

NFPA 52

Vehicular Fuel Systems Code

2006 Edition



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Vehicular Fuel Systems Code

2006 Edition

This edition of NFPA 52, *Vehicular Fuel Systems Code*, was prepared by the Technical Committee on Vehicular Alternative Fuel Systems and acted on by NFPA at its June Association Technical Meeting held June 6–10, 2005, in Las Vegas, NV. It was issued by the Standards Council on July 29, 2005, with an effective date of August 18, 2005, and supersedes all previous editions.

This edition of NFPA 52 was approved as an American National Standard on August 18, 2005.

Origin and Development of NFPA 52

While compressed natural gas (CNG) vehicles have been used extensively in other countries since the late 1940s, it was not until the late 1970s that their use in the United States became extensive enough to warrant preparation of a national standard.

Between 1980 and 1982, a committee of the American Gas Association (AGA) developed a draft of a fire safety standard for vehicular fuel systems. This was based on existing worldwide standards and current U.S. practice.

In late 1981, the AGA petitioned the NFPA to establish a technical committee project on the subject. The normal NFPA solicitation of comments revealed sufficient response from various interested parties, and the Committee on Compressed Natural Gas Vehicular Fuel Systems was established by the Standards Council in July 1982.

The first edition of NFPA 52 was issued in 1984, and it was revised in 1988, 1992, 1995, and 1998.

The 2002 edition of NFPA 52 contained minor revisions, most of these in the chapter on engine fuel systems. There also were some changes made to comply with the *Manual of Style for NFPA Technical Committee Documents*. The most significant of these were reordering of chapters and numbering of definitions.

The 2006 edition of NFPA 52 is a complete revision. NFPA 57, *LNG Vehicular Fuel Systems Code*, has been incorporated into NFPA 52. Additionally, the scope of the committee has been expanded to include hydrogen, and new chapters have been added that address general gaseous hydrogen requirements and equipment qualifications; service and maintenance of gaseous hydrogen engine fuel systems; gaseous hydrogen compression, gas processing, storage, and dispensing systems; and liquefied hydrogen fueling facilities.

Technical Committee on Vehicular Alternative Fuel Systems

Nancy C. Pehrson, *Chair*
CenterPoint Energy, Inc., MN [U]

Ronald C. Adcock, Marsh USA Inc., AZ [I]
Denise Beach, National Propane Gas Association, DC [IM]
C. Everett Brett, The University of Alabama, AL [SE]
Herbert F. Burnett, Burnett and Burnette, CA [SE]
Eugene Bushmelov, Nuvera Fuel Cells, MA [M]
William P. Chernicoff, U.S. Department of Transportation, DC [E]
Ronald R. Czischke, Underwriters Laboratories Inc., IL [RT]
Steven Dallman, U.S. Department of Transportation, OK [SE]
Larry L. Fluer, Fluer, Inc., CA [IM]
Rep. Compressed Gas Association
George Godson, Portland Bureau of Fire, OR [E]
Stan R. Gornick, Autocar, LLC & Union City Body Company, IN [M]

Richard A. Hoffmann, Hoffmann & Feige, NY [SE]
Douglas B. Horne, DBHorne LLC, GA [M]
Rep. Clean Vehicle Education Foundation
Gary W. Howard, Stuart Energy Systems, Canada [M]
Thomas Joseph, Air Products and Chemicals, Inc., PA [M]
James P. Lewis, Project Technical Liaison Associates, Inc., TX [SE]
Michael W. Mackey, General Physics Corporation, CA [SE]
Robert E. Petsinger, CNG Services International Inc., PA [IM]
Gary Pope, Hughes Associates, Inc., CA [SE]
Ralph Rackham, FuelMaker Corporation, Canada [M]
Prentiss Searles, American Petroleum Institute, DC [M]
Michael Short, UTC Power, UTC Fuel Cells, CT [M]
Michael R. Swain, University of Miami, FL [U]
Rep. U.S. Department of Energy

Alternates

Mervin E. Bohrer, Jr., Bauer Compressors, Inc., VA [M]
(Alt. to R. Rackham)
Thomas J. Forsythe, Hughes Associates, Inc., CA [SE]
(Alt. to G. Pope)
Henry E. Seiff, Natural Gas Vehicle Coalition, DC [M]
(Alt. to D. B. Horne)

Roger A. Smith, Compressed Gas Association, VA [IM]
(Alt. to L. L. Fluer)
Robert A. Zeman, Underwriters Laboratories Inc., IL [RT]
(Alt. to R. R. Czischke)

Carl H. Rivkin, NFPA Staff Liaison

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

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

Committee Scope: This Committee shall have primary responsibility for documents on fire and explosion hazards associated with compressed natural gas (CNG), liquefied natural gas (LNG) engine fuel systems, compressed hydrogen gas (GH₂) engine fuel systems, and liquefied hydrogen gas (LH₂) engine fuel systems on vehicles of all types and for refueling stations and associated storage.

The Committee shall coordinate its documents with the Committee on the National Fuel Gas Code with respect to natural gas piping within the scope of that Committee; with the Committees on Industrial Trucks, Fire Safety for Recreational Vehicles, and Marine Fire Protection with respect to engine fuel systems and refueling stations within their scopes; and with the Liquefied Natural Gas Committee with respect to storage of LNG within its scope.

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Information on referenced publications can be found in Chapter 2 and Annex E.

Chapter 1 Administration

1.1* Scope.

1.1.1 This code shall apply to the design, installation, operation, and maintenance of compressed natural gas (CNG) and liquefied natural gas (LNG) engine fuel systems on vehicles of all types and for fueling vehicle (dispensing) systems and associated storage, including the following:

- (1) Original equipment manufacturers
- (2) Final-stage vehicle integrator/manufacturer (FSVM)
- (3) Vehicle fueling (dispensing) systems

1.1.2 Vehicles and fuel supply containers complying with federal motor vehicle safety standards covering the installation of CNG fuel systems on vehicles and certified by the respective manufacturer as meeting these standards shall not be required to comply with Section 4.4, 4.8.4, and Chapter 6 (except Section 6.11, 6.12.4, 6.13, and Section 6.14).

1.1.3 This code shall apply to the design, installation, operation, and maintenance of compressed hydrogen (GH_2), liquefied compressed hydrogen (LH_2), and blends of hydrogen up to 20 percent with the balance natural gas (NG) vehicle fueling (dispensing) systems and engine fuel systems and facilities.

1.1.4 This code shall apply to the design and installation of engine fuel systems up to 3600 psi (25 MPa) for vehicles operating on mixtures of GH_2 up to 20 percent with the balance natural gas (NG). These blends shall be treated as CNG.

1.1.5 This code shall apply to the design, installation, operation, and maintenance of LNG engine fuel systems on vehicles

of all types, to their associated fueling (dispensing) facilities, and to LNG to CNG facilities with LNG storage in ASME containers of 70,000 gal (265 m^3) or less.

1.1.6 This code shall include marine, highway, rail, off-road, and industrial vehicles.

1.1.7 Vehicles that are required to comply with applicable federal motor vehicle safety standards covering the installation of LNG fuel systems on vehicles and that are certified by the manufacturer as meeting these standards shall not be required to comply with Chapter 11, except 11.12.8.

1.1.8 This code shall apply to testing, service, and maintenance of GH_2 engine fuel systems.

1.1.9 Vehicles that meet FMVSS requirements for hydrogen-fueled vehicles shall not be subject to this document.

1.2 Purpose. (Reserved)

1.3 Retroactivity. The provisions of this code reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this code at the time the code was issued.

1.3.1 Unless otherwise specified, the provisions of this code are not intended to require upgrading facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the code. Where specified, the provisions of this code shall be retroactive.

1.3.2 In those cases where the authority having jurisdiction determines that the existing situation presents an unacceptable degree of risk, the authority having jurisdiction shall be permitted to apply retroactively any portions of this code deemed appropriate.

1.3.3 The retroactive requirements of this code shall be permitted to be modified if their application clearly would be impractical in the judgment of the authority having jurisdiction, and only where a reasonable degree of safety is provided and is clearly evident.

1.4 Alternate Provisions.

1.4.1 Advancements in technology and improvements in system design and equipment can result in equipment fabrication methods, component design requirements, and installation and operating practices that differ from those specified in this code.

1.4.1.1 Such deviations or improvements can provide equivalent safety and compatible operation that meet the intent of this code.

1.4.1.2 Such deviations shall be permitted where the authority having jurisdiction has seen evidence that a special investigation of all factors has been made and, based on sound experience and engineering judgment, has concluded that the proposed deviations meet the intent of this code.

1.4.2 Designers, fabricators, and constructors of LNG and LGH_2 fueling facilities shall be competent and have expertise in the design, fabrication, and construction of LNG and LGH_2 containers, cryogenic equipment, loading and unloading systems, fire protection equipment, detection, siting, containment, piping systems, and other components of the facility.

1.4.3 The installation of GH_2 , LNG, and LH_2 systems shall be supervised by personnel familiar with proper practices with reference to their construction and use.

1.4.4 LNG, L/CNG, CNG, hydrogen, and other gaseous/cryogenic installations shall be permitted to use alternate site distances, operating requirements, and equipment locations with validation by qualified engineer(s) with proven expertise in mechanical systems, electrical systems, gaseous storage systems, cryogenic storage systems, fire protection, and gas detection.

1.4.4.1 The validation shall at a minimum include the following:

- (1) Process safety analysis and hazard and operability studies (HAZOPS)
- (2) Mitigating fire protection measures such as suppression systems
- (3) Aboveground or belowground systems or vaults for the containers
- (4) Fire and gas detection systems designed to interface with emergency shutdown device (ESD)
- (5) Ventilation and other facility features
- (6) Drainage and impounding for the individual site as administered by qualified engineer(s) with proven expertise in these fields

1.4.5 Vehicles compliant with federal motor-vehicle safety standards (FMVSS) for on-road use are compliant with this code at the point in time of original manufacture.

1.5 Units.

1.5.1 Metric units in this code are based on ANSI SI 10, *Standard for Use of the International System of Units (SI): The Modern Metric System*.

1.5.2 All pressures in this document are gauge pressures, unless otherwise indicated.

1.6 Enforcement. This code shall be administered and enforced by the authority having jurisdiction designated by the governing authority. (See Annex B for sample wording for enabling legislation.)

1.7 Training. Persons engaged in the handling and storage of LNG, CNG, GH₂, LGH₂, and L/CNG shall be trained in the hazards and properties of these materials.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this code and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages*, 2003 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 2002 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2003 edition.

