NFPA 52

Compressed Natural Gas (CNG) Vehicular Fuel Systems Code

2002 Edition

NFPA, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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This edition of NFPA 52, *Compressed Natural Gas (CNG) Vehicular Fuel Systems Code*, was prepared by the Technical Committee on Vehicular Alternative Fuel Systems and acted on by NFPA at its May Association Technical Meeting held May 19–23, 2002, in Minneapolis, MN. It was issued by the Standards Council on July 19, 2002, with an effective date of August 8, 2002, and supersedes all previous editions.

This edition of NFPA 52 was approved as an American National Standard on July 19, 2002.

Origin and Development of NFPA 52

While 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 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 contains minor revisions, most of these in the chapter on engine fuel systems. There also have been some changes made to comply with NFPA's *Manual of Style*. The most significant of these are reordering of chapters and numbering of definitions.

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Committee Scope: This Committee shall have primary responsibility for documents on fire and explosion hazards associated with compressed natural gas (CNG) and liquefied natural gas (LNG) 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.

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.

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

Changes other than editorial are indicated by a vertical rule beside the paragraph, table, or figure in which the change occurred. These rules are included as an aid to the user in identifying changes from the previous edition. Where one or more complete paragraphs have been deleted, the deletion is indicated by a bullet between the paragraphs that remain.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, Annex D lists the complete title and edition of the source documents for both mandatory and nonmandatory extracts. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text shall be sent to the appropriate technical committee.

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

Chapter 1 Administration

1.1* Scope. This code shall apply to the design and installation of compressed natural gas (CNG) engine fuel systems on vehicles of all types, including the following:

(1) Original equipment manufacturers
(2) Vehicle converters
(3) Vehicle fueling (dispensing) systems

1.1.1 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 5 (except Section 5.11, 5.12.4, Section 5.13, and Section 5.14.).

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 shall not apply to 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 it is clearly evident that a reasonable degree of safety is provided.

1.4 Alternate Provisions. It is recognized that 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. Such deviations or improvements can provide equivalent safety and compatible operation that meet the intent of this code. 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.

1.5 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.)*

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, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 30, *Flammable and Combustible Liquids Code,* 2000 edition.

NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages,* 2000 edition.

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

NFPA 54, *National Fuel Gas Code,* 2002 edition.

NFPA 70, *National Electrical Code®,* 2002 edition.

NFPA *101®*, *Life Safety Code®,* 2000 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials,* 1998 edition.

NFPA 302, *Fire Protection Standard for Pleasure and Commercial Motor Craft,* 1998 edition.

NFPA 303, *Fire Protection Standard for Marinas and Boatyards,* 2000 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment,* 1998 edition.

2.3 Other Publications.

2.3.1 ANSI Publications. American National Standards Institute, Inc., 11 West 42nd Street, 13th Floor, New York, NY 10036.

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, *Personnel Protection — Protective Headgear for Industrial Workers — Requirements*, 1997.

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

API RP 2003, *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents*, 1991.

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

ANSI/ASME B31.3, *Chemical Plant and Petroleum Refinery Piping*, 1996.

ASME *Boiler and Pressure Vessel Code*, Section VIII, 1995.

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 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 Degrees C*, 1996.

2.3.5 CGA Publication. Compressed Gas Association, 1725 Jefferson Davis Highway, Arlington, VA 22202-4100.

CGA S-1.1, *Pressure Relief Device Standards — Part 1 — Cylinders for Compressed Gases,* 1994.

2.3.6 CSA Publication. Canadian Standards Association, 178 Rexdale Boulevard, Rexdale, Ontario, Canada M9W 1R3.

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

2.3.7 IAS Publications. International Approval Services, 8501 East Pleasant Valley Road, Cleveland, Ohio 44131.

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*, 1992.

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

2.3.8 SAE Publication. Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

SAE J1616, *Recommended Practice for Compressed Natural Gas Vehicle Fuel*, 1994.

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

Title 49, *Code of Federal Regulations.*

2.3.10 U.S. DOT and TC container data are available from the U.S. Department of Transportation, 400 7th Street SW, Washington, DC 20590, and the Canadian Transport Commission, Transport Canada Building, Place de Ville, Ottawa, Ontario, K1A ON5.

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 included, common usage of the terms shall apply.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

3.2.3 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.

3.2.4* 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.

3.2.5 Shall. Indicates a mandatory requirement.

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

3.3 General Definitions.

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

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

3.3.3 Cascade Storage System. Storage in multiple pressure vessels, cylinders, or containers.

3.3.4 Container. A pressure vessel, cylinder, or cylinders permanently manifolded together used to store CNG.

3.3.4.1 Composite Container. A container fabricated of two or more materials that interact to facilitate the container design criteria.

3.3.4.2 Fuel Supply Container. A container mounted on a vehicle to store CNG as the fuel supply to the internal combustion engine of the vehicle.

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

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

3.3.7 Cylinder. A container constructed, inspected, and maintained in accordance with U.S. Department of Transportation or Transport Canada regulations or ANSI/IAS NGV2, *Basic Requirements for Compressed Natural Gas Vehicle (NGV) Fuel Containers,* or CSA B51, *Boiler, Pressure Vessel and Pressure Piping Code.*

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

3.3.9 Dispensing Station. A natural gas installation that dispenses CNG from storage containers or a distribution pipeline into fuel supply containers or into portable cylinders by means of a compressor or pressure booster.

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

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

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

3.3.13 Gas Detection System. A grouping of one or more sensors capable of detecting a natural gas leak at specified concentrations and activating alarms and safety systems.

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

3.3.15 LFL. That concentration of a combustible material in air below which ignition will not occur. Also known as the Lower Explosive Limit (LEL). Mixtures below this limit are said to be "too lean." [**329:**1.2]

3.3.16* Limited-Combustible Material. A building construction material that does not comply with the definition of noncombustible material, that, in the form in which it is used, has a potential heat value not exceeding 3500 Btu/lb (8141 kJ/kg) *(see NFPA 259, Standard Test Method for Potential Heat of Building Materials),* and that complies with either of the following (a) or (b). Materials subject to an increase in combustibility or flame spread rating beyond the limits herein established through the effects of age, moisture, or other atmospheric conditions shall be considered combustible. (a) Materials having a structural base of noncombustible material, with a surface not exceeding a thickness of ⅛ in. (3.2 mm), and with a flame spread rating not greater than 50. (b) Materials in the form and thickness used, other than as described in (a), having neither a flame spread rating greater than 25 nor evidence of continued progressive combustion and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread rating greater than 25 nor evidence of continued progressive combustion. [**96:**1.2]

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

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

3.3.18.1 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.

3.3.19 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. [**220:**2.1]

3.3.20 Overhead (Marine). Overhead is the unfinished area in the top of a room or compartment — not a ceiling.

3.3.21 Piping. A means of transporting natural gas. This term applies to refueling facilities.

3.3.22 Point of Transfer. The location where connections and disconnections are made or where CNG is vented to the atmosphere in the course of transfer operations.

3.3.23 Pressure.

3.3.23.1* Fill Pressure. The pressure attained at the actual time of filling.

3.3.23.2 Operating Pressure. The varying pressure in a fuel supply container during normal vehicle operation.

3.3.23.3 Service Pressure. The nominal gas pressure at a uniform gas temperature of 70°F (21°C) when the equipment is properly and completely charged with gas; the nominal design pressure for which the equipment has been constructed.

3.3.23.4 Settled Pressure. The pressure in a container at 70°F (21°C).

3.3.24 Pressure Relief Device. A device operated by temperature, pressure, or both, used to prevent the pressure from rising above a predetermined maximum and for the purpose of preventing the rupture of a normally charged cylinder where subjected to a standard fire test as required by Title 49, *Code of Federal Regulations*, 173.34(d) or 73.34(d), of the Canada Transport (TC) Regulations. Pressure relief devices for DOT/TC cylinders also include devices capable of protecting partially charged cylinders where subjected to these fire tests.

3.3.25 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.

3.3.26 Pressure Vessel. A container or other component designed in accordance with the ASME *Boiler and Pressure Vessel Code.*

3.3.27 Residential Fueling Facility (RFF). An assembly used for the compression and delivery of natural gas into vehicles along with its associated equipment and piping.

