** Storage containers, piping, valves, regulating equipment, and other accessories shall be protected against physical damage and against tampering.
- (vii) **"Venting."** Any enclosure containing oxygen control or operating equipment shall be adequately vented.
- (viii) **"Placarding."** The bulk oxygen storage location shall be permanently placarded to indicate:

"OXYGEN - NO SMOKING - NO OPEN FLAMES"

or an equivalent warning.

- (ix) **"Electrical wiring."** Bulk oxygen installations are not hazardous locations as defined and covered in subpart S of this part. Therefore, general purpose or weatherproof types of electrical wiring and equipment are acceptable depending upon whether the installation is indoors or outdoors. Such equipment shall be installed in accordance with the applicable provisions of subpart S of this part.

(9) **"Operating instructions."** For installations which require any operation of equipment by the user, legible instructions shall be maintained at operating locations.

(10) **"Maintenance."** The equipment and functioning of each charged bulk oxygen system shall be maintained in a safe operating condition in accordance with the requirements of this section. Wood and long dry grass shall be cut back within 15 feet of any bulk oxygen storage container.

1910.105 Nitrous Oxide.

The piped systems for the in-plant transfer and distribution of nitrous oxide shall be designed, installed, maintained, and operated in accordance with Compressed Gas Association Pamphlet G-8.1-1964, which is incorporated by reference as specified in Sec. 1910.6.



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