NFPA 54, *National Fuel Gas Code*, 2006 edition.

NFPA 55, *Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks*, 2005 edition.

NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)*, 2006 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2002 edition.

NFPA 70, *National Electrical Code*®, 2005 edition.

NFPA 80, *Standard for Fire Doors and Fire Windows*, 1999 edition.

NFPA 101®, *Life Safety Code*®, 2006 edition.

NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*, 2006 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, 2003 edition.

NFPA 302, *Fire Protection Standard for Pleasure and Commercial Motor Craft*, 2004 edition.

NFPA 303, *Fire Protection Standard for Marinas and Boatyards*, 2006 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, 2003 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 2001 edition.

NFPA 5000®, *Building Construction and Safety Code*®, 2006 edition.

2.3 Other Publications.

2.3.1 ANSI Publications. American National Standards Institute, Inc., 11 West 43rd Street, 4th Floor, New York, NY 10036.

ANSI/ISA PRD-1, *Pressure Relief Devices for Natural Gas Vehicle (NGV) Fuel Containers*, 1998.

ANSI SI 10, *Standard for Use of the International System of Units (SI): The Modern Metric System*, 1997.

ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protection*, 1979.

ANSI Z89.1, *Personal Protection — Protective Headwear for Industrial Workers — Requirements*, 1997.

2.3.2 API Publication. American Petroleum Institute, 1220 L Street NW, Washington, DC 20005-4070.

API 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*, 1996.

2.3.3 ASME Publications. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

ANSI/ASME B31.3, *Process Piping*, 2004.

ASME Boiler and Pressure Vessel Code, Section VIII, X, 2004.

2.3.4 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A 47, *Standard Specification for Ferritic Malleable Iron Castings*, 1995.

ASTM A 395, *Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*, 1993.

ASTM A 536, *Standard Specification for Ductile Iron Castings*, 1993.

ASTM E 84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 2005.

ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube at 750°C*, 2004.

2.3.5 CGA Publications. Compressed Gas Association, 4221 Walney Rd., 5th Floor, Chantilly, VA 20151-2923.

CGA C-6, *Standards for Visual Inspection of Steel Compressed Gas Cylinders*, 2001.

CGA G-5.5, *Hydrogen Vent Systems*, 2004.

CGA S-1.1, *Pressure Relief Device Standards — Part 1 — Cylinders for Compressed Gases*, 2003.

CGA S-1.3, *Pressure Relief Device Standards — Part 3 — Stationary Storage Containers for Compressed Gases*, 2003.

CGA 341, *Standard for Insulated Cargo Tank Specification for Nonflammable Cryogenic Liquids*, 2002.

2.3.6 CSA Publications. Canadian Standards Association, 5060 Spectrum Way, Mississauga, Ontario, Canada M4W 5N6.

CSA B51, *Boiler, Pressure Vessel and Pressure Piping Code*, 1995.

CSA 12.54, *Breakaway Devices for Dispensing Systems*, 1999.

2.3.7 ICC Publication. International Code Council, 5203 Leesburg Pike, Suite 600, Falls Church, VA 22041.

ICBO *Uniform Building Code*, 1997.

2.3.8 IHS-CSA America Publications. International Approval Services, 15 Inverness Way East, Englewood, CO 80112.

ANSI/IAS NGV1, *Standard for Compressed Natural Gas Vehicle (NGV) Fueling Connection Devices*, 1994.

ANSI/IAS NGV2, *Basic Requirements for Compressed Natural Gas Vehicle (NGV) Fuel Containers*, 2000.

ANSI/IAS NGV 4.4, *Breakaway Devices for Dispensing Systems*, 1999.

IAS U.S. Requirement 5-96, *Basic Requirements for Natural Gas Vehicle (NGV) Fuel Containers*, 1996.

2.3.9 NACE Publication. National Association of Corrosion Engineers, 1440 South Creek Drive, Houston, TX 77084.

NACE RP0169, *Control of External Corrosion of Underground or Submerged Metallic Piping Systems*, 1996.

2.3.10 NB Publication. National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Avenue, Columbus, OH 43229.

NB-23, *National Board Inspection Code*, 2004.

2.3.11 SAE Publications. Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

SAE J2343, *Recommended Practices for LNG Heavy Duty Trucks*, 1997.

SAE J2578, *Recommended Practice for General Fuel Cell Safety*, 2002.

SAE J2600, *Compressed Hydrogen Surface Refueling Connection Devices*, 2002.

2.3.12 SSPC Publications. Steel Structures Painting Council, 4516 Henry Street, Pittsburgh, PA 15213.

SSPC-PA 1, *Shop, Field and Maintenance Painting*, 1991.

SSPC-PA 2, *Measurement of Dry Paint Thickness with Magnetic Gages*, 1991.

SSPC-SP 6, *Commercial Blast Cleaning*, 1991.

2.3.13 TC Publication. Transport Canada, 330 Sparks Street, Ottawa, Ontario K1A 0N5.

TC container data.

2.3.14 U.S. Government Publication. U.S. Government Printing Office, Washington, DC 20402.

Title 29, Code of Federal Regulations, Part 1910.

2.3.15 U.S. Department of Transportation. 400 7th Street SW, Washington, DC 20590.

D.O.T Specification 4L.

2.3.16 Other Publication.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections.

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

NFPA 1925, *Standard on Marine Fire-Fighting Vessels*, 2004 edition.

NFPA 5000®, *Building Construction and Safety Code*®, 2006 edition.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this code. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3* Code. A standard that is an extensive compilation of provisions covering broad subject matter or that is suitable for adoption into law independently of other codes and standards.

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

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

3.2.6 Shall. Indicates a mandatory requirement.

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

3.3 General Definitions.

3.3.1 ANSI. American National Standards Institute.

3.3.2 ASME Code. The American Society of Mechanical Engineers *Boiler and Pressure Vessel Code*.

3.3.3 Buildings. Structures, usually enclosed by walls and a roof, constructed to provide support or shelter for an intended occupancy. [5000, 2006]

3.3.4 Capacity. The water volume of a container in liters (gallons).

3.3.5 Container. A pressure vessel, cylinder, or cylinder(s) permanently manifolded together used to store CNG, GH₂, LNG, or LH₂.

3.3.5.1 Cargo Transport Container. A mobile unit designed to transport LNG, CNG, GH₂, or LH₂.

3.3.5.2 Composite Container. A container consisting of an inner metal or plastic gas-containing component, reinforced with a filament and resin outer layer.

3.3.5.3 Fueling Facility Container. Primary storage for vehicular fueling.

3.3.5.4 Vehicular Fuel Supply Container. A container mounted on a vehicle to store LNG, CNG, LH₂, or GH₂ as the fuel supply to the vehicle.

3.3.6 Container Appurtenances. Devices connected to container openings for safety, control, or operating purposes.

3.3.7 Container Valve. A valve connected directly to a container outlet.

3.3.8 Cylinder. A container constructed, inspected, and maintained in accordance with DOT and Transport Canada regulations or ANSI/IAS NGV2, *Basic Requirements for Compressed Natural Gas Vehicle (NGV) Fuel Containers*.

3.3.9 Device.

3.3.9.1 Emergency Shutdown Device (ESD). A device that closes all operations within the fueling facility from either local or remote locations.

3.3.9.2 Fixed Liquid Level Device. A device that indicates when the container is filled to its maximum permitted filling volume.

3.3.9.3 Pressure Relief Device. A device designed to open to prevent a rise of internal pressure in excess of a specified value due to emergency or abnormal conditions. The device can be of the reclosing or other type, such as one having a rupture disk or fusible plug that requires replacement after each use.

3.3.10* Dew Point (at Container Pressure). The dew point value of the gas at the maximum anticipated container pressure of the CNG or GH₂ vehicular fuel system usually measured in the container prior to pressure reduction.

3.3.11 Dike. A structure used to establish an impounding area or containment.

3.3.12 Dispensing Station. A natural gas or hydrogen installation that dispenses CNG, LNG, LGH₂, GH₂/CNG mixtures, or GH₂ from storage containers or a distribution pipeline into fuel supply containers or into portable cylinders by means of a compressor, reformer, vaporizer, or pressure booster.

3.3.13 DOT. U.S. Department of Transportation.

3.3.14 Enclosure. A structure that protects equipment from the environment or provides noise attenuation.

3.3.14.1 Dispenser Enclosure. A cabinet that contains process piping and equipment for dispensing fuel.

3.3.15 Engine Compartment (on a marine vessel). An engine space on a marine vessel that is too small for an individual to enter.

3.3.16 Fail-Safe. A design feature that provides for the maintenance of safe operating conditions in the event of a malfunction of control devices or an interruption of an energy source.

3.3.17 Flame Spread Index. A comparative measure, expressed as a dimensionless number, derived from visual measurements of the spread of flame vs. time for a material tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*, or with ASTM E 84, *Standard Test Method for Surface Burning Characteristics of Building Materials*.

3.3.18 Fuel Line. The pipe, tubing, or hose on a vehicle, including all related fittings, through which natural gas or hydrogen passes.

3.3.19 Fueling Nozzle. A mating device at the refueling station, including shutoff valves, that connects the fueling dispenser hose to the vehicle fuel filling system receptacle for the transfer of liquid or vapor.

3.3.20 Fueling Receptacle. The mating part of the fueling connector mounted on a vehicle.

3.3.21 Gas.

3.3.21.1 Liquefied Natural Gas (LNG). A fluid in the cryogenic liquid state that is composed predominantly of methane.

3.3.21.1.1* Saturated LNG Gas. Preheated LNG held under pressure and released to atmosphere as a gas.

3.3.21.2 Natural Gas. Mixtures of hydrocarbon gases and vapors consisting principally of methane in gaseous form.

3.3.21.2.1 Compressed Natural Gas (CNG). Mixtures of hydrocarbon gases and vapors consisting principally of methane in gaseous form that has been compressed for use as a vehicular fuel.

3.3.22 Gaseous Fuels. All combinations of gaseous natural gas, hydrogen, propane, ethane, and butane commonly used as automotive fuels as they pertain to refueling sites, onboard fuel systems, safety, dispensing, and vehicle onboard use regardless of the fuel combinations.

