

(b) *Piped systems.* The piped systems for the inplant transfer and distribution of acetylene shall be designed, installed, maintained, and operated in accordance with Compressed Gas Association Pamphlet G-1.3-1959, which is incorporated by reference as specified in § 1910.6.

(c) *Generators and filling cylinders.* Plants for the generation of acetylene and the charging (filling) of acetylene cylinders shall be designed, constructed, and tested in accordance with the standards prescribed in Compressed Gas Association Pamphlet G-1.4-1966, which is incorporated by reference as specified in § 1910.6.

[39 FR 23502, June 27, 1974, as amended at 61 FR 9236, Mar. 7, 1996]

§ 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 § 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 non-combustible supports on firm non-combustible foundations.

(c) Each portable container shall be legibly marked with the name "Hydrogen" in accordance with "Marking Portable Compressed Gas Containers to Identify the Material Contained" ANSI Z48.1—1954, which is incorporated by reference as specified in § 1910.6. 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 § 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.

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. |

(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.

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 | ² 25 |
| 2. Wall openings | Fire-resistive construction ¹ | 0 | 0 | 0 |
| | Not above any part of a system | 10 | 10 | 10 |
| 3. Flammable liquids above ground. | Above any part of a system | 25 | 25 | 25 |
| | 0 to 1,000 gallons | 10 | 25 | 25 |
| 4. Flammable liquids below ground—0 to 1,000 gallons. | In excess of 1,000 gallons | 25 | 50 | 50 |
| | Tank | 10 | 10 | 10 |
| 5. Flammable liquids below ground—in excess of 1,000 gallons. | Vent or fill opening of tank | 25 | 25 | 25 |
| | Tank | 20 | 20 | 20 |
| 6. Flammable gas storage, either high pressure or low pressure. | Vent or fill opening of tank | 25 | 25 | 25 |
| | 0 to 15,000 CF capacity | 10 | 25 | 25 |
| 7. Oxygen storage | In excess of 15,000 CF capacity | 25 | 50 | 50 |
| | 12,000 CF or less ⁴ | | | |
| 8. Fast burning solids such as ordinary lumber, excelsior or paper | More than 12,000 CF ⁵ | | | |
| | | 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 |

¹ Refer to NFPA No. 220 Standard Types of Building Construction for definitions of various types of construction. (1969 Ed.)
² But not less than one-half the height of adjacent side wall of the structure.
³ In congested areas such as offices, lunchrooms, locker rooms, time-clock areas.
⁴ Refer to NFPA No. 51, gas systems for welding and cutting (1969).
⁵ Refer to NFPA No. 566, bulk oxygen systems at consumer sites (1969).

(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.

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

protective walls or roofs are provided, they shall be constructed of non-combustible 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 non-combustible 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) Electric 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 § 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 § 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 °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 °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 are incorporated by reference as specified in § 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 § 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.

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. |

TABLE H-3—MAXIMUM TOTAL QUANTITY OF LIQUEFIED HYDROGEN STORAGE PERMITTED—
Continued

| 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 |
| 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.

(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-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 building 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 |

¹ The 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.

² Where 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.

³ Refer 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 paragraph (c)(3)(i)(a) of this section.

(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 paragraph (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

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shall not be permitted within 25 feet of any liquefied hydrogen equipment.

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§ 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.*