3.3.28 Room.

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

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

3.3.29 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:**1.4]

3.3.30 Sources of Ignition. Devices or equipment that, because of their intended modes of use or operation, are capable of providing sufficient thermal energy to ignite flammable gas–air mixtures. [**54:**3.3]

3.3.31 Space.

3.3.31.1 Accommodation Space. Space on a marine vessel that has been designed for living purposes.

3.3.31.2 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.

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

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

3.3.31.5 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.

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

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

3.3.34 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:**1.3]

Chapter 4 General CNG and Equipment Qualifications

4.1* General. The provisions of this chapter apply only to pressurized system components handling CNG.

4.2* Gas Composition. Gas composition in the container shall comply with either 4.2.1 or 4.2.2, as applicable.

4.2.1 The contained gas shall be composed as follows:

(1) *Hydrogen sulfide (H_2S) and soluble sulfides.* 1 grain/100 Scf (23 mg/m^3)
(2) *Water (H_2O).* 7.0 lb/MMScf (110 kg/m^3 × 10^6)
(3) *Carbon dioxide (CO_2).* 3.0 volume percent, max
(4) *Oxygen (O_2).* 0.5 volume percent, max

Exception: Where the dew point of the 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 standard 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.

4.2.2 Gas Composition. Containers made to this standard shall be designed to be used with gas complying with the SAE J1616, *Recommended Practice for Compressed Natural Gas Vehicle Fuel*, or an equivalent national standard.

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

4.2.2.2 Recognizing that the 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. Water vapor would normally be limited to less than 32 mg/m^3 (2 lb/MMScf), a pressure dew point of –9°C (16°F) at 20,700 kPa (3,000 psi). There would be no maximum constituent limits for dry gas, except for the following:
   (a) Hydrogen sulfide, 23 mg/m^3
   (b) Oxygen, 1 percent by volume
(2) Wet Gas. Gas that contains 32 mg/m^3 (2 lb/MMScf) of water or more normally meets the following maximum constituent limits:
   (a) H_2S and other soluble sulfides, 23 mg/m^3 (1 gr/100 Scf)
   (b) Total sulfur, 115 mg/m^3 (5 gr/MMScf)
   (c) Oxygen, 1 percent by volume
   (d) CO_2, 3 percent by volume
   (e) Hydrogen, 0.1 percent by volume

4.2.2.3 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 Approval.

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
(7) Engine fuel systems
(8) Electrical equipment related to CNG systems

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 standard 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 U.S. Department of Transportation (DOT) or Canada Transport (TC) regulations, exemptions, or special permits or with ANSI/IAS NGV2, *Basic Requirements for Compressed Natural Gas Vehicle (NGV) Fuel Containers*, specifically for CNG service.

4.4.5 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 suitable for CNG service. Adherence to applicable ASME *Boiler and*

Pressure Vessel Code, case interpretations and addenda shall be considered as compliance with the ASME *Boiler and Pressure Vessel Code*.

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

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

4.4.7.1 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) Pressure relief devices for cylinders shall be in accordance with any of the following:
   (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*
(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. The adjustment, if external, shall be provided with a means for sealing the adjustment to prevent tampering. 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. 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. 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 the ASME *Boiler and Pressure Vessel 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.

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

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 service conditions.

4.8.2 Pipe, tubing, fittings, and other piping components shall be capable of withstanding a hydrostatic test of at least four times the rated service pressure without structural failure.

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

4.8.4 The following components shall not be used:

(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

Exception No. 1: The refueling connection shall be permitted to be made of nonsparking wrought aluminum alloy designed for the pressure employed.

Exception No. 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 tem-

peratures 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. Leakage shall not occur at less than one-and-a-half times the rated service pressure, using dry air as the test medium.

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 expected 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 manufacturer 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 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. Vehicle fueling connection devices shall be listed in accordance with ANSI/IAS NGV1, *Standard for Compressed Natural Gas Vehicle (NGV) Fueling Connection Devices.* The use of adapters shall be prohibited.

Chapter 5 Engine Fuel Systems

5.1* Application.

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

5.1.2 Components shall be installed in accordance with the manufacturer's instructions.

5.2 System Component Qualifications.

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

5.2.2 Components in the engine compartment shall be designed or selected for service for a temperature range of −40°F to 250°F (−40°C to 121°C). All other components shall be designed or selected for service for a range of −40°F to 180°F (−40°C to 82.2°C).

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

5.2.4 Fuel-carrying components shall be labeled or stamped with the following:

(1) The manufacturer's name or symbol
(2) The model designation
(3) The design service pressure
(4) The direction of fuel flow where necessary for correct installation
(5) The capacity or electrical rating, as applicable

Exception: This requirement shall not apply to container valves, tubing, and fittings.

5.3 Installation of Fuel Supply Containers.

5.3.1 Fuel supply containers shall be installed in accordance with the instructions of the container manufacturer and the following requirements.

5.3.2 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.

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

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

5.3.2.2 The container shall be positioned to prevent contact with vehicle components such as frame members, body panels, brake lines, and so on, that may lead to container fretting or abrasion over time.

5.3.3 Each fuel supply container shall be mounted in a location to minimize damage from collision. No part of a container or its appurtenances shall protrude beyond the sides or top of the vehicle at the point where it is installed.

5.3.3.1 Where a container is installed above the operator or passenger compartment of a vehicle, the following requirements shall apply.

(1) The container and its piping, fittings, and valves shall be protected from damage by the following:
   (a) A guard rail or similar device that is designed to absorb the impact of a collision with a stationary object when the vehicle is moving either forward or backward at 5 mph (8 kph). The guard rail or similar device shall be free of projections that could damage the container or its valves and fittings.
   (b) A shield designed to absorb impacts that can occur during loading, unloading, or use of the vehicle. The shield shall be free of projections that could damage the container or its valves and fittings.

(2) The top of the container and any CNG piping, fitting, valve, housing, guardrail, or shield shall not be more than 13½ ft (4.12 m) above the road surface.
(3) The cylinder shall be protected from accidental contact with overhead electrical wiring by metallic or nonmetallic covers.

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

5.3.3.3 Containers shall not be mounted ahead of the front axle or beyond the rear bumper on motor vehicles. No part of the container or its appurtenances shall protrude beyond the sides or top of any vehicle where the container can be struck or punctured.

5.3.4 Each 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 *(see Figure 5.3.4)* of eight times the weight of a fully pressurized container(s).

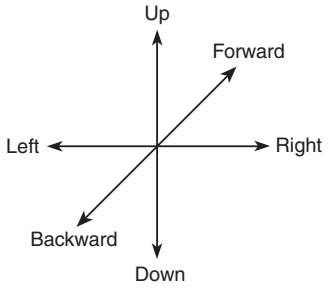

FIGURE 5.3.4 The Six Principal Directions.

5.3.5 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 5.3.4)*, of eight times the weight of the fully pressurized container with a maximum displacement of ½ in. (13 mm).

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

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

5.3.8 The mounting system shall minimize fretting corrosion between the container and the mounting system.

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

5.3.10 Metal clamping bands and their supports shall not be in direct contact with a container. A resilient gasket that does not retain water shall be installed between the clamping bands and their supports and a container. The resilient gasket shall provide insulation to protect clamping bands from galvanic corrosion in contact with carbon fiber containers.

5.3.11 The minimum clearance from the road to a 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 5.3.11.

Table 5.3.11 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

5.3.12 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.

5.4* Installation of Venting Systems.

5.4.1* All pressure relief devices and connections between pressure-carrying components installed within driver, passenger, or a closed compartment *(see 5.3.2)* shall be vented to the outside of the vehicle. This requirement shall not include plugs in the ends of containers with openings in each end.

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

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

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

5.4.5 Means shall be provided to prevent water, dirt, insects, and any foreign objects from collecting in the vent lines or pressure relief devices. Protective devices shall not restrict the flow of gas.

5.4.6 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 (200 mm) or an equally gastight alternate enclosure that is vented directly to the outside of the vehicle.

5.4.7 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) 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) Having a burst pressure of at least 1½ times the pressure in the vent that results from activation of the PRO.
(c) The vent line should not lose its gas-carrying ability when exposed to 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.

5.5 Installation of Piping.

5.5.1 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.

5.5.2 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.

5.5.3 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.

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

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

5.5.6 Fuel lines shall have the maximum practical clearance from the engine exhaust system.

5.5.7 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. A fuel line shall be installed, supported, protected, and secured 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.

