

CHAPTER 35

FLAMMABLE GASES AND FLAMMABLE CRYOGENIC FLUIDS

SECTION 3501 GENERAL

3501.1 Scope. The storage and use of flammable gases shall be in accordance with this chapter. *Compressed gases* shall also comply with Chapter 30 and *cryogenic fluids* shall also comply with Chapter 32. Bulk hydrogen *compressed gas* systems and bulk liquefied hydrogen gas systems shall comply with NFPA 55. Hydrogen motor fuel-dispensing stations and repair garages and their associated above-ground hydrogen storage systems shall also be designed and constructed in accordance with Chapter 22.

Exceptions:

1. Gases used as refrigerants in refrigeration systems (see Section 606).
2. Liquefied petroleum gases and natural gases regulated by Chapter 38.
3. Fuel-gas systems and appliances regulated under the *International Fuel Gas Code* other than gaseous hydrogen systems and appliances.
4. Pyrophoric gases in accordance with Chapter 41.

3501.2 Permits. Permits shall be required as set forth in Section 105.6.

SECTION 3502 DEFINITIONS

3502.1 Definitions. The following words and terms shall, for the purposes of this chapter and as used elsewhere in this code, have the meanings shown herein.

BULK HYDROGEN COMPRESSED GAS SYSTEM. An assembly of equipment, consisting of, but not limited to, storage containers, pressure regulators, pressure relief devices, vaporizers, manifolds and piping, with a storage capacity of more than 400 ft³ (scf) (11 m³) of compressed hydrogen gas, including unconnected reserves integral to the system. The bulk system terminates at the point where the gas supply, at service pressure, first enters the supply line. The containers are either stationary or portable, and the gas is stored as a compressed gas.

BULK LIQUEFIED HYDROGEN GAS SYSTEM. An assembly of equipment, consisting of, but not limited to, storage containers, pressure regulators, pressure relief devices, vaporizers, manifolds and piping, with a storage capacity of more than 39.7 gallons (150 L) of liquefied hydrogen, including unconnected reserves integral to the system. The bulk system terminates at the point where the gas supply, at service pressure, first enters the supply line. The containers are either stationary or portable, and the gas is stored as a cryogenic fluid.

FLAMMABLE GAS. A material which is a gas at 68°F (20°C) or less at 14.7 pounds per square inch atmosphere (psia)

(101 kPa) of pressure [a material that has a *boiling point* of 68°F (20°C) or less at 14.7 psia (101 kPa)] which:

1. Is ignitable at 14.7 psia (101 kPa) when in a mixture of 13 percent or less by volume with air; or
2. Has a flammable range at 14.7 psia (101 kPa) with air of at least 12 percent, regardless of the lower limit.

The limits specified shall be determined at 14.7 psi (101 kPa) of pressure and a temperature of 68°F (20°C) in accordance with ASTM E 681.

FLAMMABLE LIQUEFIED GAS. A liquefied *compressed gas* which, under a charged pressure, is partially liquid at a temperature of 68°F (20°C) and which is flammable.

METAL HYDRIDE. A generic name for compounds composed of metallic element(s) and hydrogen.

METAL HYDRIDE STORAGE SYSTEM. A *closed system* consisting of a group of components assembled as a package to contain metal-hydrogen compounds for which there exists an equilibrium condition where the hydrogen-absorbing metal alloy(s), hydrogen gas and the metal-hydrogen compound(s) coexist and where only hydrogen gas is released from the system in normal use.

SECTION 3503 GENERAL REQUIREMENTS

3503.1 Quantities not exceeding the maximum allowable quantity per control area. The storage and use of flammable gases in amounts not exceeding the *maximum allowable quantity per control area* indicated in Section 2703.1 shall be in accordance with Sections 2701, 2703, 3501 and 3503.

3503.1.1 Special limitations for indoor storage and use. Flammable gases shall not be stored or used in Group A, E, I or R occupancies or in offices in Group B occupancies.