3.3.23 Hydrogen (H₂). Hydrogen in gaseous or liquid form for use as a vehicular fuel.

3.3.23.1 GH₂. Hydrogen in a gaseous form.

3.3.23.2 LH₂. Hydrogen in a liquid form normally stored below its critical pressure (190.43 psi).

3.3.24 Hydrogen Generator. A packaged or factory matched hydrogen gas generation device that (a) uses electrochemical reactions to electrolyze water to produce hydrogen and oxygen gas (electrolyzer) and (b) converts hydrocarbon fuel to a hydrogen-rich stream of composition and conditions suitable for the type of device (e.g., fuel cells) using the hydrogen (reformer).

3.3.25 Ignition Source. Any item or substance capable of an energy release of type and magnitude sufficient to ignite any flammable mixture of gases or vapors that could occur at the site or onboard the vehicle.

3.3.26 Impounding Area. An area that can be defined through the use of containment or the topography at the site for the purpose of containing any accidental spill of LNG, LH₂, or flammable refrigerants.

3.3.27* Installation. A system that includes natural gas or hydrogen containers, pressure booster, compressors, vaporizers, and all attached valves, piping, and appurtenances.

3.3.28 Lower Flammability Limit (LFL). That concentration of a combustible material in air below which ignition will not occur.

3.3.29 Material.

3.3.29.1 Combustible Material. A material that, in the form in which it is used and under the conditions anticipated, will ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat, when tested in accordance with ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*.

3.3.29.2* Limited-Combustible Material. As applied to a material of construction, any material that does not meet the definition of noncombustible, as stated elsewhere in this section, and that, in the form in which it is used, has a potential heat value not exceeding 8141 kJ/kg (3,500 Btu/lb) when tested in accordance with NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, and also meets one of the following subparagraphs (a) or (b). (a) Materials having a structural base of noncombustible material, with a surfacing not exceeding a thickness of 3.2 mm (0.13 in.) that has a flame spread index not greater than 50, when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*. (b) Materials, in the form and thickness used and not described by (a) above, having neither a flame spread index greater than 25 nor evidence of continued progressive combustion and having such composition that surfaces that would be exposed by cutting through the material in any plane have neither a flame spread index greater than 25 nor evidence of continued progressive combustion, when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*.

3.3.29.3 Noncombustible Material. A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. Materials that are reported as passing ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, shall be considered noncombustible materials.

3.3.30 Maximum Filling Volume. The maximum volume to which a liquid-containing vessel could be filled.

3.3.31 Metallic Hose. A hose whose strength depends primarily on the strength of its metallic parts; it can have metallic liners or covers, or both.

3.3.32 Mobile Refueling. A DOT-approved vehicle with tank(s) and pump(s) that dispenses engine fuel directly to vehicles.

3.3.33 Operating Company. The individual, partnership, corporation, public agency, or other entity that owns or operates a plant or site.

3.3.34* Original Equipment Manufacturer (OEM). Any vehicle manufacturer or importer that is subject to DOT regulations and first introduces a vehicle for sale.

3.3.35 Overhead (Marine). The unfinished area in the top of a room or compartment but not a ceiling.

3.3.36 Overpressure. The pressure in a blast wave above atmospheric pressure, or a pressure within a containment structure that exceeds the maximum allowable working pressure of the containment structure.

3.3.37 Piping. A means of transporting natural gas or hydrogen. This term applies to refueling facilities.

3.3.38 Point of Transfer. The location where connections and disconnections are made.

3.3.39 Pressure.

3.3.39.1 Compression Discharge Pressure. The varying pressure at the point of discharge from the compressor.

3.3.39.2 Maximum Allowable Working Pressure (MAWP). The maximum pressure to which any component or portion of the pressure system can be subjected over the entire range of design temperatures. This value is $1.1 \times 1.25 \times$ the service pressure.

3.3.39.3 Operating Pressure. The varying pressure in a fuel supply container during normal container use.

3.3.39.3.1* Maximum Operating Pressure. The steady-state gauge pressure at which a part or system normally operates. This value is $1.25 \times$ the pressure.

3.3.39.4 Service Pressure. The settled gas pressure at a uniform gas temperature of 21°C (70°F) in CNG systems, and at 15°C (59°F) for CH₂ systems when the equipment is properly and completely charged with gas.

3.3.39.5 Set Pressure. The start-to-discharge pressure for which a relief valve is set and marked.

3.3.39.6 Settled Pressure. The pressure in a container at 21°C (70°F) for CNG and 15°C (59°F) for H₂.

3.3.39.7 Storage Pressure. The varying pressure in the storage containers.

3.3.40 Pressure Regulator. A device, either adjustable or non-adjustable, for controlling and maintaining, within acceptable limits, a uniform outlet pressure.

3.3.41 Pressure Relief Device Channels. The passage or passages beyond the operating parts of the pressure relief device through which fluid passes to reach the atmosphere.

3.3.42 Pressure Vessel. A container or other component designed in accordance with the ASME *Boiler and Pressure Vessel Code* or the CSA B51, *Boiler, Pressure Vessel and Pressure Piping Code*.

3.3.43 Residential Fueling Facility (RFF). An assembly with a capacity not exceeding 5 Scf/min (0.14 standard cubic meter/min) of natural gas, that can be used for fueling a vehicle at a home or residence.

3.3.44 Room.

3.3.44.1 Engine Room (on a marine vessel). An engine space on a marine vessel that is large enough for an individual to enter.

3.3.44.2 Tank Room. A space on a marine vessel dedicated for fuel tanks that is large enough for an individual to enter.

3.3.45 Scf (Standard Cubic Foot). One cubic foot of gas at 70°F (21°C) and 14.7 psia (an absolute pressure of 101 kPa). [55, 2005]

3.3.46 Space.

3.3.46.1 Accommodation Space. Space designed for human occupancy as living space for persons aboard a vessel.

3.3.46.2 Control Space. Space on a marine vessel in which the vessel's radio, the main navigation equipment, or the emergency source of power is located or in which the fire control equipment, other than fire-fighting control equipment, is centralized.

3.3.46.3 Gas-Dangerous Space. An enclosed or semi-enclosed space on a marine vessel in which piping contains compressed natural gas or where fuel containers or the engine room or compartment is located.

3.3.46.4 Gas-Safe Space. Any space on a marine vessel that is not a gas-dangerous space.

3.3.46.5 Service Space. Space on a marine vessel outside the cargo area that is used for a galley; a pantry containing cooking appliances, lockers, or storerooms; workshops (except those workshops located in machinery spaces); and other similar spaces and access trunk to those spaces.

3.3.47 System.

3.3.47.1 Cascade Storage System. Storage in multiple pressure vessels, cylinders, or containers, which can be at different pressures, such that fueling is normally done initially from lower pressure containers and completed from higher pressure containers.

3.3.47.2 Fuel Dispenser System. All the pumps, meters, piping, hose, and controls used for the delivery of fuel to, and the removal of vapor from, a vehicle.

3.3.47.3 Gas Detection System. One or more sensors capable of detecting natural gas or hydrogen at specified concentrations and activating alarms and safety systems.

3.3.47.4 Metal Hydride Storage System. A system for the storage of hydrogen gas in metal hydride material.

3.3.48 Tank Compartment. A space on a marine vessel that is dedicated for fuel tanks and is too small for an individual to enter.

3.3.49 TC. Transport Canada.

3.3.50 Vaporizer. A device other than a container that receives LNG or LH_2 in liquid form and adds sufficient heat to convert the liquid to a gaseous state, or a device used to add heat to LNG or LH_2 for the purpose of saturating LNG or LH_2 .

3.3.50.1 Ambient Vaporizer. A vaporizer that derives heat for vaporization from a naturally occurring heat source such as the atmosphere, seawater, or geothermal waters. If the naturally occurring heat source is separated from the actual vaporizing heat exchanger and a controllable heat transport medium is used between the heat source and the vaporizing exchanger, the vaporizer shall be considered to be a remote heated vaporizer.

3.3.50.2 Heated Vaporizer. A vaporizer that derives heat for vaporization from the combustion of fuel, electric power, or waste heat, such as from boilers or internal combustion engines.

3.3.50.2.1 Integral Heated Vaporizer. A vaporizer, including submerged combustion vaporizers, in which the heat source is integral to the actual vaporizing exchanger.

3.3.50.2.2 Remote Heated Vaporizer. A vaporizer in which the primary heat source is separated from the actual vaporizing exchanger and an intermediate fluid (e.g., water, steam, isopentane, and glycol) is used as the heat transport medium.

3.3.51 Vehicle. A device or structure for transporting persons or things; a conveyance (e.g., automobiles, trucks, marine vessels, railroad trains, and so forth).

3.3.52 Vehicle Fueling Appliance (VEA). A listed, self-contained system that compresses natural gas, hydrogen, or a blend of the two, and dispenses it to a vehicle's engine fueling system.

3.3.53 Vehicular Fuel. Fuel stored on board a vehicle.

3.3.54 Water Capacity. The amount of water at 60°F (16°C) required to fill a container.

3.3.55 Weather Deck. Any deck that is exposed to the weather and normally accessible to personnel and that permits walking or moving around outboard of the superstructure. [1925, 2004]

Chapter 4 General CNG Requirements and Equipment Qualifications

4.1* Application. This chapter applies only to pressurized system components handling CNG.

4.2* Composition. Natural gas composition in the container shall comply with 4.2.1.

4.2.1 The contained natural gas shall be composed of the following:

- (1) Hydrogen sulfide and soluble sulfides, 1 gr/100 Scf (23 mg/m³) maximum
- (2) Water (GH_2O) 7.0 lb/MMScf (110 mg/m³), maximum
- (3) Carbon dioxide, 3.0 volume percent, maximum
- (4) Oxygen 0.5 volume percent, maximum

Exception: Where the dew point of the natural gas entering the cylinder is below the lowest anticipated container temperature at the maximum anticipated container pressure, no limits shall apply.

4.2.1.1 Natural gas introduced into any system covered by this code shall have a distinctive odor potent enough for its presence to be detected down to a concentration in air of not over one-fifth of the lower limit of flammability. Natural gas or blends not meeting this definition shall have site and onboard methane detection systems installed and certified by a qualified engineer with expertise in methane detection or fire protection.