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

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

5.5.10 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.

5.6 Installation of Valves.

5.6.1 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. Remotely actuated valves shall be equipped to bleed the cylinder manually.

5.6.2 In addition to the valve required by 5.6.1, 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. Where a manual shutoff valve is used, it shall be in an accessible location and shall have not more than 90 degrees rotation from the open to the closed positions. Access to the manual shutoff valve shall not require the use of any key or tool.

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.

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

5.6.2.2 Where a manual valve is used, the valve location shall be indicated with the words "MANUAL SHUTOFF VALVE." A weather-resistant decal or label with red, blue, or black letters on a white or silver reflective background shall be used.

5.6.3 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.

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

5.6.5* 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. The backflow check valve shall be mounted to withstand the breakaway force specified in 6.11.8.

5.7 Installation of Pressure Gauges.

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

5.7.2 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.

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

5.8 Installation of Pressure Regulators.

5.8.1 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.

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

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

5.9 Installation of Fueling Connection.

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

5.9.2 The fueling connection receptacle shall be mounted to withstand the breakaway force specified in 6.11.8. The receptacle shall be installed in accordance with the manufacturer's instructions.

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

5.10 Wiring Installation.

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

5.10.2 All wiring shall be sized and fuse-protected.

5.11 Labeling.

5.11.1 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

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

5.11.2 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. The label shall be a minimum of 4¾ in. long × 3¼ in. high (120 mm × 83 mm). 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.

5.12 System Testing.

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

5.12.2 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.

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

5.12.4* 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.

5.12.5 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 5.13)* before being returned to service.

5.12.6 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.

5.13 Maintenance and Repair.

5.13.1 Damaged fuel lines shall be replaced. Fuel lines shall not be repaired.

5.13.2 All containers, container appurtenances, piping systems, venting systems, and other components shall be maintained in a safe condition. It shall be verified that the container retest date or expiration date is current.

5.13.3 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.*

5.13.4 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 suitable tests.
(4) No pressure relief device that has been in service shall be reinstalled on another fuel cylinder.

5.13.5 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 composite wrapped containers to strong chemicals such as battery acid or metal cleaning solvents.
(5) Store compressed natural gas containers in a manner to avoid damage.
(6) Reinstall containers to their original configuration using approved gaskets, bolts, nuts, washers, and so on, 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.

5.14 Discharge of CNG from Vehicle Containers.

5.14.1 The venting or depressurization of a compressed natural gas container shall be performed only by trained personnel using written procedures. 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.

5.14.2 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.

5.14.3 Direct gas venting shall be done through a vent tube that will divert the gas flow to atmosphere. The vent tube shall have a gas-tight connection to the container prior to venting, and all components shall be properly grounded. The vent tube shall be constructed of Schedule 80 pipe of at least 2-in. diameter. The vent tube shall not be provided with any feature that would limit or obstruct gas flow.

Chapter 6 CNG Compression, Storage, and Dispensing Systems

6.1* Application. 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.

6.2 System Component Qualifications. System components shall comply with the appropriate provisions in Chapter 4 and with Sections 6.5 through 6.13.

6.3 General.

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

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

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

6.3.4 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.

6.3.5 The fueling connection shall prevent the escape of gas where the connector is not properly engaged or becomes separated. Fueling nozzles shall be listed in accordance with ANSI/IAS NGV1, *Standard for Compressed Natural Gas Vehicle (NGV) Fueling Connection Devices.*

6.3.6 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. It 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.

6.3.7 Where CNG compression equipment is operated unattended, it shall be equipped with a high discharge and a low suction pressure automatic shutdown control. Control circuits that shut down shall remain down until manually activated or reset after a safe shutdown is performed.

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

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

6.4 Siting.

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

6.4.2 Outdoors.

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

6.4.2.2 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.

6.4.2.3 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.

6.4.2.4 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.

6.4.2.5 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.

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

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

6.4.2.8 During outdoor fueling operations, the point of transfer *(see 3.3.22, 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.

6.4.3 Indoors.

6.4.3.1 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.

6.4.3.2 Limits of Storage in Buildings. Storage shall be limited to not more than 10,000 Scf (283 m^3) of natural gas in each building or room.

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

6.4.3.3* Deflagration Venting. Deflagration (explosion) venting shall be provided in exterior walls or roof only. Vents shall be permitted to consist of any one or any combination of the following:

(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
(5) Where applicable, snow loads shall be considered.

6.4.3.4 Rooms within Buildings. Rooms within or attached to other buildings shall be constructed of noncombustible or limited-combustible materials. 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. At least one wall shall be an exterior wall.

Exception: Window glazing shall be permitted to be plastic.

6.4.3.4.1 Explosion venting shall be provided in accordance with 6.4.3.3.

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

6.4.3.4.3 If such access 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.

6.4.3.5 Ventilation. Indoor locations shall be ventilated utilizing air supply inlets and exhaust outlets arranged to provide uniform air movement to the extent practical. Inlets shall be uniformly arranged on exterior walls near floor level. Outlets shall be located at the high point of the room in exterior walls or the roof.

(A) 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. In either case, the system shall shut down the fueling system in the event of failure of the ventilation system.

(B)* The ventilation rate shall be at least 1 ft^3/min·12 ft^3 (1 m^3/min·12 m^3) of room volume.

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

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

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

6.4.3.8 Buildings and rooms used for compression, storage, and dispensing shall be classified in accordance with Table 6.4.3.8 for installations of electrical equipment.

6.4.3.9 Non-electrical sources of ignition, other than electrical installations as permitted by 6.4.3.8, shall not be permitted.

6.4.3.10 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).

6.4.3.11 Access doors shall have warning signs with the words "WARNING — NO SMOKING — FLAMMABLE GAS." Such wording shall be in plainly legible, bright red letters on a white background with letters not less than 1 in. (25 mm) high.

Table 6.4.3.8 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 *(see 6.4.3)*
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)

6.4.3.12 Indoor Fast-Fill Fueling, Outdoor Storage, and Compression. Fast-fill fueling indoors is permitted where storage and compression equipment is located outdoors complying with 6.4.2.1 through 6.4.2.7.

6.4.3.13 Where attended fast-fill fueling is performed indoors, the following shall be installed.

(1) An emergency manual shutdown device shall be installed as required by 6.11.6.
(2) A gas detection system equipped to sound an alarm and visually indicate when a maximum of one-fifth of the lower flammable limit is reached shall be installed.

6.4.3.13.1 The detector shall shut down the compressor and stop the flow of gas into the structure.

6.5 Installation of Containers and Container Appurtenances (Other Than Pressure Relief Devices).

6.5.1* Storage containers shall be installed aboveground on stable, noncombustible foundations or in vaults with ventilation and drainage. Horizontal containers shall have no more than two points of support longitudinally. Where flooding can occur, each container shall be securely anchored to prevent floating.

6.5.2 Containers shall be protected by painting or other equivalent means where necessary to inhibit corrosion. Horizontally installed containers shall not be in direct contact with each other.

Exception: Composite containers shall not be painted without prior permission from the container manufacturer.

6.5.3 Means shall be provided to prevent the flow or accumulation of flammable or combustible liquids under containers, such as by grading, pads, or diversion curbs.

6.6 Installation of Pressure Relief Devices.

6.6.1 Pressure relief valves shall be so arranged that they discharge to a safe area and so that escaping gas does not impinge on buildings, other equipment, or areas that could be occupied by the public. *(See 6.4.3.10.)*

6.6.2 Pressure relief valves on pressure vessels shall be installed so that any discharge is in a vertical position and shall be fitted with rain caps.

6.6.3 An overpressure protection device, other than a rupture disc, shall be installed in the fueling transfer system to prevent overpressure in the vehicle. The set pressure of the device shall not exceed 125 percent of the service pressure of the fueling nozzle it supplies.

6.7 Installation of Pressure Regulators. Regulators shall be designed, installed, or protected so that their operation is not affected by freezing rain, sleet, snow, ice, mud, insects, or debris. This protection shall be permitted to be integral with the regulator.

6.8 Installation of Pressure Gauges. Gauges shall be installed to indicate compression discharge pressure, storage pressure, and fuel supply container fill pressure.