Exceptions:

1. Cylinders of nonliquefied *compressed gases* not exceeding a capacity of 250 cubic feet (7.08 m³) or liquefied gases not exceeding a capacity of 40 pounds (18 kg) each at *normal temperature and pressure (NTP)* used for maintenance purposes, patient care or operation of equipment.
2. Food service operations in accordance with Section 3803.2.1.7.

3503.1.1.1 Medical gases. Medical gas system supply cylinders shall be located in medical gas storage rooms or gas cabinets as set forth in Section 3006.

3503.1.1.2 Aggregate quantity. The aggregate quantities of flammable gases used for maintenance purposes and operation of equipment shall not exceed the *maximum allowable quantity per control area* indicated in Table 2703.1.1(1).

3503.1.2 Storage containers. Cylinders and pressure vessels for flammable gases shall be designed, constructed, installed, tested and maintained in accordance with Chapter 30.

3503.1.3 Emergency shutoff. *Compressed gas* systems conveying flammable gases shall be provided with *approved* manual or automatic emergency shutoff valves that can be activated at each point of use and at each source.

3503.1.3.1 Shutoff at source. A manual or automatic fail-safe emergency shutoff valve shall be installed on supply piping at the cylinder or bulk source. Manual or automatic cylinder valves are allowed to be used as the required emergency shutoff valve when the source of supply is limited to unmanifolded cylinder sources.

3503.1.3.2 Shutoff at point of use. A manual or automatic emergency shutoff valve shall be installed on the supply piping at the point of use or at a point where the equipment using the gas is connected to the supply system.

3503.1.4 Ignition source control. Ignition sources in areas containing flammable gases in storage or in use shall be controlled in accordance with Section 2703.7.

Exception: Fuel gas systems connected to building service utilities in accordance with the *International Fuel Gas Code*.

3503.1.4.1 Static-producing equipment. Static-producing equipment located in flammable gas storage areas shall be grounded.

3503.1.4.2 Signs. “No Smoking” signs shall be posted at entrances to rooms and in areas containing flammable gases in accordance with Section 2703.7.1.

3503.1.5 Electrical. Electrical wiring and equipment shall be installed and maintained in accordance with Section 605 and NFPA 70.

3503.1.5.1 Bonding of electrically conductive materials and equipment. Exposed noncurrent-carrying metal parts, including metal gas piping systems, that are part of flammable gas supply systems located in a hazardous (electrically classified) location shall be bonded to a grounded conductor in accordance with the provisions of NFPA 70.

3503.1.5.2 Static-producing equipment. Static-producing equipment located in flammable gas storage or use areas shall be grounded.

3503.1.6 Liquefied flammable gases and flammable gases in solution. Containers of liquefied flammable gases and flammable gases in solution shall be positioned in the upright position or positioned so that the pressure relief valve is in direct contact with the vapor space of the container.

Exceptions:

1. Containers of flammable gases in solution with a capacity of 1.3 gallons (5 L) or less.
2. Containers of flammable liquefied gases, with a capacity not exceeding 1.3 gallons (5 L), designed to preclude the discharge of liquid from safety relief devices.

3503.2 Quantities exceeding the maximum allowable quantity per control area. The storage and use of flammable gases in amounts exceeding the *maximum allowable quantity per control area* indicated in Section 2703.1 shall be in accordance with Chapter 27 and this chapter.

**SECTION 3504
STORAGE**

3504.1 Indoor storage. Indoor storage of flammable gases in amounts exceeding the *maximum allowable quantity per control area* indicated in Table 2703.1.1(1), shall be in accordance with Sections 2701, 2703 and 2704, and this chapter.

3504.1.1 Explosion control. Buildings or portions thereof containing flammable gases shall be provided with explosion control in accordance with Section 911.

3504.2 Outdoor storage. Outdoor storage of flammable gases in amounts exceeding the *maximum allowable quantity per control area* indicated in Table 2703.1.1(3) shall be in accordance with Sections 2701, 2703 and 2704, and this chapter.