4.2.1.2 Methanol and/or glycol shall not be deliberately added to the natural gas at the fueling station.

4.2.1.3 Recognizing that the natural gas supplied to the vehicle might not always be in compliance with these documents, containers shall be designed to tolerate being filled with natural gas meeting both of the following conditions:

- (1) Dry gas in which water vapor would normally be limited to less than 2 lb/MMScf (32 mg/m³), a pressure dew point of -9°C (7°F) at 3000 psi (20,700 kPa). There would be no maximum constituent limits for dry gas, except for the following:
 - (a) GH_2S , 23 mg/m³
 - (b) O_2 , 1 percent by volume

(2) Wet gas in which gas that contains 2 lb/MMScf (32 mg/m³) of water or more normally meets the following maximum constituent limits:

- (a) GH₂S and other soluble sulfides, 1 gr/100 Scf (23 mg/m³)
- (b) Total sulfur, 5 gr/MMScf (115 mg/m³)
- (c) O₂, 1 percent by volume
- (d) CO₂, 3 percent by volume
- (e) Hydrogen, 0.1 percent by volume

4.2.1.4 Under wet gas conditions, a minimum of 1 mg of compressor oil per kilogram of gas (0.007 grains of compressor oil per pound of gas) shall be considered necessary to protect metallic containers, liners, and bosses.

4.3 System Approvals.

4.3.1 The following systems and system components shall be listed or approved:

- (1) Pressure relief devices, including pressure relief valves
- (2) Pressure gauges
- (3) Pressure regulators
- (4) Valves
- (5) Hose and hose connections
- (6) Vehicle fueling connections (nozzle and receptacle)
- (7) Engine fuel systems
- (8) Electrical equipment related to CNG systems
- (9) Gas detection equipment and alarms
- (10) Fire protection and suppression equipment

Exception: Vehicles certified by the manufacturer to be in compliance with applicable federal motor vehicle safety standards.

4.3.2 Devices not otherwise specifically provided for shall be constructed to provide safety equivalent to that required for other parts of a system.

4.4* Design and Construction of Containers.

4.4.1 Containers shall be fabricated of steel, aluminum, or composite materials.

4.4.2 The container shall be designed for CNG service and shall be permanently marked "CNG" by the manufacturer.

4.4.3 Containers manufactured prior to the effective date of this code shall be permitted to be used in CNG service if recommended for CNG service by the container manufacturer or if approved by the authority having jurisdiction.

4.4.4* Cylinders shall be manufactured, inspected, marked, tested, retested, equipped, and used in accordance with the following:

- (1) U.S. Department of Transportation (DOT) or Transport Canada (TC) regulations, exemptions, or special permits
- (2) ANSI/IAS NGV2, *Basic Requirements for Compressed Natural Gas Vehicle (NGV) Fuel Containers*, specifically for CNG service
- (3) CSA B51, *Boiler, Pressure Vessel and Pressure Piping Code*

4.4.5 ASME Compliance.

4.4.5.1 Pressure vessels shall be manufactured, inspected, marked, and tested in accordance with ASME *Boiler and Pressure Vessel Code*, Section VIII or Section X.

4.4.5.2 Adherence to applicable ASME *Boiler and Pressure Vessel Code*, case interpretations, and addenda shall be considered as compliant with the ASME *Boiler and Pressure Vessel Code*.

4.4.5.3 Pressure vessels manufactured to the requirements of the ASME *Boiler and Pressure Vessel Code* shall be registered with the National Board of Boiler and Pressure Vessel Inspectors.

4.4.6 The + (plus) and * (star) markings on DOT and TC cylinders shall not apply in accordance with DOT and TC regulations for cylinders for flammable compressed gases.

4.4.6.1 The star marking shall be removed or obliterated.

4.4.6.2 The removal of the star marking shall be by peening and otherwise shall be in accordance with DOT or TC regulations.

4.4.6.3 Grinding shall be prohibited.

4.4.7 The repair or alteration of an ASME pressure vessel shall comply with the requirements of the NB-23, *National Board Inspection Code*.

4.4.7.1 Other welding or brazing shall be permitted only on saddle plates, lugs, or brackets attached to the pressure vessel by the pressure vessel manufacturer.

4.4.7.2 The exchange or interchange of pressure vessel appurtenances intended for the same purpose shall not be considered a repair or alteration.

4.5 Pressure Relief Devices. (See Annex C.)

4.5.1 Each cylinder complying with 4.4.4 shall be fitted with one or more pressure relief devices in accordance with the following:

- (1) The pressure relief device for a cylinder shall be in accordance with the applicable following requirements:
 - (a) CGA S-1.1, *Pressure Relief Device Standards — Part 1 — Cylinders for Compressed Gases*
 - (b) Devices qualified by test in accordance with DOT and TC specifications, standards, exemptions, or special permits or with ANSI/IAS NGV2, *Basic Requirements for Compressed Natural Gas Vehicle (NGV) Fuel Containers*
 - (c) IAS U.S. Requirement 5-96, *Basic Requirements for Natural Gas Vehicle (NGV) Fuel Containers*
 - (d) ANSI/ISA PRD-1, *Pressure Relief Devices for Natural Gas Vehicle (NGV) Fuel Containers*
- (2) The pressure relief device shall be in direct communication with the fuel and shall be vented to the atmosphere by a method that can withstand the maximum pressure that results.

4.5.1.1 The discharge flow rate of the pressure relief device shall not be reduced below that required for the capacity of the container upon which the device is installed.

4.5.1.2 Pressure relief devices shall be located so that the temperature to which they are subjected shall be representative of the temperature to which the cylinder is subjected.

4.5.2 Pressure vessels complying with 4.4.5 or cylinders used for stationary storage without temperature compensation of the storage pressure shall be protected with one or more spring-loaded pressure relief valves in accordance with the ASME *Boiler and Pressure Vessel Code*.

4.5.2.1 The minimum rate of discharge of pressure relief devices on containers shall be in accordance with CGA S-1.1, *Pressure Relief Device Standards — Part 1 — Cylinders for Compressed Gases*, or the ASME *Boiler and Pressure Vessel Code*, whichever is applicable.

4.5.2.2 Pressure relief valves for CNG service shall not be fitted with lifting devices.

4.5.2.2.1 The adjustment, if external, shall be provided with a means for sealing the adjustment to prevent tampering.

4.5.2.2.2 If at any time it is necessary to break such a seal, the valve shall be removed from service until it has been reset and sealed.

4.5.2.2.3 Adjustments shall be made only by the manufacturer or other companies having competent personnel and facilities for the repair, adjustment, and testing of such valves.

4.5.2.2.4 The organization making such adjustment shall attach a permanent tag with the setting, capacity, and date.

4.5.2.3 Pressure relief valves protecting ASME pressure vessels shall be repaired, adjusted, and tested in accordance with NB-23, *National Board Inspection Code*.

4.5.3 Containers and pressure vessels not constructed in accordance with 4.4.4 or 4.4.5 shall be provided with pressure relief devices approved by the authority having jurisdiction.

4.6 Pressure Gauges.

4.6.1 A pressure gauge, if provided, shall be capable of reading at least 1.2 times the system design pressure.

4.7 Pressure Regulators.

4.7.1 A pressure regulator inlet and each chamber shall be designed for its service pressure with a pressure safety factor of at least 4.

4.7.2 Low-pressure chambers shall provide for overpressure relief or shall be able to withstand the service pressure of the upstream pressure chamber.

4.8 Fuel Lines.

4.8.1 Pipe, tubing, fittings, gaskets, and packing material shall be compatible with the fuel under the maximum service conditions.

4.8.2 Pipe, tubing, fittings, and other components shall be designed with a minimum safety factor of 3.

4.8.3 Natural gas piping shall be fabricated and tested in accordance with ANSI/ASME B31.3, *Process Piping*.

4.8.4 The following components shall not be used for CNG service:

- (1) Fittings, street els, and other piping components of cast irons other than those complying with ASTM A 47, *Standard Specification for Ferritic Malleable Iron Castings (Grade 35018)*, ASTM A 395, *Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*, and ASTM A 536, *Standard Specification for Ductile Iron Castings (Grade 60-40-18)*
- (2) Plastic pipe, tubing, and fittings for high-pressure service
- (3) Galvanized pipe and fittings
- (4) Aluminum pipe, tubing, and fittings
- (5) Pipe nipples for the initial connection to a container
- (6) Copper alloy with copper content exceeding 70 percent

4.8.4.1 The refueling connection shall be permitted to be made of nonsparking wrought aluminum alloy designed for the pressure employed.

4.8.4.2 Aluminum pipe, tubing, and fittings shall be permitted to be used downstream of the first-stage pressure regulator in an engine fuel system.

4.8.5 Piping components such as strainers, snubbers, and expansion joints shall be permanently marked by the manufacturer to indicate the service ratings.

4.9 Valves.

4.9.1 Valves, valve packing, and gaskets shall be designed or selected for the fuel over the full range of pressures and temperatures to which they can be subjected under normal operating conditions.

4.9.1.1 Shutoff valves shall have a rated service pressure not less than the rated service pressure of the entire system and shall be capable of withstanding a hydrostatic test of at least four times the rated service pressure without rupture.

4.9.1.2 Leakage shall not occur at less than one-and-a-half the rated service pressure.

4.9.2 Valves of cast irons other than those complying with ASTM A 47, *Standard Specification for Ferritic Malleable Iron Castings (Grade 35018)*; ASTM A 395, *Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*; and ASTM A 536, *Standard Specification for Ductile Iron Castings (Grade 60-40-18)*, shall not be used as primary stop valves.

4.9.3 Valves of a design that allows the valve stem to be removed without removal of the complete valve bonnet or without disassembly of the valve body shall not be used.

4.9.4 The manufacturer shall stamp or otherwise permanently mark the valve body to indicate the service ratings.

Exception: Container valves incorporating integral pressure relief devices complying with 4.5.1 shall not require additional marking.

4.10 Hose and Hose Connections.

4.10.1 Hose and metallic hose shall be constructed of or lined with materials that are resistant to corrosion and exposure to natural gas.

4.10.2 Hose, metallic hose, flexible metal hose, tubing, and their connections shall be designed or selected for the most severe pressures and temperatures under normal operating conditions with a burst pressure of at least four times the service pressure.

4.10.3 Prior to use, hose assemblies shall be tested by the OEM or its designated representative at a pressure at least twice the service pressure.

4.10.4 Hose and metallic hose shall be distinctly marked by the OEM or component manufacturer, either by the manufacturer's permanently attached tag or by distinct markings indicating the manufacturer's name or trademark, applicable service identifier, and design pressure.

4.11 Vehicle Fueling Connection.

4.11.1 CNG vehicle fueling connection devices shall be listed in accordance with ANSI/IAS NGV1, *Standard for Compressed Natural Gas Vehicle (NGV) Fueling Connection Devices*.

4.11.2 The use of adapters shall be prohibited.

Chapter 5 General GH₂ Requirements and Equipment Qualifications

5.1* Application. This chapter applies only to pressurized system components handling GH₂ at fueling stations.