6.9 Installation of Piping and Hoses.

6.9.1* Piping and hose shall be run as directly as practical and with adequate provisions for expansion, contraction, jarring, vibration, and settling. Exterior piping shall be either buried or installed above ground and shall be supported and protected against mechanical damage. Underground piping shall be buried not less than 18 in. (460 mm) below the surface of the ground unless otherwise protected from damage by movement of the ground. Underground and aboveground piping shall be protected from corrosion in compliance with recognized practices. Threaded pipe and fittings shall not be used under ground.

6.9.1.1 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.

6.9.1.2 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.

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

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

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

6.9.2 Natural gas shall be vented only to a safe point of discharge. A vent pipe or stack shall have the open end protected to prevent entrance of rain, snow, and solid material. Vertical vent pipes and stacks shall have provision for drainage.

6.9.3 The use of hose in an installation shall be limited to the following:

(1) A vehicle fueling hose
(2) An inlet connection to compression equipment
(3) A section of metallic hose not exceeding 36 in. (910 mm) in length in a pipeline to provide flexibility where necessary. Each section shall be so installed that it is protected against mechanical damage and is readily visible for inspection. The manufacturer's identification shall be retained in each section.

6.9.4 At public fueling stations, provision shall be provided to recycle gas used for calibration and testing.

6.10 Testing.

6.10.1 Piping, tubing and hose, and hose assemblies shall be leak tested after assembly to prove them free from leaks at a pressure equal to at least the normal service pressure of that portion of the system.

6.10.2 Pressure relief valves shall be tested at least every 5 years.

6.11 Installation of Emergency Shutdown Equipment.

6.11.1 A manually operated container valve shall be provided for each DOT or TC storage cylinder. Each group of ASME storage vessels up to a maximum combined capacity of 10,000 Scf (283 m^3) shall be provided with a manually operated shutoff valve.

6.11.2 The fill line on a storage container shall be equipped with a backflow check valve to prevent discharge of natural gas from the container in case of the rupture of the line, hose, or fittings.

6.11.3 A manually operated shutoff valve shall be installed in a manifold as close to a container or group of containers as practical. This valve shall be located downstream of the backflow check valve specified in 6.11.2.

6.11.4 Where excess-flow check valves are used, the closing flow shall be less than the flow rating of the piping system that would result from a pipeline rupture between the excess-flow valve and the equipment downstream of the excess-flow check valve.

6.11.5 Gas piping from an outdoor compressor or storage system into a building shall be provided with shutoff valves located outside the building.

6.11.6 An emergency manual shutdown device shall be provided at the dispensing area and also at a location remote from the dispensing area. This device, when activated, shall shut off the power supply and gas supply to the compressor and the dispenser.

6.11.6.1 Emergency shutdown devices shall be distinctly marked for easy recognition with a permanently affixed legible sign.

6.11.7 Breakaway protection shall be provided in a manner that, in the event of a pullaway, natural gas ceases to flow at any separation.

6.11.8 A breakaway device shall be installed at every dispensing point. Such a device shall be arranged to separate using a force not greater than 150 lb (68 kg) when applied in any horizontal direction.

6.11.9 Control circuits shall be arranged so that, when an emergency shutdown device is activated or electric power is cut off, systems that shut down shall remain down until manually activated or reset after a safe condition is restored.

6.11.10 Each line between a gas storage facility and a dispenser at a fast-fill station shall have a valve that closes when one of the following occurs:

(1) The power supply to the dispenser is cut off.
(2) Any emergency shutdown device at the refueling station is activated.

6.11.11 A fast-closing, "quarter turn" manual shutoff valve shall be provided at a fast-fill station upstream of the breakaway device specified in 6.11.8, where it is readily accessible to the person dispensing natural gas, unless one of the following occurs:

(1) The self-closing valve referred to in 6.11.10 is located immediately upstream of the dispenser.
(2) The dispenser is equipped with a self-closing valve that closes each time the control arm is turned to the off position or when an emergency device is activated.

6.11.12 A self-closing valve shall be provided on the inlet of the compressor that shuts off the gas supply to the compressor when one of the following occurs:

(1) An emergency shutdown device is activated.
(2) A power failure occurs.
(3) The power to the compressor is switched to the off position.

6.12* Installation of Electrical Equipment. Fixed electrical equipment and wiring within areas specified in Table 6.4.3.8 shall comply with Table 6.4.3.8 and shall be installed in accordance with NFPA 70, *National Electrical Code®*.

Exception: Electrical equipment on internal combustion engines installed in accordance with NFPA 37, Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines.

6.12.1 With the approval of the authority having jurisdiction, the classified areas specified in Table 6.4.3.8 shall be permitted to be reduced or eliminated by positive pressure ventilation from a source of clean air or inert gas in conjunction with effective safeguards against ventilator failure by purging methods recognized in NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment.*

6.12.2 Classified areas shall not extend beyond an unpierced wall, roof, or vaportight partition. Space around welded pipe and equipment without flanges, valves, or fittings shall be a nonhazardous location.

Exception: Listed dispensers shall be permitted to be installed using classified areas in accordance with the terms of the listing.

6.13 Stray or Impressed Currents and Bonding.

6.13.1 Where stray or impressed currents are used or can be present on dispensing systems (such as cathodic protection), protective measures to prevent ignition shall be taken in accordance with API RP 2003, *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents.*

6.13.2 Static protection shall not be required where CNG is loaded or unloaded by conductive or nonconductive hose, flexible metallic tubing, or pipe connections where both halves of the metallic couplings are in contact.

6.14 Operation.

6.14.1 A cylinder shall not be charged in excess of the design pressure at the normal temperature for that cylinder. DOT, TC, and ANSI/IAS NGV2 cylinders shall be charged in accordance with DOT, TC, and ANSI/IAS NGV2 regulations. DOT, TC, and ANSI/IAS NGV2 cylinders shall not be subjected to pressure in excess of 125 percent of the marked service pressure even if, on cooling, the pressure settles to the marked service pressure.

6.14.2 A fuel supply container shall not have a settled pressure above the service pressure that is stamped on the container and displayed on a label near the filling connection, corrected for the ambient temperature at the time of filling.

6.14.3 CNG dispensing systems shall be equipped to stop fuel flow automatically when a fuel supply container reaches the temperature-corrected fill pressure *(see 6.6.3)*. Where an overpressure incident that results in operation of the overpressure protection system occurs, the dispenser pressure control system shall be examined and certified by a qualified technician prior to being returned to service.

6.14.4 The transfer of CNG into a fuel supply container shall be performed in accordance with instructions posted at the dispensing station.

6.14.5 Where CNG is being transferred to or from a motor vehicle, the engine shall be turned off.

6.14.6 During the transfer of CNG to or from cargo vehicles, the hand or emergency brake of the vehicle shall be set, and chock blocks shall be used to prevent rolling of the vehicle.

6.14.7 Transfer systems shall be capable of depressurizing to facilitate disconnection. Bleed connections shall lead to a safe point of discharge.

6.14.8 CNG shall not be used to operate any device or equipment that has not been designed or properly modified for CNG service.

6.14.9 Sources of ignition shall not be permitted within 10 ft (3.0 m) of any filling connection during a transfer operation.

6.14.10 A warning sign with the words "STOP MOTOR, NO SMOKING, FLAMMABLE GAS" shall be posted at dispensing station and compressor areas. The location of signs shall be determined by local conditions, but the lettering shall be large enough to be visible and legible from each point of transfer.

6.15 Fire Protection. A portable fire extinguisher having a rating of not less than 20-B:C shall be provided at the dispensing area.

6.16* Maintenance.

6.16.1 Containers and their appurtenances, piping systems, compression equipment, controls, and detection devices shall be maintained in proper operating condition and according to manufacturer's instructions.

6.16.2 After the original installation, vehicle fueling hoses shall be examined visually at such intervals as are necessary to ensure that they are safe for use. Hose shall be tested for leaks per manufacturer's requirements, but at least annually, and any unsafe leakage shall be reason for rejection.

6.16.3 While in transit, fueling hose and flexible metal hose on a cargo vehicle to be used in a transfer operation, including their connections, shall be depressurized and protected from wear and injury.

6.16.4* Pressure relief valves shall be maintained in proper operating condition.

6.17 Vehicle Fueling Appliances in Nonresidential Occupancies.

6.17.1 Vehicle fueling appliances (VFAs) shall not exceed a gas flow of 10 Scf/min (0.28 standard cubic meter/min). VFAs shall be listed.