3504.2.1 Distance limitation to exposures. Outdoor storage or use of flammable *compressed gases* shall be located from a *lot line*, public street, public alley, *public way* or building not associated with the manufacture or distribution of such gases in accordance with Table 3504.2.1.

3504.2.1.1 Weather protection canopies. Where weather protection is provided for sheltering outdoor flammable gas storage or use areas, such areas shall be constructed in accordance with Section 2704.13 and the *International Building Code*. Outdoor storage or use of flammable *compressed gases* shall be located from a *lot line*, public street, public alley or *public way* in accordance with Table 3504.2.1, except that Note a of Table 3504.2.1 shall not apply to areas sheltered by weather protection.

**SECTION 3505
USE**

3505.1 General. The use of flammable gases in amounts exceeding the *maximum allowable quantity per control area* indicated in Table 2703.1.1(1) or 2703.1.1(3) shall be in accordance with Sections 2701, 2703 and 2705, and this chapter.

**SECTION 3506
FLAMMABLE CRYOGENIC FLUIDS**

3506.1 General. The storage and use of flammable *cryogenic fluids* shall be in accordance with Sections 3506.2 through 3506.4.8.3 and Chapter 32.

3506.2 Limitations. Storage of flammable *cryogenic fluids* in stationary containers outside of buildings is prohibited within the limits established by law as the limits of districts in which such storage is prohibited (see Section 3 of the Sample Ordinance for Adoption of the *International Fire Code* on page xiii).

TABLE 3504.2.1
FLAMMABLE GASES—DISTANCE FROM STORAGE TO EXPOSURES

MAXIMUM AMOUNT PER STORAGE AREA (cubic feet)	MINIMUM DISTANCE BETWEEN STORAGE AREAS (feet)	MINIMUM DISTANCE TO LOT LINES OF PROPERTY THAT CAN BE BUILT UPON (feet) ^a	MINIMUM DISTANCE TO PUBLIC STREETS, PUBLIC ALLEYS OR PUBLIC WAYS (feet) ^a	MINIMUM DISTANCE TO BUILDINGS ON THE SAME PROPERTY		
				Nonrated construction or openings within 25 feet	2-hour construction and no openings within 25 feet	4-hour construction and no openings within 25 feet
0 - 4,225	5	5	5	5	0	0
4,226 - 21,125	10	10	10	10	5	0
21,126 - 50,700	10	15	15	20	5	0
50,701 - 84,500	10	20	20	20	5	0
84,501 or greater	20	25	25	20	5	0

For SI: 1 foot = 304.8 mm, 1 cubic foot = 0.02832 m³.

a. The minimum required distances shall not apply when fire barriers without openings or penetrations having a minimum fire-resistance rating of 2 hours interrupt the line of sight between the storage and the exposure. The configuration of the fire barrier shall be designed to allow natural ventilation to prevent the accumulation of hazardous gas concentrations.

3506.3 Above-ground tanks for liquid hydrogen. Above-ground tanks for the storage of liquid hydrogen shall be in accordance with Sections 3506.3 through 3506.3.2.1.

3506.3.1 Construction of the inner vessel. The inner vessel of storage tanks in liquid hydrogen service shall be designed and constructed in accordance with Section VIII, Division 1, of the ASME *Boiler and Pressure Vessel Code* and shall be vacuum jacketed in accordance with Section 3506.3.2.

3506.3.2 Construction of the vacuum jacket (outer vessel). The vacuum jacket used as an outer vessel for storage tanks in liquid hydrogen service shall be of welded steel construction designed to withstand the maximum internal and external pressure to which it will be subjected under operating conditions to include conditions of emergency pressure relief of the annular space between the inner and outer vessel. The jacket shall be designed to withstand a minimum collapsing pressure differential of 30 psi (207 kPa).

3506.3.2.1 Vacuum level monitoring. A connection shall be provided on the exterior of the vacuum jacket to allow measurement of the pressure within the annular space between the inner and outer vessel. The connection shall be fitted with a bellows-sealed or diaphragm-type valve equipped with a vacuum gauge tube that is shielded to protect against damage from impact.