5.2 System Approvals.

5.2.1 The following systems and system components shall be listed or approved:

- (1) Pressure relief devices, including pressure relief valves
- (2) Pressure gauges
- (3) Pressure regulators
- (4) Valves
- (5) Hose and hose connections
- (6) Vehicle fueling connections (nozzle)
- (7) Metal hydride storage
- (8) Electrical equipment used with GH₂ systems
- (9) Gas detection equipment and alarms
- (10) Hydrogen generators
- (11) Hydrogen dispensers
- (12) Pressure switches
- (13) Flow meters

5.2.2 Devices not otherwise specifically provided for shall be constructed to provide safety equivalent to that required for other parts of a system.

5.3* Design and Construction of Containers.

5.3.1 Containers shall be fabricated of materials suitable for hydrogen service.

5.3.2 The container shall be designed for GH₂ service and shall be permanently marked "Hydrogen" by the manufacturer.

5.3.3 Containers manufactured prior to the effective date of this code shall be permitted to be used in GH₂ service if recommended for GH₂ service by the container manufacturer or if approved by the AHJ.

5.3.4 ASME Compliance.

5.3.4.1 Pressure vessels shall be manufactured, inspected, marked, and tested in accordance with ASME *Boiler and Pressure Vessel Code*, Section VIII or Section X, and shall be designed for GH₂ service.

5.3.4.2 Adherence to applicable ASME *Boiler and Pressure Vessel Code*, case interpretations, and addenda shall be considered as compliant with the ASME *Boiler and Pressure Vessel Code*.

5.3.5 Welding or brazing for the repair or alteration of an ASME pressure vessel shall comply with the documents under which the pressure vessel was fabricated.

5.3.5.1 Other welding or brazing shall be permitted only on saddle plates, lugs, or brackets attached to the pressure vessel by the pressure vessel manufacturer.

5.3.5.2 The exchange or interchange of pressure vessel appurtenances intended for the same purpose shall not be considered a repair or alteration.

5.3.5.3 Seal welding of components such as bullplug in a cylinder is permitted and shall comply with the documents under which the pressure vessel was fabricated.

5.4* Pressure Relief Devices.

5.4.1 Each pressure vessel or group of pressure vessels complying with 5.3.4 shall be fitted with one or more pressure relief devices in accordance with the following:

- (1) Vent system meets the requirements of CGA G-5.5, *Hydrogen Vent Systems*.
- (2) Pressure relief device is in direct communication with the fuel and is vented to the atmosphere by a method that can withstand the resulting maximum pressure.
- (3) Vents from pressure relief devices are vented to a safe location.
- (4) Vent locations are designed such that if the safety valve is relieving at capacity and ignited, radiated heat felt by an individual who could be present at grade will not exceed 1500 Btu/hr-ft².

5.4.1.1 The discharge flow rate of the pressure relief device shall not be reduced below that required for the capacity of the container upon which the device is installed.

5.4.2 Pressure vessels complying with 5.3.4 or cylinders used for stationary storage without temperature compensation of the storage pressure shall be protected with one or more spring-loaded pressure relief valves in accordance with the ASME *Boiler and Pressure Vessel Code*.

5.4.2.1 The minimum rate of discharge of pressure relief devices on containers shall be in accordance with the ASME *Boiler and Pressure Vessel Code*.

5.4.2.2 Pressure relief valves for GH₂ service shall not be fitted with lifting devices.

5.4.2.2.1 The adjustment, if external, shall be provided with a means for sealing the adjustment to prevent tampering.

5.4.2.2.2 If at any time it is necessary to break such a seal, the valve shall be removed from service until it has been reset and sealed.

5.4.2.2.3 Adjustments shall be made only by the manufacturer or other companies having competent personnel and facilities for the repair, adjustment, and testing of such valves.

5.4.2.2.4 The organization making such adjustment shall attach a permanent tag with the setting, capacity, and date.

5.4.2.3 Pressure relief valves protecting ASME pressure vessels shall be repaired, adjusted, and tested in accordance with the ASME *Boiler and Pressure Vessel Code*.

5.4.3 Containers and pressure vessels not constructed in accordance with 4.4.4 or 5.3.4 shall be provided with pressure relief devices approved by the AHJ.

5.5 Vent Pipe Termination.

5.5.1 Venting of gas through pressure relief devices shall be to an approved location.

5.5.2 The termination point for piped vent systems serving cylinders, containers, tanks, and gas systems used for the purpose of operational or emergency venting shall be located to prevent impingement exposure on the system served, and to minimize the effects of high temperature, thermal radiation or the effects of contact with the gas from the escaping plume to the supply system, personnel, adjacent structures, and ignition sources.

5.6 Pressure Gauges.

5.6.1 A pressure gauge, if provided, shall be capable of reading at least 1.2 times the system design pressure.

5.6.2 A gauge shall have an opening not to exceed 0.055 in. (1.4 mm) (No. 54 drill size) at the inlet connection.

5.7 Pressure Regulators.

5.7.1 A pressure regulator inlet and each chamber shall be designed for its service pressure with a safety factor of at least 3.

5.7.2 Low-pressure chambers shall provide for overpressure relief or shall be able to withstand the service pressure of the upstream pressure chamber.

5.8 Fuel Lines.

5.8.1 Pipe, tubing, and fittings shall be suitable for hydrogen service and for maximum pressures and minimum and maximum temperatures.

5.8.1.1 Pipe, tubing, fittings, gaskets, and packing material shall be compatible with the fuel under service conditions.

5.8.1.2 Gray, ductile, and cast iron pipe and fittings shall not be used.

5.8.2 Pipe, tubing, fittings, and other components shall be designed with a minimum safety factor of 3.

5.8.3* Hydrogen gas piping shall be fabricated and tested in accordance with ANSI/ASME B31.3, *Process Piping*.

5.8.4 Piping joints made with tapered threaded pipe and sealant shall not be used in hydrogen service above 3000 psi.

Exception: Tapered threads are allowed where valves and instrumentation is not available with straight threads or in cylinder/storage tube necks, and in outlet threads.

5.8.5 The number of joints in hydrogen service shall be minimized and placed in a location considering personnel safety.

5.8.6 Piping components such as strainers, snubbers, and expansion joints shall be permanently marked by the manufacturer to indicate the service ratings.

5.9 Valves.

5.9.1 Valves, valve packing, and gaskets shall be designed or selected for the fuel over the full range of pressures and temperatures to which they can be subjected under any operating conditions.

5.9.1.1 Shutoff valves shall have a rated service pressure not less than the rated service pressure of the entire system and shall be designed with a minimum safety factor of 3.

5.9.1.2 Leakage shall not occur when tested to at least one-and-a-half of the rated service pressure, using an inert gas as the test medium.

5.9.2 Valves of a design that allows the valve stem to be removed without removal of the complete valve bonnet or without disassembly of the valve body shall not be used.

5.9.3 The manufacturer shall stamp or otherwise permanently mark the valve body to indicate the service ratings.

Exception: Container valves incorporating integral pressure relief devices complying with Section 5.4 shall not require additional marking.

5.10 Hose and Hose Connections.

5.10.1 Hose shall be constructed of or lined with materials that are resistant to corrosion and exposure to hydrogen.

5.10.2 Hose, metallic hose, flexible metal hose, tubing, and their connections shall be designed or selected for the most severe pressures and temperatures expected under normal

operating conditions with a burst pressure of at least three times the MAWP.

5.10.3 Prior to use, hose assemblies shall be tested by the component OEM or its designated representative at a pressure at least twice the maximum allowable pressure.

5.10.4 Hose and metallic hose shall be distinctly marked by the manufacturer, either by the manufacturer's permanently attached tag or by distinct markings indicating the manufacturer's name or trademark, applicable service identifier, design pressure, and flow direction.

5.11 Vehicle Fueling Connection.

5.11.1 Fueling nozzles for GH₂ service shall be listed in accordance with SAE J2600, *Compressed Hydrogen Surface Refueling Connection Devices*.

5.11.2 The use of adapters shall be prohibited.

Chapter 6 CNG Engine Fuel Systems

6.1* Application.

6.1.1 This chapter applies to the design, installation, inspection, and testing of CNG fuel supply systems for vehicular internal combustion engines.

6.1.2* Final-Stage Vehicle Integrator/Manufacturer.

6.1.2.1* The final-stage vehicle integrator/manufacturer (FSVIM) shall have the responsibility for integration of the engine, fuel system, and gaseous detection system, where required, onto the vehicle chassis and for the safe operation of the vehicle.

6.1.2.2 The FSVIM shall obtain documented approval of the chassis original equipment and component manufacturers of the onboard fuel and detection systems components, proper installation, and application from each of the following:

- (1) Automobile
- (2) Truck
- (3) Bus
- (4) Chassis
- (5) Engine
- (6) Gas detection
- (7) Fuel system

6.1.2.3 All gaseous fuel modifications of a vehicle shall conform with the engineering recommendations of the original specifications of the original chassis vehicle manufacturer.

6.2 System Component Qualifications.

6.2.1 System components shall comply with the appropriate provisions in Chapter 4 and with this section.

6.2.2 Temperature Range.

6.2.2.1 Components in the engine compartment shall be designed or selected for at least a minimum temperature range of -40°F to 250°F (-40°C to 121°C).

6.2.2.2 All other components shall be designed or selected for service per the OEM's engineering requirements.

6.2.3 Aluminum or copper pipe, tubing, or fittings shall not be used between the fuel container and the first-stage pressure regulator.

6.2.4 Fuel-carrying components, with the exception of container valves, tubing, and fittings, shall be labeled or stamped with the following:

- (1) Manufacturer's name or symbol
- (2) Model designation
- (3) Design service pressure
- (4) Direction of fuel flow where necessary for correct installation
- (5) Capacity or electrical rating, as applicable

6.3 Installation of Fuel Supply Containers.

6.3.1 Fuel supply containers shall be installed in accordance with the instructions of the container manufacturer and the requirements in 6.3.2 through 6.3.12.

6.3.2 Fuel supply containers on vehicles shall be permitted to be located within, below, or above the driver or passenger compartment, provided all connections to the container(s) are external to, or sealed and vented from, these compartments.

6.3.2.1 Fuel supply containers shall be protected with a means to prevent damage that can occur due to road hazards, loading, unloading, direct sunlight, exhaust heat, and vehicle use including accidental cargo leakage.