6.17.2 The installation of VFAs shall be exempt from the requirements of Sections 4.5 through 4.10, 6.2 through 6.4, 6.6, and 6.8 through 6.16.

6.17.3 VFAs shall be permitted to be used to fill stationary containers at vehicle fueling locations. The method of connecting the VFA to such storage shall comply with the provisions of Chapters 4 and 6 and shall be approved. The provisions of 6.17.2 shall apply to the VFA where connected to stationary containers at vehicle fueling locations.

6.17.4 The installation of VFAs shall comply with the requirements of Chapter 7.

Exception No. 1: The requirements of 7.1.1 shall not apply to the installation of VFAs.

Exception No. 2: Gas detectors shall be located in accordance with good engineering practice.

6.17.5 VFAs shall not be installed within 10 ft (3.0 m) of any storage.

Exception: Storage in the vehicle fuel supply container

6.17.6 Where installed indoors in public assembly and educational occupancies, a VFA shall be located in a portion of the occupancy where NFPA *101®*, *Life Safety Code®*, or the local building code permits the installation of hazardous equipment.

Exception: Where the VFA is located outdoors, the dispensing point shall be permitted to be located indoors without the need for a separate room.

Chapter 7 Residential Fueling Facility

7.1 Scope.

7.1.1 The capacity of a residential fueling facility (RFF) shall not exceed 5 Scf/min (0.14 standard cubic meter/min) of natural gas. Storage of CNG shall be prohibited.

Exception: CNG shall be permitted to be stored in the vehicle fuel supply container.

7.1.2 This chapter applies to the design, construction, installation, and operation of an RFF as defined in 7.1.1.

7.2 System Component Qualifications.

7.2.1 System components not part of a listed fueling appliance shall comply with the appropriate provisions in Chapter 4.

7.2.2* Fueling appliances shall be listed.

7.2.3 VFAs shall be exempt from the requirements of Sections 4.5 through 4.9, 6.2 through 6.4, 6.6, and 6.8 through 6.16.

7.3 General.

7.3.1 All equipment related to RFF installation shall be protected to minimize the possibility of physical damage and vandalism. This requirement shall be permitted to be met by the use of an enclosure for the compressor package, similar to that of a central air conditioner.

7.3.2 All equipment related to RFF installation shall be designed for the pressure, temperature, and service expected.

7.3.3 Vehicles shall be considered as unclassified electrically with respect to NFPA 70, *National Electrical Code*, Article 500.

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

7.3.4 Natural gas shall not be vented to the atmosphere under normal operation.

Exception: Leakage of 1.0 standard in.^{3} (1.64×10^{-2} standard mm^3) of gas shall be permitted to be released to the atmosphere per filling during disconnection of the fueling hose.

7.3.5 Unless specifically permitted by the installation instructions, multiple VFAs shall not be manifolded together on the discharge side.

7.3.6 Where more than one VFA is located in a common area, spacing between the VFAs shall not be less than 3 ft (1 m) unless permitted by the installation instructions.

7.4 Installation.

7.4.1 General.

7.4.1.1 CNG compression and dispensing shall be located and conducted outdoors wherever practical. However, where not practical (e.g., where inclement weather is common), compression and dispensing shall be permitted to be located indoors.

7.4.1.2 All RFF equipment shall be installed in accordance with the equipment manufacturer's instructions.

7.4.1.3 The RFF shall have a nameplate marked with minimum and maximum gas inlet pressure and flow rate, gas outlet maximum pressure, and electrical requirements.

7.4.2 Indoor Installations.

7.4.2.1 Where it is necessary to install the compression unit and refueling connections indoors, the compression unit shall be mounted or otherwise located such that the compression unit is vented outdoors.

7.4.2.2 Where the RFF or the vehicle being fueled is located indoors, a gas detector set to operate at one-fifth the lower limit of flammability of natural gas shall be installed in the room. The detector shall be located within 6 in. (150 mm) of the ceiling or the highest point in the room. The detector shall stop the compressor and operate an audible or a visual alarm.

7.4.3 Outdoor Installations. The RFF shall be installed on a firm, noncombustible support to prevent undue stress on piping and conduit.

7.5 Installation of Pressure Relief Valves. Pressure relief valves shall have pressure relief device vents or vent lines 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).

7.6 Installation of Pressure Gauges. For measurement and test purposes, pressure gauges shall be permitted to be installed but shall not be required.

7.7 Pressure Regulation. An RFF shall be equipped to stop fuel flow automatically when the container(s) reaches the temperature-corrected fill pressure.

7.8 Piping and Hose.

7.8.1 All piping and hose from the outlet of the compressor shall be supplied as part of the RFF.

7.8.2 All gas piping to the RFF shall be installed in accordance with NFPA 54, *National Fuel Gas Code*.

7.8.3 The use of hose in an installation shall be restricted to the following:

(1) A fueling hose that shall be limited to a maximum length of 25 ft (7.6 m) and shall be supported above the floor/ground level or otherwise protected from mechanical damage from abrasion and being driven over by a vehicle
(2) A maximum of 3 ft (1 m) in length where used to prevent abrasion damage resulting from vibration on the inlet or outlet, or both

7.8.4 Transfer systems shall be capable of depressurizing to facilitate disconnection. Bleed connections shall lead to a safe point of discharge.

7.9 Testing. All piping and tubing shall be tested after assembly to be proven free of leaks at a pressure equal to the maximum service pressure of that portion of the system.

7.10 Installation of Emergency Shutdown Equipment.

7.10.1 An RFF shall be equipped with emergency manual shutdown of the gas supply and electric power. The emergency electrical switch shall be at least 5 ft (1.5 m) from the RFF and in view of the RFF.

7.10.2 Breakaway protection shall be provided in a manner so that, in the event of a pullaway, natural gas ceases to flow.

7.10.3 A breakaway device shall be installed at every dispensing point. Such a device shall be arranged to separate using a force not greater than 150 lb (68 kg) when applied in any horizontal direction.

7.11 Operation.

7.11.1 An RFF shall be operated in accordance with the manufacturer's instructions.

7.11.2 A fuel supply container shall not be charged in excess of its maximum allowable service pressure at normal temperature. DOT and TC containers shall be charged in accordance with DOT and TC regulations.

7.11.3 Where CNG is being transferred to a motor vehicle, the engine shall be stopped.

7.12 Maintenance and Inspection.

7.12.1 All RFF equipment shall be inspected and maintained in accordance with the manufacturer's instructions.

7.12.2 After installation, all hose shall be examined visually as part of this inspection. Hose that are kinked or worn shall be replaced.

7.12.3 All safety relief valves shall be maintained in proper operating condition in accordance with the manufacturer's/supplier's recommendation.

Chapter 8 Commercial Marine Vessels and Pleasure Craft

8.1 Scope. This chapter shall apply to all commercial marine vessels and pleasure craft operating on CNG, including new and retrofit construction.

8.2 Modifications to NFPA 52, *Compressed Natural Gas (CNG) Vehicular Fuel Systems Code*.

8.2.1 Chapters 3, 4, 6, and 7 of this code shall apply to commercial marine vessels and pleasure craft operating on compressed natural gas with the exception of subsections 6.14.5, 6.14.6, and 6.14.10.

8.2.2 The following subsections from Chapter 5 of this code shall apply to commercial marine vessels and pleasure craft operating on compressed natural gas: 5.4.1, 5.4.2, 5.4.4, 5.5.1 through 5.5.9, 5.6.1 through 5.6.5, 5.7.3, 5.8.1 through 5.8.3, 5.9.1, 5.9.2, 5.10.1, 5.10.2, 5.11.1, 5.12.1 through 5.12.6, and 5.13.1 through 5.13.4.

8.2.3 The following paragraphs shall apply only to commercial marine vessels and pleasure craft operating on compressed natural gas.

8.2.3.1 Installation of Fuel Supply Containers.

8.2.3.1.1 Fuel supply containers on marine vessels shall be permitted to be located on the weather deck above accommodation and service space or below deck adjacent to accommodation and service space, provided all connections to the containers are external to or sealed and vented from these spaces.