3506.4 Underground tanks for liquid hydrogen. Underground tanks for the storage of liquid hydrogen shall be in accordance with Sections 3506.4.1 through 3506.4.8.3.

3506.4.1 Construction. Storage tanks for liquid hydrogen shall be designed and constructed in accordance with ASME *Boiler and Pressure Vessel Code* (Section VIII, Division 1) and shall be vacuum jacketed in accordance with Section 3506.4.8.

3506.4.2 Location. Storage tanks shall be located outside in accordance with the following:

1. Tanks and associated equipment shall be located with respect to foundations and supports of other struc-

tures such that the loads carried by the latter cannot be transmitted to the tank.

2. The distance from any part of the tank to the nearest wall of a *basement*, pit, cellar or *lot line* shall not be less than 3 feet (914 mm).
3. A minimum distance of 1 foot (305 mm), shell to shell, shall be maintained between underground tanks.

3506.4.3 Depth, cover and fill. The tank shall be buried such that the top of the vacuum jacket is covered with a minimum of 1 foot (305 mm) of earth and with concrete a minimum of 4 inches (102 mm) thick placed over the earthen cover. The concrete shall extend a minimum of 1 foot (305 mm) horizontally beyond the footprint of the tank in all directions. Underground tanks shall be set on firm foundations constructed in accordance with the *International Building Code* and surrounded with at least 6 inches (152 mm) of noncorrosive inert material, such as sand.

Exception: The vertical extension of the vacuum jacket as required for service connections.

3506.4.4 Anchorage and security. Tanks and systems shall be secured against accidental dislodgement in accordance with this chapter.

3506.4.5 Venting of underground tanks. Vent pipes for underground storage tanks shall be in accordance with Sections 2209.5.4 and 3203.3.

3506.4.6 Underground liquid hydrogen piping. Underground liquid hydrogen piping shall be vacuum jacketed or protected by *approved* means and designed in accordance with Chapter 32.

3506.4.7 Overfill protection and prevention systems. An *approved* means or method shall be provided to prevent the overfill of all storage tanks.

3506.4.8 Vacuum jacket construction. The vacuum jacket shall be designed and constructed in accordance with Section VIII of ASME *Boiler and Pressure Vessel Code* and shall be designed to withstand the anticipated loading, including loading from vehicular traffic, where applicable.

Portions of the vacuum jacket installed below grade shall be designed to withstand anticipated soil, seismic and hydrostatic loading.

3506.4.8.1 Material. The vacuum jacket shall be constructed of stainless steel or other *approved* corrosion-resistant material.

3506.4.8.2 Corrosion protection. The vacuum jacket shall be protected by *approved* or *listed* corrosion-resistant materials or an engineered cathodic protection system. Where cathodic protection is utilized, an *approved* maintenance schedule shall be established. Exposed components shall be inspected at least twice a year. Maintenance and inspection events shall be recorded and those records shall be maintained on the premises for a minimum of three years and made available to the *fire code official* upon request.

3506.4.8.3 Vacuum level monitoring. An *approved* method shall be provided to indicate loss of vacuum within the vacuum jacket(s).

SECTION 3507 METAL HYDRIDE STORAGE SYSTEMS

3507.1 General requirements. The storage and use of metal hydride storage systems shall be in accordance with Sections 3501, 3503, 3504, 3505 and 3507. Those portions of the system that are used as a means to store or supply hydrogen shall also comply with Chapters 27 and 30, as applicable.

3507.1.1 Classification. The hazard classification of the metal hydride storage system, as required by Section 2701.2.2, shall be based on the hydrogen stored without regard to the metal hydride content.

3507.1.2 Listed or approved systems. Metal hydride storage systems shall be *listed* or *approved* for the application and designed in a manner that prevents the addition or removal of the metal hydride by other than the original equipment manufacturer.

3507.1.3 Containers, design and construction. *Compressed gas* containers, cylinders and tanks shall be designed and constructed in accordance with Section 3003.2.