6.3.2.2 Shields, if present, shall be installed in a manner that prevents the following occurrences:

- (1) Direct contact between the shield and the fuel supply container
- (2) Trapping of solid materials or liquids between the shield and fuel supply container that could damage the container or its coating

6.3.2.3 The fuel supply container shall be positioned to prevent contact with vehicle components such as frame members, body panels, brake lines, and so forth, that can lead to container fretting or abrasion over time.

6.3.3 Each automobile fuel supply container shall be mounted in a location to minimize damage from collision.

6.3.3.1 No part of a container or its appurtenances shall protrude beyond the sides or top of the automobile at the point where it is installed.

6.3.3.2 The cylinder shall be protected by covers from accidental contact with overhead electrical wiring.

6.3.3.3 The fuel system shall be installed with as much road clearance as practical but with not less than the minimum road clearance of the vehicle when loaded to its gross vehicle weight rating.

6.3.3.4 This minimum clearance shall be measured from the lowest part of the fuel system.

6.3.3.5 The minimum clearance in 6.3.3.4 shall be met when the vehicle tires are deflated.

6.3.3.6 No portion of a fuel supply container or container appurtenance mounted on the undercarriage of the vehicle shall be located ahead of the front axle or behind the point of attachment of the rear bumper to the vehicle. Container valves shall be protected from physical damage using the vehicle structure, valve protectors, or a suitable metal shield.

6.3.3.7 No part of the fuel supply container or its appurtenances shall protrude beyond the sides or top of any vehicle where the container can be struck or punctured.

6.3.4 Each fuel supply container rack shall be secured to the vehicle body, bed, or frame to prevent damage from road hazards, slippage, loosening, or rotation using a method capable of withstanding a static force in the six principal directions shown in Figure 6.3.4 of eight times the weight of a fully pressurized container(s).

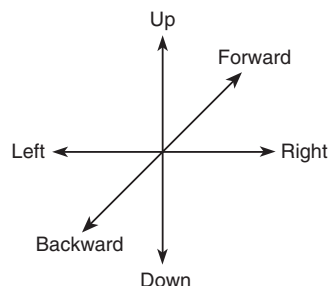


FIGURE 6.3.4 The Six Principal Directions.

6.3.5 Each fuel supply container in the rack shall be secured to its cradle in a manner that it is capable of withstanding a static force, applied in the six principal directions (see Figure 6.3.4), of eight times the weight of the fully pressurized container with a maximum displacement of 0.50 in. (13 mm).

6.3.6 The fuel supply container weight shall not be supported by outlet valves, manifolds, or other fuel connections.

6.3.7 Fuel supply containers located less than 8 in. (200 mm) from the exhaust system shall be shielded against direct heat.

6.3.8 The mounting system shall minimize fretting corrosion between the fuel supply container and the mounting system.

6.3.9 Fuel supply containers shall not be installed so as to adversely affect the driving characteristics of the vehicle.

6.3.10 Metal clamping bands and their supports shall not be in direct contact with a fuel supply container.

6.3.10.1 A resilient gasket that does not retain water shall be installed between the clamping bands and their supports and a container.

6.3.10.2 The resilient gasket shall provide insulation to protect clamping bands from galvanic corrosion in contact with the containers.

6.3.11 The minimum clearance from the road to a fuel supply container, its housing, or fittings, whichever is lowest where the container is installed below the frame and between the axles of a CNG vehicle, with the vehicle loaded to its gross weight rating, shall be in accordance with Table 6.3.11.

Table 6.3.11 Fuel Supply Container (and Container Housing and Fitting) Road Clearance

Vehicle Wheel Base		Minimum Road Clearance	
in.	mm	in.	mm
≤127	≤3230	7	180
>127	>3230	9	230

6.3.12 Fuel supply containers that are installed behind a rear axle of a CNG vehicle shall be installed transversely.

Exception: Containers shall be permitted to be installed in other orientations where the container valve and fittings are located at the end of the container most protected from a source of impact.

6.4* Installation of Venting Systems.

6.4.1* All pressure relief devices and connections between pressure-carrying components installed within driver, passenger, or a closed compartment (see 5.2.2) shall be vented to the outside of the vehicle.

Exception: This requirement shall not include plugs in the ends of containers with openings in each end.

6.4.2 The venting system for the discharge of pressure relief devices (PRDs) (pressure relief device channels) shall be constructed of metallic tubing with threaded, compression, or flare fittings.

6.4.3 The venting system shall be secured at intervals in such a manner as to minimize the possibility of damage, corrosion, or breakage due to expansion, contraction, vibration, strains, or wear and to preclude any loosening while in operation.

6.4.4 The vent or vents for the venting system shall not exit into a wheel well.

6.4.5 A vent shall not restrict the operation of a container pressure relief device or pressure relief device channel.

6.4.6 Means shall be provided to prevent water, dirt, insects, and any foreign objects from collecting in the vent lines or pressure relief devices.

6.4.7 Protective devices in 6.4.6 shall not restrict the flow of gas.

6.4.8 The neck of the container and all CNG fittings within the compartment shall be enclosed in a gastight enclosure made of linear, low-density polyethylene having a minimum thickness of 8 mils (0.20 mm) or an equally gastight alternate enclosure that is vented directly to the outside of the vehicle.

6.4.9 Where located in a vehicle compartment capable of accumulating natural gas, a container shall be installed so that the following conditions are met:

- (1) The pressure relief device for the protection of the container is installed in the same vehicle compartment as the container.
- (2) The discharge from the pressure relief device is vented to the outside through an electrically conductive tube or hose, which shall be in accordance with the following:
 - (a) The tube or hose is secured at intervals in such a manner as to minimize the possibility of damage, corrosion, or breakage of either the vent line or the pressure relief device due to expansion, contraction, vibration, strains, or wear and to preclude any loosening while in operation.
 - (b) The tube or hose has a burst pressure of at least 1½ times the pressure in the vent that results from activation of the PRD.
 - (c) The vent line should not lose its gas-carrying ability when exposed to 1120°F (590°C) for 20 minutes.
- (3) The vent opening is not blocked by debris thrown up from the road, such as snow, ice, mud, and so forth, or otherwise affected by the elements.

6.5 Installation of Piping.

6.5.1 Manifolds connecting fuel containers shall be fabricated to minimize vibration and shall be installed in a protected location or shielded to prevent damage from unsecured objects.

6.5.2 Manifolds connecting containers or container pressure relief devices shall be designed to vent gas from the individual container(s) exposed to a fire so that all containers meet the requirements of Section 4.5.

6.5.3 A pipe thread jointing material impervious to the action of the natural gas used in the system shall be applied to all male pipe threads prior to assembly.

6.5.4 Piping and fittings shall be clear and free from cutting or threading burrs and scales, and the ends of all piping shall be reamed.

6.5.5 Where necessary to prevent abrasion, fuel lines passing through a panel shall be protected by grommets or similar devices.

6.5.6 Fuel lines shall have the maximum practical clearance from the engine exhaust system to protect the fuel lines from excessive heat by durable and effective means.

6.5.7 Fuel lines shall be mounted, braced, and supported to minimize vibration and shall be protected against damage, corrosion, or breakage due to strain or wear.

6.5.8 A bend in piping or tubing shall be prohibited where such a bend weakens the piping or tubing.

6.5.9 A joint or connection shall be located in an accessible location.

6.5.10 Where a fuel supply container is located on a trailer, the fuel supply line shall contain an emergency breakaway device designed to retain CNG on both sides of the breakaway point.

6.6 Installation of Valves.

6.6.1 Every cylinder shall be equipped with either of the following:

- (1) A manual valve
- (2) A normally closed, remotely actuated shutoff valve connected directly to the cylinder and equipped to bleed the cylinder manually

6.6.2 In addition to the valve required by 6.6.1, a manual shutoff valve or a normally closed, automatically actuated shutoff valve shall be installed that allows isolation of the container(s) from the remainder of the fuel system.

Exception: In installations on vehicles that are not normally operated on public streets, that have a single fuel supply cylinder, and that are equipped with an accessible manual cylinder shutoff valve, no additional manual shutoff valve shall be required.

6.6.2.1 The valve shall be securely mounted and shielded or installed in a protected location to minimize damage from vibration and unsecured objects.

6.6.2.2 Where a manual shutoff valve is used, it shall be in an accessible location and shall have not more than 90 degrees rotation (quarter turn fuel delivery valve) from the open to the closed positions.

6.6.2.3 Access to the manual shutoff valve shall not require the use of any key or tool.

6.6.2.4 Where a manual valve is used, the valve location shall be indicated with the words "MANUAL SHUTOFF VALVE."

6.6.2.5 A weather-resistant decal or label with red, blue, or black letters on a white or silver reflective background shall be used.

6.6.3 A valve that automatically prevents the flow of gaseous fuel to the engine when the engine is not running, even if the ignition is switched on, shall be provided in the system.

6.6.4* Where multiple fuel systems are installed on the vehicle, automatic valves shall be provided, as necessary, to shut off the fuel not being used.

6.6.5 The fueling system shall be equipped with a backflow check valve that prevents the return flow of gas from the container(s) to the filling connection.

6.6.5.1 The backflow check valve shall be mounted to withstand the breakaway force specified in 8.11.6.2.

6.6.5.2 A second check valve shall be located between the fueling receptacle and the cylinders.

6.7 Installation of Pressure Gauges.

6.7.1 A pressure gauge located within a driver or passenger compartment shall be installed in such a manner that no gas flows into the passenger compartment in the event of failure.

6.7.2 A pressure gauge installed outside a driver or passenger compartment shall be equipped with a limiting orifice, a shatterproof dial lens, and a body relief.

6.7.3 Gauges shall be securely mounted, shielded, and installed in a protected location to prevent damage from vibration and unsecured objects.

6.8 Installation of Pressure Regulators.

6.8.1 An automatic pressure-reducing regulator(s) shall be installed to reduce the fuel container pressure to a level consistent with the service pressure required by the gas-air mixer, throttle body, or fuel injectors.

6.8.2 Means shall be provided to prevent regulator malfunctions due to refrigeration effects.

6.8.3 Regulators shall be installed so that their weight is not placed on, or supported by, the attached gas lines.

6.9 Installation of Fueling Connection.

6.9.1 A fueling connection receptacle complying with Section 4.11 shall be installed in each vehicle.

6.9.2 The fueling connection receptacle shall be mounted to withstand the breakaway force specified in 8.11.6.2.

6.9.3 The receptacle shall be installed in accordance with the manufacturer's instructions.

6.9.4 The clearance around the fueling connection shall be free of interference that prevents the connection of the fueling nozzle.

6.10 Wiring Installation.

6.10.1 All wiring shall be secured and protected from abrasion and corrosion to the same standard as the original wiring on the vehicle.