8.2.3.1.1.1 Containers on the weather deck shall be protected with a housing to prevent damage that can occur due to loading, unloading, direct sunlight, and the general use of the vessel. The housing shall be installed in such a way that contact of the housing with the container and entrapment of materials that could damage the container or its coating are prevented. The shelter for storing the containers on the weather deck shall be an enclosure constructed of noncombustible or

limited-combustible materials that has at least one side predominantly open, facing outboard, and a roof designed for ventilation and dispersal of escaped gas.

8.2.3.1.2 Each fuel supply container shall be mounted in a location to minimize damage from collision. No part of a container or its appurtenances on the weather deck shall protrude beyond the sides or top of the vessel at the point where it is installed.

8.2.3.1.3 No portion of a fuel supply container or container appurtenances shall protrude beyond the bow or the stern of the vessel. Container valves shall be protected from physical damage using the vessel structure, valve protectors, or a suitable metal shield.

8.2.3.1.4 Each container rack shall be secured to the vessel frame, either above or below or both, using a method capable of withstanding a static force in the six principal directions to prevent damage from slippage, loosening, or rotation directions *(see Figure 5.3.4)* of four times the weight of the fully pressurized container.

8.2.3.1.5 Each fuel supply container in the rack shall be secured to its cradle in such a manner that it is capable of withstanding a static force applied in the six principal directions *(see Figure 5.3.4)* of four times the weight of the fully pressurized container with a maximum displacement of 0.5 in. (13 mm).

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

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

8.2.3.1.8 The mounting system shall minimize fretting corrosion between the container and the mounting system.

8.2.3.1.9 Fuel supply containers shall not be installed so as to adversely affect the balance of the marine vessel.

8.2.3.1.10 Metal clamping bands and their supports shall not be in direct contact with a container. A resilient gasket that does not retain water shall be installed between the clamping bands and their supports and the container.

8.2.3.1.11 Where located in a below-deck tank room or tank compartment that is capable of accumulating natural gas, a container shall be installed so that the pressure relief device for the protection of the container is installed in the same space as the container and the discharge from the pressure relief device meets the following requirements:

(1) It is vented to the outside through a metallic tube (vent mast) or hose no smaller than the outlet diameter of the relief device, secured at 12-in. (300-mm) intervals where the tube exceeds 24 in. (610 mm) in length, and has a minimum burst pressure of at least 1.5 times the service pressure of the container at 400°F (204°C).
(2) It is located so that the vent opening is not blocked by debris or otherwise affected by the elements.

8.2.3.2 Installation of Pressure Gauges.

8.2.3.2.1 A pressure gauge located within the wheelhouse (bridge) or accommodation or service space shall be installed in such a manner that no gas flows through the gauge in the event of failure.

8.2.3.2.2 A pressure gauge installed in the engine compartment, fuel container compartment, or other gas-dangerous space shall be equipped with a limiting orifice, a shatter-proof dial lens, and a body relief.

8.2.3.3 Labeling. Each marine vessel or pleasure craft shall be identified with weather-resistant, diamond-shaped labels located on an exterior vertical surface or near-vertical surface, at a location, as near to eye level as possible, where the vessel is routinely boarded, both port and starboard. Depending on the size of the vessel, other labels shall be placed at logical locations to alert persons not familiar with the vessel, such as fire fighters or service personnel, about the nature of the vessel. The label shall be a minimum of 4¾ in. long by 3¾ in. high (120 mm by 83 mm). The marking shall consist of a border with the letters CNG, a minimum of 1 in. (25 mm) high, shown in silver or white reflective luminous material on a blue background.

8.2.3.4 Operation.

8.2.3.4.1 Where CNG is being transferred to or from a marine vessel, the engines shall be turned off.

Exception: It shall be permitted to operate the engine when it is necessary to hold the vessel in position while refueling or when, in the opinion of the master, the safety of the vessel is at issue. The master shall also be permitted to elect to operate generators during refueling.

8.2.3.4.2 A warning sign with the words "STOP ENGINES, NO SMOKING, FLAMMABLE GAS" shall be posted at dispensing stations and compressor areas where it is possible to secure a vessel to a dock or anchor buoys. Otherwise, a sign shall be posted with the words "NO SMOKING, FLAMMABLE GAS." The location of signs shall be determined by local conditions, but the lettering shall be large enough to be visible and legible from each point of transfer.

8.3 Fire Protection for Vessels.

8.3.1 Fire protection for vessels shall be in accordance with NFPA 302, *Fire Protection Standard for Pleasure and Commercial Motor Craft,* except for the following.

8.3.1.1* Installation of Powered Ventilation.

8.3.1.1.1 Blower(s) capacity shall be selected in accordance with the blower capacity curve in Figure 2.5.2.3 of NFPA 302, *Fire Protection Standard for Pleasure and Commercial Motor Craft.* More than one blower shall be permitted.

8.3.1.1.2 As installed, the blower system(s) shall exhaust air from the boat at a rate in accordance with the system performance curve in Figure 2.5.2.3 of NFPA 302, *Fire Protection Standard for Pleasure and Commercial Motor Craft*, when the engine is not operating and the blower is operating at the electrical system's nominal voltage.

8.3.1.1.3 Blowers shall be mounted above the normal level of accumulated bilge water.

Exception: Submersible blower motors.

8.3.1.1.4 Blowers shall be installed with ducts having intake openings that are as follows:

(1) Permanently secured
(2) Located in the upper one-third of the compartment
(3) Located above the normal level of accumulated bilge water
(4) Located as near below the engine(s) that they serve as practicable

8.3.1.1.5 Electrical wiring shall be installed in accordance with Chapter 7 or Chapter 8 of NFPA 302, *Fire Protection Standard for Pleasure and Commercial Motor Craft.*

8.3.1.1.6 Each boat that requires a powered ventilation system shall display a warning label that provides the information that follows, located in plain view of the operator, and located as close as practicable to each ignition switch (including auxiliary equipment). The powered ventilation label shall read as follows:

WARNING
Gas Can Explode
Before Starting Engine:
1. Check Engine Compartment for Gasoline, Gas, or Vapors
2. Operate Blower for 4 Minutes

8.3.1.2* Exhaust systems shall conform to the following:

(1) Be gastight to hull interiors
(2) Have all connections accessible
(3) Be supported to minimize failure from vibration, shock, expansion, and contraction
(4) Have no threaded fittings into nonmetallic exhaust system components
(5) Have no discharge from other devices into the exhaust

Exception: Engine-cooling water or exhaust-cooling water.

8.3.2 NFPA 52 shall have precedence over the requirements of NFPA 302, *Fire Protection Standard for Pleasure and Commercial Motor Craft*, as they relate to the use of compressed natural gas.

8.4 Fire Protection for Marinas and Boatyards.

8.4.1 Fire protection for marinas and boatyards shall be in accordance with NFPA 303, *Fire Protection Standard for Marinas and Boatyards,* except for the following.

8.4.1.1* Storage and Handling of Fuels.

8.4.1.1.1 The fueling station shall be located to minimize the exposure of all other plant facilities. All fueling stations shall be accessible by boat without entering or passing through the main berthing area.

Exception: Where inside fueling stations are made necessary by prevailing sea conditions (wake, surge, tide, etc.), such stations shall be located near an exit by water from the berthing area or at some other location from which, in case of fire aboard a boat alongside, the stricken craft can be quickly removed without endangering other boats nearby.

8.4.1.1.2 All boat fueling operations shall be carefully accomplished in accordance with NFPA 302, *Fire Protection Standard for Pleasure and Commercial Motor Craft,* and this code, at the fueling station or other specifically designated remote location.

8.4.1.1.3 No tank barge or other fuel supply boat shall be permitted within the berthing area. Outside berths and connections shall be provided for the use of tank barges or fuel supply boats.

8.4.1.1.4 Fuel storage tanks shall be installed in accordance with NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages,* and this code.

8.4.1.1.5 Fuel storage tanks shall be securely anchored where they are located subject to flooding or tidal conditions, and the applicable precautions outlined in Chapter 2 of NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages,* shall be observed.

8.4.1.1.6 Fuel storage tanks and pumps, other than those integral to approved dispensing units supplying gasoline or Class I or Class II flammable liquids at marine service stations, shall be located only on shore or, with the express permission of the authority having jurisdiction, on a pier of solid-fill type. Approved dispensing units with or without integral pumps shall be permitted to be located on shore, on piers of solid-fill type, or on open piers, wharves, or floating piers.