3507.1.4 Service life and inspection of containers. Metal hydride storage system cylinders, containers or tanks shall be inspected, tested and requalified for service at not less than five-year intervals.

3507.1.5 Marking and labeling. Marking and labeling of cylinders, containers, tanks and systems shall be in accordance with Sections 3003.4 and 3507.1.5.1 through 3507.1.5.4.

3507.1.5.1 System marking. Metal hydride storage systems shall be marked with the following.

1. Manufacturer's name;
2. Service life indicating the last date the system can be used;
3. A unique code or serial number specific to the unit;

4. System name or product code that identifies the system by the type of chemistry used in the system;
5. Emergency contact name, telephone number or other contact information; and
6. Limitations on refilling of containers to include rated charging pressure and capacity.

3507.1.5.2 Valve marking. Metal hydride storage system valves shall be marked with the following:

1. Manufacturer's name;
2. Service life indicating the last date the valve can be used; and
3. Metal hydride service in which the valve can be used, or a product code that is traceable to this information.

3507.1.5.3 Pressure relief device marking. Metal hydride storage system pressure relief devices shall be marked with the following:

1. Manufacturer's name;
2. Metal hydride service in which the device can be used, or a product code that is traceable to this information; and
3. Activation parameters to include temperature, pressure or both.

3507.1.5.3.1 Pressure relief devices integral to container valves. The required markings for pressure relief devices that are integral components of valves used on cylinders, containers and tanks shall be allowed to be placed on the valve.

3507.1.5.4 Pressure vessel markings. Cylinders, containers and tanks used in metal hydride storage systems shall be marked with the following:

1. Manufacturer's name;
2. Design specification to which the vessel was manufactured;
3. Authorized body approving the design and initial inspection and test of the vessel;
4. Manufacturer's original test date;
5. Unique serial number for the vessel;
6. Service life identifying the last date the vessel can be used; and
7. System name or product code that identifies the system by the type of chemistry used in the system.

3507.1.6 Temperature extremes. Metal hydride storage systems, whether full or partially full, shall not be exposed to artificially created high temperatures exceeding 125°F (52°C) or subambient (low) temperatures unless designed for use under the exposed conditions.

3507.1.7 Falling objects. Metal hydride storage systems shall not be placed in areas where they are capable of being damaged by falling objects.

3507.1.8 Piping systems. Piping, including tubing, valves, fittings and pressure regulators, serving metal hydride stor-

age systems, shall be maintained gas tight to prevent leakage.

3507.1.8.1 Leaking systems. Leaking systems shall be removed from service.

3507.1.9 Refilling of containers. The refilling of *listed* or *approved* metal hydride storage systems shall be in accordance with the listing requirements and manufacturers' instructions.

3507.1.9.1 Industrial trucks. The refilling of metal hydride storage systems serving powered industrial trucks shall be in accordance with Section 309.

3507.1.9.2 Hydrogen purity. The purity of hydrogen used for the purpose of refilling containers shall be in accordance with the listing and the manufacturer's instructions.

3507.1.10 Electrical. Electrical components for metal hydride storage systems shall be designed, constructed and installed in accordance with NFPA 70.

3507.2 Portable containers or systems. Portable containers or systems shall comply with Sections 3507.2.1 through 3507.2.2.

3507.2.1 Securing containers. Containers, cylinders and tanks shall be secured in accordance with Section 3003.5.3.

3507.2.1.1 Use on mobile equipment. Where a metal hydride storage system is used on mobile equipment, the equipment shall be designed to restrain containers, cylinders or tanks from dislodgement, slipping or rotating when the equipment is in motion.

3507.2.1.2 Motorized equipment. Metal hydride storage systems used on motorized equipment, shall be installed in a manner that protects valves, pressure regulators, fittings and controls against accidental impact.

3507.2.1.2.1 Protection from damage. Metal hydride storage systems, including cylinders, containers, tanks and fittings, shall not extend beyond the platform of the mobile equipment.

3507.2.2 Valves. Valves on containers, cylinders and tanks shall remain closed except when containers are connected to *closed systems* and ready for use.