6.10.2 All wiring shall be sized according to the Society of Automotive Engineers (SAE) and fuse-protected.

6.11 Labeling.

6.11.1 A vehicle equipped with a CNG fuel system shall bear the following durable labels:

- (1) A label readily visible and located in the engine compartment shall include the following:
 - (a) Identification as a CNG-fueled vehicle
 - (b) System service pressure
 - (c) Installer's name or company
 - (d) Container retest date(s) or expiration date
 - (e) Total container water volume in gallons (liters)
- (2) A label located at the fueling connection receptacle shall include the following:
 - (a) Identification as a CNG-fueled vehicle
 - (b) System working pressure
 - (c) Container retest date(s) or expiration date

6.11.2 If both labels are located in one of the above areas, the labels shall be permitted to be combined into a single label.

6.11.3 Each vehicle shall be identified with a weather-resistant, diamond-shaped label located on an exterior vertical surface or near-vertical surface on the lower right rear of the vehicle (e.g., on the trunk lid of a vehicle so equipped, but not on the bumper of any vehicle) inboard from any other markings.

6.11.3.1 The label shall be a minimum of 4.72 in. long × 3.27 in. high (120 mm × 83 mm).

6.11.3.2 The marking shall consist of a border and the letters "CNG" [1 in. (25 mm) minimum height centered in the diamond] of silver or white reflective luminous material on a blue background.

6.12 System Testing.

6.12.1 The complete assembly shall be leak tested using natural gas or nonflammable gas.

6.12.2 Before use, every connection shall be verified leak free with a noncorrosive leak detector solution or a leak detector instrument after the equipment is connected and pressurized to its service pressure.

6.12.3 If the completed assembly is leak tested with natural gas, the testing shall be done under ventilated conditions.

6.12.4* Where a vehicle is involved in an accident or fire causing damage to the CNG container, or if the container is subjected to a pressure greater than 125 percent of service pressure, the CNG container shall be replaced or removed, inspected, and retested in accordance with the document under which it was originally manufactured before being returned to service.

6.12.5 Where a vehicle is involved in an accident or fire causing damage to any part of the CNG fuel system, the system shall be repaired and retested (*see Section 6.13*) before being returned to service.

6.12.6 Where a CNG container is removed from a vehicle in order to be installed within a different vehicle, it shall be inspected or retested in accordance with the inspection or requalification procedures of the standard under which it was originally manufactured before it is reinstalled.

6.13 System Maintenance and Repair.

6.13.1 Damaged fuel lines shall be replaced and not repaired.

6.13.2 All containers, container appurtenances, piping systems, venting systems, and other components shall be maintained in a safe condition.

6.13.3 The container retest date or expiration date shall be verified to be current.

6.13.4 Pressure relief devices on the cylinder shall be maintained in accordance with CGAS-1.1, *Pressure Relief Device Standards — Part 1 — Cylinders for Compressed Gases*.

6.13.5 Pressure relief devices on all other containers shall be maintained in accordance with the following:

- (1) Pressure relief device channels or other parts that could interfere with the functioning of the device shall not be plugged by paint or accumulation of dirt.
- (2) Only qualified personnel shall be permitted to service pressure relief devices.
- (3) Only assemblies or original manufacturer's parts shall be used in the repair of pressure relief devices unless the interchange of parts has been proved by tests.
- (4) No pressure relief device that has been in service shall be reinstalled on another fuel cylinder.

6.13.6 The following shall be done during vehicle maintenance:

- (1) Ensure the engine is isolated from the fuel supply unless engine operation is required. If a manual valve is used it shall comply with 6.6.2.
- (2) Prohibit torches, welding, or grinding equipment on or near high-pressure fuel lines and containers.
- (3) Prevent damage to containers, including actions such as dropping, dragging, or rolling of the container.
- (4) Prevent exposure of containers to strong chemicals such as battery acid or metal cleaning solvents.
- (5) Store CNG containers in a manner to avoid damage.
- (6) Reinstall containers to their original configuration using approved gaskets, bolts, nuts, washers, and so forth, per recommendations of the container manufacturer.
- (7) Prevent hoists or jacks from coming into direct contact with containers.
- (8) Prohibit personnel from walking on roof-mounted containers.

6.14 Discharge from Vehicle Containers.

6.14.1 The venting or depressurization of a CNG container shall be performed only by trained personnel using written procedures.

6.14.1.1 The gas to be removed from the container shall be discharged into a closed transfer system or shall be vented by an approved method of atmospheric venting.

6.14.1.2 A valve shall be used to control the discharge of gas from high-pressure systems to a venting system.

6.14.2 Personnel performing container depressurization shall do the following:

- (1) Use grounding to prevent static electrical charge buildup.
- (2) Limit the rate of gas release from plastic-lined containers to a value not greater than that specified by the container manufacturer.
- (3) Restrain containers during depressurization to prevent container movement.

6.14.3 Direct gas venting shall be done through a vent tube that diverts the gas flow to atmosphere.

6.14.3.1 The vent tube shall have a gastight connection to the container prior to venting, and all components shall be grounded.

6.14.3.2 The vent tube shall be constructed of Schedule 80 pipe of at least 2 in. (51 mm) diameter.

6.14.3.3 The vent tube shall not be provided with any feature that limits or obstructs gas flow.

Chapter 7 Service and Maintenance of GH₂ Engine Fuel Systems

7.1* Application.

7.1.1 This chapter applies to service, maintenance, and testing facilities for hydrogen-fueled vehicles.

7.1.2* Final-Stage Vehicle Integrator/Manufacturer.

7.1.2.1* The final-stage vehicle integrator/manufacturer (FSVIM) shall have the responsibility for integration of the engine, fuel system, and gaseous detection system, where required, onto the vehicle chassis and for the safe operation of the vehicle.

7.1.2.2 The FSVIM shall obtain documented approval of the original equipment/component manufacturers of the onboard fuel and detection systems components, proper installation, and application from each of following:

- (1) Automobile
- (2) Truck
- (3) Bus
- (4) Chassis
- (5) Engine
- (6) Gas detection
- (7) Fuel system

7.1.2.3 All gaseous fuel modifications of a vehicle shall conform with the specifications of the original vehicle manufacturer.

7.2 System Component Qualifications.

7.2.1 Vehicles, receptacles, and fuel supply containers for use with hydrogen shall comply with SAE J2578, *Recommended Practice for General Fuel Cell Safety*, SAE J2600, *Compressed Hydrogen Surface Refuelling Connection Devices*, and ANSI/IAS NGV2, *Basic Requirements for Compressed Natural Gas Vehicle (NGV) Fuel Containers*.

7.2.2 Components shall be installed in accordance with the original component manufacturer's instructions and engineering recommendations.

7.3 System Testing. Unless specified by the vehicle manufacturers and importers regulated by FMVSS requirements, the requirements of Section 7.3 shall apply.

7.3.1 The requirements of Section 7.3 shall apply only to vehicle importers and manufacturers not regulated by FMVSS.

7.3.2 The complete assembly shall be leak tested at the maximum system operating pressure using hydrogen or helium.

7.3.3 Where hydrogen is to be used as the leak test media, the system first shall be purged with an inert gas to ensure that all oxygen is removed.

7.3.4 If the completed assembly is leak tested with hydrogen, the testing shall be done under ventilated conditions.

7.3.5 Before use, every connection shall be verified leak free with a noncorrosive leak detector solution or a leak detector instrument after the equipment is connected and pressurized to its service pressure.

7.3.6 Where a vehicle is involved in an accident or fire causing damage to the GH_2 container, or if the container is subjected to a pressure greater than 125 percent of service pressure, the GH_2 container shall be replaced or removed, inspected, and retested in accordance with the document under which it was originally manufactured before being returned to service.

7.3.7 Cylinder damage assessment for tanks shall be done in accordance with the manufacturer's instructions, or CGA C-6, *Standards for Visual Inspection of Steel Compressed Gas Cylinders*.

7.3.8 Where a vehicle is involved in an accident or fire causing damage to any part of the GH_2 fuel system, the system shall be repaired and retested (*see Section 7.4*) before being returned to service.

7.3.9 Where a GH_2 container is removed from a vehicle in order to be installed within a different vehicle, it shall be inspected or retested in accordance with the inspection or requalification procedures of the standard under which it was originally manufactured before it is reinstalled.

7.4 System Maintenance and Repair. System maintenance and repair shall comply with maintenance and repair guidelines and specifications of the original system manufacturer.

7.4.1 The requirements of Section 7.4 shall apply only to non-OEM vehicles.

7.4.2 Damaged fuel lines shall be replaced and not repaired.

7.4.3 All containers, container appurtenances, piping systems, venting systems, and other components shall be maintained in a safe condition.

7.4.4 The container retest date or expiration date shall be verified to be current.

7.4.5 Pressure relief devices on the cylinder shall be maintained in accordance with CGA S-1.1, *Pressure Relief Device Standards — Part 1 — Cylinders for Compressed Gases*.

7.4.6 Pressure relief devices on all other containers shall be maintained in accordance with the following:

- (1) Pressure relief device channels or other parts that could interfere with the functioning of the device shall not be plugged by paint or accumulation of dirt.
- (2) Only qualified personnel shall be permitted to service pressure relief devices.
- (3) Only assemblies and components of original manufacturer's parts shall be used in the repair of pressure relief devices unless the interchange of parts has been proved by tests.
- (4) No pressure relief device that has been in service shall be reinstalled on another fuel cylinder.

7.4.7 The following shall be done during vehicle maintenance:

- (1) Close the quarter turn fuel delivery valve nearest the engine unless engine operation is required.
- (2) Prohibit torches, welding, or grinding equipment on or near high-pressure fuel lines and containers.
- (3) Prevent damage to containers, including actions such as dropping, dragging, or rolling of the container.

- (4) Prevent exposure of containers to strong chemicals such as battery acid or metal cleaning solvents.
- (5) Store compressed hydrogen containers in a manner to avoid damage.
- (6) Reinstall containers to their original configuration using approved gaskets, bolts, nuts, washers, and so forth, per recommendations of the container manufacturer.
- (7) Prevent hoists or jacks from coming into direct contact with containers.
- (8) Prohibit personnel from walking on roof-mounted containers.

7.5 Discharge from Vehicle Containers.

7.5.1 The requirements of Section 7.5 shall apply only to non-OEM vehicles.

7.5.2 The venting or depressurization of a hydrogen container shall be performed only by trained personnel using written procedures from the OEM fuel system supplier.