8.4.1.1.7 Tanks and pumps supplying diesel Class III flammable liquids at marine service stations shall be permitted to be located on shore, on piers of solid-fill type, or on open piers, wharves, or floating piers. Class III flammable liquid tanks that are located other than on shore or on piers of the solid-fill type shall be limited to 550 gal (2.08 m^3) aggregate capacity. Pumps not a part of the dispensing unit shall be located adjacent to the tanks.

8.4.1.1.8 Fuel pipelines shall be installed in accordance with the provisions of NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages.*

8.4.1.1.9 Dispensing units for transferring fuels from storage tanks shall be in accordance with the provisions of NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages*, and this code. Gasoline delivery nozzles shall be equipped with a self-closing control valve that will shut off the flow of fuel when the operator's hand is removed from the nozzle. The use of any device to override this safety feature is prohibited. The nozzle shall be inspected daily for proper operation. Any nozzle that shows evidence of possible malfunction or leaking shall be removed from service. The use of any automatic nozzle with a latch-open device is prohibited for the delivery of gasoline. In the construction of the fuel hose assembly, provision shall be made so the fuel delivery nozzle is properly bonded to the shore electric grounding facilities as required in Section 5.6 of this code.

8.4.1.1.10 Gasoline and other flammable liquids stored in drums or cans shall be kept separate from other plant facilities and stored and dispensed in accordance with applicable requirements of NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages.*

8.4.1.1.11 Hand carriage of gasoline within the plant area shall be restricted to containers designed for carrying and storing such fuel. Open buckets, cans, or glass jars shall not be used.

8.5 Fuel Dispensing.

8.5.1* CNG dispensing shall be in accordance with NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages*, except for the following.

8.5.1.1 The design, fabrication, assembly, test, and inspection of the piping system shall be in accordance with NFPA 30, *Flammable and Combustible Liquids Code,* Chapter 3, and this code.

8.6 Engine Rooms or Engine Compartments.

8.6.1 Location of Fuel Lines in Engine Rooms and Engine Compartments. All fuel lines shall be mounted in the overhead to provide the shortest route for leaking gas to flow to the exterior.

8.6.2 Fuel Line Pressure. The pressure in the fuel lines passing through the engine room or engine compartment shall not exceed the pressure required to operate the engines.

8.6.3 Pressure Regulators. All pressure regulators, except those mounted on the engine(s), shall be located in the tank room or compartment.

8.6.4 Ventilation.

8.6.4.1 Engine rooms or compartments shall be provided with positive pressure and passive ventilation. Positive pressure ventilation shall provide a minimum of 30 volumetric exchanges per hour.

8.6.4.2 The ventilation system shall be capable of handling a combustible mixture, if necessary. The ventilation fans shall take air from the weather deck and discharge it back to the weather deck through ducts that shall have a maximum separation from the fans. Multiple discharge ducts shall be used if practical to enhance ventilation.

8.6.4.3 If engine combustion air is taken from the engine room or engine compartment, the 30 air exchanges per hour shall be in excess of the maximum air volume per hour required by the engines.

8.6.5 Engines.

8.6.5.1 Since compressed natural gas engines have a natural gas atmosphere in the crankcase, they shall be provided with blowout plugs to relieve pressure in the event of a crankcase explosion. Blowout plugs shall be located so as to limit risk to the crew.

8.6.5.2 Engines shall be permitted to be located on the weather deck.

8.6.5.3 Engines located on the weather deck shall be protected with a housing to prevent damage that can occur due to loading, unloading, or the general use of the vessel.

8.6.5.4 A shelter for an engine installed on the weather deck shall be an enclosure that is constructed of noncombustible or limited-combustible materials and that has at least one side predominantly open, facing outboard, and a roof designed for dispersal of escaped gas.

8.6.5.5 An engine or engines on the weather deck shall be mounted in a location that shall ensure minimum damage from collision. No part of an engine or its appurtenances shall protrude beyond the sides or top of the vessel at the point where it is installed.

8.6.5.6 No portion of an engine on the weather deck shall protrude beyond the bow or stern of the vessel.

8.6.6 Natural Gas Monitoring.

8.6.6.1 Engine Rooms.

8.6.6.1.1 Engine rooms shall have at least two natural gas detectors placed in the overhead at the fore and aft locations.

8.6.6.1.2 Monitoring stations shall be located in the engine room, in the wheelhouse (bridge), and in an accommodation or service space, such as a galley, where crew members are likely to congregate.

8.6.6.1.3 When no gas is detected, the monitoring stations shall show a green light.

8.6.6.1.4 At one-tenth of the lower flammable level (LFL) of the concentration, power ventilation shall activate simultaneously with a flashing yellow light accompanied by a Klaxon™ at each monitoring station.

8.6.6.1.5 When the monitoring system detects a concentration that is one-fifth of the LFL, a flashing red light accompanied by a siren shall activate at each monitoring station. When the one-fifth LFL is detected and the alarm system activated, an emergency fuel shutoff shall be activated simultaneously, which will terminate the flow of natural gas to the engine room.

8.6.6.1.6 A manual override switch shall be mounted in the engine room so that the crew can turn off the alarm and restore natural gas to the engines in the event of a false alarm or other contingency.

8.6.6.1.7 When the compressed natural gas fuel supply is shut down due to loss of ventilation or detection of gas, the master shall ensure that the compressed natural gas fuel supply is not used until the leak or other cause of the shutdown is found and corrected.

8.6.6.2 Engine Compartments. Engine compartments shall be equipped with a natural gas detection and shutoff system as required for engine rooms, except that a monitoring station shall be placed only at the wheelhouse (bridge). If the vessel is large enough, however, and the alarm cannot be heard if no one is manning the wheelhouse (bridge), the equipment shall also be placed in accommodation or service space.

8.6.7 Fire Equipment and Systems.

8.6.7.1 Compressed natural gas-powered marine vessels of all sizes shall carry fire equipment and systems that are required by the U.S. Coast Guard.

8.6.7.2 In addition, engine rooms and engine compartments shall have a 150°F (66°C) thermal switch that shall activate fire-fighting equipment. When the thermal switch is activated, a flashing red light and an audible alarm shall activate in the engine room wheelhouse (bridge) and other accommodation space or service space where crew are likely to congregate, such as a galley, signaling the possible presence of a fire.

8.6.7.3 There shall be a 1-minute time delay, after which the engine room or compartment shall be flooded with CO_2 or other USCG-approved inert gas for 2 minutes. Simultaneously, the ventilation fans shall be cut off for 2 minutes and then reactivated. Sufficient CO_2 or other USCG-approved inert gas shall be provided for two cycles.

8.6.7.4 A manual override switch shall be provided in the engine room or near the engine compartment to allow termination of the response in the event of false alarm or other contingency.

8.6.7.5 Controls shall be provided to allow manual activation of the CO_2 system without a delay.

8.7 Tank Rooms or Compartments.

8.7.1 Tank rooms and tank compartments shall be airtight as well as watertight with appropriate fittings used to seal penetrations through the bulkheads for wire or pipes passing through the tank rooms.

8.7.2 The tank rooms shall be provided with positive pressure and passive ventilation.

8.7.3 Ventilation of the tank rooms (compartments) shall be provided at 30 exchanges per hour minimum.

8.7.4 Air shall be taken from the weather deck and discharged back to the weather deck through ducts that have a maximum separation from the fans.

8.7.5 The fans shall be capable of handling a combustible mixture, if necessary.

8.7.6 Multiple discharge ducts shall be used if practical to enhance ventilation.

8.7.7 Natural Gas Monitoring.

8.7.7.1 Tank rooms or compartments shall have at least two natural gas sensors placed at or near the ceiling at fore and aft locations.

8.7.7.2 When no gas is detected, the monitoring stations shall show a green light.

8.7.7.3 Two levels of alarm shall be used for signaling the need for intervention.

8.7.7.4 An alarm shall activate when one-tenth of the LFL is detected by a monitor. A flashing yellow light and a Klaxon™ shall be activated in the engine room and in the wheelhouse (bridge), as well as in an accommodation or service space (such as a galley) where crew are likely to congregate. Simultaneously, power ventilation shall activate. On vessels with a tank compartment, a flashing yellow light and an audible signal shall activate in the wheelhouse (bridge). If the vessel is large enough that the alarm cannot be heard if no one is manning the wheelhouse (bridge), a second warning station shall activate in an accommodation or service space where crew are likely to congregate.