7.5.2.1 The hydrogen to be removed from the container shall be discharged into a closed transfer system or shall be vented by an approved method of atmospheric venting.

7.5.2.2 A valve shall be used to control the discharge of gas from high-pressure systems to a venting system.

7.5.3 Container depressurization systems shall include provisions for doing the following:

- (1) Common grounding to prevent static electrical charge buildup between the vehicle container and venting system
- (2) Limit the rate of gas release from plastic-lined containers to a value not greater than that specified by the container manufacturer
- (3) If used for portable containers, a method to restrain containers during depressurization to prevent container movement

7.5.4 Hydrogen shall be vented in accordance with guidelines and specifications of the vehicle integrator/manufacturer.

7.5.4.1 Direct gas venting shall be done through a vent tube that diverts the gas flow to the atmosphere.

7.5.4.2 The vent tube shall have a gastight connection to the container prior to venting, and all components shall be grounded.

7.5.4.3 The vent tube shall be constructed of suitable material and be designed so as to not reduce the discharge flow rate below that required for the pressure relief devices.

7.5.4.4 The vent tube shall not be provided with any feature that limits or obstructs gas flow.

7.5.4.5 A valve shall be used to control the discharge of gas from high-pressure systems to a venting system.

Chapter 8 CNG Compression, Gas Processing, Storage, and Dispensing Systems

8.1 Application.

8.1.1 This chapter applies to the design, construction, installation, and operation of containers, pressure vessels, compression equipment, buildings and structures, and associated equipment used for storage and dispensing of CNG as an engine fuel in fleet and public dispensing operations.

8.1.2 Mobile refueling vehicles, temporary trailers (with or without tractors), and other means of providing vehicle refueling or onsite storage shall be subject to the same requirements as a permanent refueling or storage installation, with the exception of vessel requirements.

8.1.3 Mobile refueling equipment shall meet the requirements of DOT or TC.

8.2 System Component Qualifications. System components shall comply with the appropriate provisions in Chapter 4 and with Sections 8.5 through 8.13.

8.3 General System Requirements.

8.3.1 Where systems are served by a gas utility, the utility shall be notified of all CNG installations.

8.3.2 Equipment related to a compression, storage, or dispensing installation shall be protected to prevent damage from vehicles and minimize the possibilities of physical damage and vandalism.

8.3.3* Control devices shall be installed so that internal or external icing or hydrate formation does not cause vehicle or fueling station malfunction.

8.3.4 Vehicles shall not be considered a source of ignition with respect to the provisions of this chapter.

Exception: Vehicles containing fuel-fired equipment (e.g., recreational vehicles and catering trucks) shall be considered a source of ignition unless this equipment is shut off completely before entering an area in which ignition sources are not permitted.

8.3.5 The fueling connection shall prevent the escape of gas where the connector is not engaged or becomes separated.

8.3.6 Fueling nozzles shall be listed in accordance with ANSI/IAS NGV1, *Standard for Compressed Natural Gas Vehicle (NGV) Fueling Connection Devices*.

8.3.7 Compression equipment shall be designed for use with CNG and for the pressures and temperatures to which it can be subjected under normal operating conditions.

8.3.8 Compression equipment shall have pressure relief devices that limit each stage pressure to the maximum allowable service pressure for the compression cylinder and piping associated with that stage of compression.

8.3.9 Where CNG compression equipment is operated unattended, it shall be equipped with a high discharge and a low suction pressure automatic shutdown control.

8.3.10 Control circuits that shut down shall remain down until manually activated or reset after a safe shutdown is performed.

8.3.11 Engine-driven compressor installations shall conform, where applicable, to NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*.

8.3.12* Compression equipment shall incorporate a means to minimize liquid carryover to the storage system.

8.4 System Siting.

8.4.1 General.

8.4.1.1 CNG compression, storage, and dispensing shall be located and conducted outdoors or indoors in compliance with this section.

8.4.1.2 This equipment shall be installed on foundations with anchoring systems designed to meet the requirements of the adopted building code for the appropriate seismic and wind conditions.

8.4.2 Outdoors.

8.4.2.1 CNG storage containers charged with CNG not connected for use shall be located outdoors.

8.4.2.2 A facility in which CNG compression, storage, and dispensing equipment are sheltered by an enclosure that is constructed of noncombustible or limited-combustible materials and that has at least one side predominantly open and a roof designed for ventilation and dispersal of escaped gas shall be considered to be located outdoors.

8.4.2.3 Compression, storage, and dispensing equipment located outdoors shall be above ground, shall not be beneath electric power lines or where exposed by their failure, and shall be a minimum of 10 ft (3.0 m) from the nearest important building or line of adjoining property that can be built upon or from any source of ignition.

8.4.2.4 Compression, storage, and dispensing equipment located outdoors shall be not less than 10 ft (3.0 m) from the nearest public street or sidewalk line and at least 50 ft (15 m) from the nearest rail of any railroad main track.

8.4.2.5 A clear space of at least 3 ft (1 m) shall be provided for access to all valves and fittings of multiple groups of containers.

8.4.2.6 Readily ignitable material shall not be permitted within 10 ft (3.0 m) of any stationary container.

8.4.2.7 The minimum separation between containers and aboveground tanks containing flammable or combustible liquids shall be 20 ft (6.1 m).

8.4.2.8 During outdoor fueling operations, the point of transfer shall be located at least 10 ft (3.0 m) from any important building, mobile home, public sidewalk, highway, street, or road and at least 3 ft (1 m) from storage containers.

Exception: The point of transfer shall be permitted to be located at a lesser distance from buildings or walls constructed of concrete or masonry materials or of other material having a fire resistance rating of at least 2 hours, but at least 10 ft (3.0 m) from any building openings.

8.4.2.9 Areas for compression, storage, and dispensing shall be classified in accordance with Table 8.4.2.9 for installations of electrical equipment.

8.4.3 Indoors.

8.4.3.1 General. Compression, dispensing equipment, and storage containers connected for use shall be permitted to be located inside of buildings reserved exclusively for these purposes or in rooms within or attached to buildings used for other purposes in accordance with this section.

8.4.3.2 Limits of Storage in Buildings. Storage shall be limited to not more than 10,000 Scf (283 m³) of natural gas in each building or room.

Exception: CNG stored in vehicle-mounted fuel supply containers.

8.4.3.3* Deflagration Venting.

8.4.3.3.1 Deflagration (explosion) venting shall be provided in exterior walls or roof only.

8.4.3.3.2 Vents shall be permitted to consist of any one or any combination of the following:

Table 8.4.2.9 Electrical Installations

Location	Division or Zone	Extent of Classified Area
Containers (other than mounted fuel supply containers)	2	Within 10 ft (3 m) of container
Area containing compression and ancillary equipment	2	Up to 15 ft (4.6 m) from equipment
Dispensing equipment outdoors	1	Inside the dispenser enclosure
Outdoors	2	From 0 to 5 ft (1.5 m) from the dispenser
Indoors	1	Inside the dispenser enclosure
Indoors	2	Entire room, with adequate ventilation (<i>see 8.4.3</i>)
Discharge from relief valves or vent		
Outdoors	1	5 ft (1.5 m) in all directions from the point source
Outdoors	2	Beyond 5 ft (1.5 m) but within 15 ft (4.6 m) in all directions from point of discharge
Valves, flanges of screwed fittings	None	Unclassified
Discharge from relief valves within 15 degrees of the line of discharge	1	15 ft (4.6 m)

- (1) Walls of light material
- (2) Lightly fastened hatch covers
- (3) Lightly fastened, outward opening doors in exterior walls
- (4) Lightly fastened walls or roofs

8.4.3.3.3 Where applicable, snow loads shall be considered.

8.4.3.4 Rooms Within Buildings.

8.4.3.4.1 Rooms within or attached to other buildings shall be constructed of noncombustible or limited-combustible materials.

Exception: Window glazing shall be permitted to be plastic.

8.4.3.4.2 Interior walls or partitions shall be continuous from floor to ceiling, shall be securely anchored, and shall have a fire resistance rating of at least 2 hours.

8.4.3.4.3 At least one wall shall be an exterior wall.

8.4.3.4.4 Explosion venting shall be provided in accordance with 8.4.3.3.

8.4.3.4.5 Access to the room shall be from outside the primary structure.

8.4.3.4.6 If access to the room from outside the primary structure is not possible, access from within the primary structure shall be permitted where such access is made through a barrier space having two vapor-sealing, self-closing fire doors having the appropriate rating for the location where installed.

8.4.3.5 Ventilation Inlets and Outlets.

8.4.3.5.1 Indoor locations shall be ventilated utilizing air supply inlets and exhaust outlets arranged to provide uniform air movement to the extent practical.

8.4.3.5.2 Inlets shall be uniformly arranged on exterior walls near floor level.

8.4.3.5.3 Outlets shall be located in exterior walls at the high point of the room or in the roof.

8.4.3.5.4 Ventilation.

8.4.3.5.4.1 Ventilation shall be by a continuous mechanical ventilation system or by a mechanical ventilation system activated by a continuously monitoring natural gas detection system where a gas concentration of not more than one-fifth of the lower flammable limit is present.

8.4.3.5.4.2 In either case in 8.4.3.5.4.1, the system shall immediately shut down the fueling system in the event of detection of an alarm condition or failure of the ventilation system, the detection system, or the controls.

8.4.3.5.5* The ventilation rate shall be at least 1 ft³/min · 12 ft³ (0.30 m³/min · 0.34 m³) of room volume.

8.4.3.5.6 A ventilation system for a room within or attached to another building shall be separate from any ventilation system for the other building.

8.4.3.6 Where installed, a gas detection system shall be equipped to sound a latched alarm and visually indicate when a maximum of one-fifth of the lower flammable limit is reached.

8.4.3.7 Reactivation of the fueling system shall be by manual restart and shall be conducted by trained personnel.

8.4.3.8 Buildings and rooms used for compression, storage, and dispensing shall be classified in accordance with Table 8.4.2.9 for installations of electrical equipment.

8.4.3.9 Nonelectrical sources of ignition shall not be permitted.

8.4.3.10 Pressure relief devices on storage systems shall have pressure relief device channels [*see 4.5.1(2)*] to convey escaping gas to the outdoors and then upward to a safe area to prevent impinging on buildings, other equipment, or areas open to the public (e.g., sidewalks).

8.4.3.11 Warning Signs.

8.4.3.11.1 Access doors shall have warning signs with the words "WARNING — NO SMOKING — FLAMMABLE GAS."