8.7.7.5 At one-fifth of LFL, a second alarm shall activate utilizing a flashing red light and a siren. These monitoring stations shall be placed in the same locations as the monitoring stations for the one-tenth LFL. When the one-fifth LFL warning is activated, an automatic fuel shutoff valve shall terminate flow of natural gas from the tank room or compartment, ventilation shall terminate, CO_2 shall flood the tank room, and a water deluge system shall be activated.

8.7.7.6 A tank compartment shall not be permitted to have a deluge system if a vessel is too small to accommodate the equipment. The judgment shall be made by the authority having jurisdiction.

8.7.7.7 When the compressed natural gas fuel supply is shut down due to loss of ventilation or detection of gas, the master shall ensure that the compressed natural gas fuel supply is not used until the leak or other cause of the shutdown is found and corrected.

8.7.8 Tank rooms and compartments shall have manual drains that remove the water produced by the deluge system.

8.7.9 A labeled override switch shall be available in a readily accessible location in order to turn off the tank room or compartment warning system in the event of a false alarm or other contingency and to shut down the CO_2 or other USCG-approved inert gas and deluge system.

8.7.10 Fire-Fighting Equipment.

8.7.10.1 Tank rooms and compartments shall have a 150°F (66°C) thermal switch that will activate automatic fire-fighting equipment.

8.7.10.2 When the switch is activated, a red flashing light and an audible alarm shall activate on a fire alarm panel in the wheelhouse (bridge) and in an accommodation or service space (such as a galley) where crew are likely to congregate.

8.7.10.3 Since the tank rooms or compartments are unmanned spaces, alarms shall not be required in those spaces.

8.7.10.4 Ventilation in the tank rooms or compartments shall be terminated simultaneously with the activation of the fire alarm. One minute after the fire alarm is activated, the tank room or compartment shall be flooded with CO_2 or other USCG-approved inert gas, and a deluge system shall activate to keep the compressed natural gas cylinders cool and to assist in terminating fire.

8.7.10.5 The tank room or compartment shall be provided with a readily accessible override switch that will allow the crew to terminate the fire-fighting system in the event of a false alarm or other contingency.

8.7.10.6 A deluge system shall be permitted to be omitted from tank compartments on vessels that are too small to accommodate them. This determination shall be made by the authority having jurisdiction.

8.7.11 Lighting.

8.7.11.1 Tank rooms shall have at least two explosionproof lighting fixtures.

8.7.11.2 Switches and overcurrent protective devices for lighting in the tank room(s) shall be in a gas-safe space.

8.8 Vent Masts.

8.8.1 All crankcases on natural gas-powered engines shall be vented to a vent mast. Vessels having more than one engine shall be permitted to utilize a manifold.

8.8.2 Relief valves or common vent headers from relief valves shall discharge to a vent mast.

8.8.3 Vent masts shall meet the following requirements:

(1) Discharge vertically upward
(2) Have a rain cap or other means of preventing the entrance of rain or snow
(3) Extend to at least a height of 10 ft (3 m) above the highest working level on the vessel

8.8.4 Relief valve vent masts and engine ventilation vent masts shall not be connected, but they shall be permitted to terminate at the same location.

8.9 Deluge Systems.

8.9.1 Each deluge system that protects more than one area shall have at least one isolation valve at each branch connection and at least one isolation valve downstream from each branch connection to isolate damaged sections.

8.9.2 Each valved cross-connection from the deluge system to the fire main shall be located outside of the tank room or compartment.

8.9.3 Each pipe, fitting, and valve for the deluge system shall be made of fire-resistant and corrosion-resistant materials such as galvanized steel or galvanized iron pipe.

8.9.4 Each deluge system shall have a means of drainage in order to prevent corrosion of the system and freezing of the accumulated water in subfreezing temperatures.

8.9.5 Each deluge system shall have a dirt strainer that is located at the deluge system manifold or pump.

8.9.6 Water to the deluge system shall be supplied by a pump that is only for the use of the system.

8.10 Alarm Systems.

8.10.1 The gas detection alarm systems shall have a means of indicating which natural gas sensor has been activated.

8.10.2 The fire alarm systems shall have a means of indicating which thermal switch has been activated.

8.10.3 Each audible alarm shall be arranged so that it can be turned off after sounding. For a remote group alarm, this arrangement shall not interrupt the alarm's actuation by other faults.

8.10.4 Each visual alarm shall be one that can be turned off only after the fault that actuated it is corrected.

8.10.5 Each vessel shall have means for testing each alarm.

8.10.6 Gas-safe spaces adjacent to gas-dangerous spaces, such as engine rooms and tank compartments, shall have positive pressure ventilation systems capable of 30 exchanges an hour. Their ventilation shall activate whenever an alarm is activated.

8.11 Safety Equipment.

8.11.1 Marine vessels with tank rooms and engine rooms shall have the following features:

(1) Three self-contained, pressure-demand-type, air-breathing apparatus approved by the Mining Enforcement and Safety Administration (MESA) or the National Institute for Occupational Safety and Health (NIOSH), each having at least a 30-minute capacity
(2) Three spare bottles of air for the self-contained air-breathing apparatus, each having at least a 30-minute capacity
(3) Three explosionproof flashlights
(4) Three helmets that meet the safety requirements for industrial head protection, ANSI Z89.1, *Personnel Protection — Protective Headgear for Industrial Workers — Requirements*
(5) Three sets of goggles that meet the specification ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protection*
(6) An air compressor to recharge the bottles for the air-breathing apparatus
(7) Portable hand-held natural gas detectors that shall be provided to aid in evaluating alarms and for making a survey of the vessel. These instruments shall allow locating specific leaks at very low levels of detection and shall be carried by personnel working in a compartment containing gas storage or transmission equipment. A vessel with a tank room shall have at least two of these sensors.

8.11.2 Vessels having engine rooms and tank rooms shall have a portable analyzer that measures oxygen levels in an inert atmosphere.

8.11.3 Before allowing anyone to enter a space that has had a gas leak that has been repaired, the master shall ensure that the space has an oxygen concentration of at least 19.5 percent oxygen by volume and is free of natural gas.

8.11.4 The master shall ensure that the compressed air-breathing equipment is inspected at least once a month by a licensed officer and that the date of inspection and the condition of the equipment are placed in the vessel's log.

8.12 Safety Training.

8.12.1 A written safety guide for the vessel and for the safety equipment and procedures shall be provided. The manual shall outline all safety systems and equipment and their operation.

8.12.2 Crews shall be trained to operate the compressed natural gas–powered vessel and to perform repairs.

8.12.3 Training drills shall be conducted monthly.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1 *Properties of CNG.* Natural gas is a flammable gas. It is colorless, tasteless, and nontoxic. It is a light gas, weighing about two-thirds as much as air. As used in the systems covered by this standard, it tends to rise and diffuses rapidly in air when it escapes from the system.

Natural gas burns in air with a luminous flame. At atmospheric pressure, the ignition temperature of natural gas–air mixtures has been reported to be as low as 900°F (482°C). The flammable limits of natural gas–air mixtures at atmospheric pressure are about 5 percent to 15 percent by volume natural gas.

Natural gas is nontoxic but can cause anoxia (asphyxiation) when it displaces the normal 21 percent oxygen in air in a confined area without adequate ventilation.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as

listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.8 Dew Point (at Container Pressure). Where stating or referencing dew point, the value is given in terms of the container pressure [e.g., –4°F (–20°C) dew point at 3600 psi (24.8 MPa)].

A.3.3.14 Installation. Where filling containers or transferring natural gas directly from distribution lines by means of a compressor, an installation includes the compressor and all piping and piping components beyond the shutoff valve between the distribution system and the compressor.

A.3.3.16 Limited-Combustible Material. For further information, see NFPA 259, *Standard Test Method for Potential Heat of Building Materials*.

A.3.3.23.1 Fill Pressure. Fill pressure varies according to the gas temperatures in the container, which are dependent on the charging parameters and the ambient conditions.

A.4.1 *Vehicle Fuel Systems.* A typical vehicle fuel system consists of one or more fuel supply containers (if more than one, the containers are manifolded together) holding CNG at high pressure and fitted with the following:

(1) Pressure relief devices and manual shutoff valves
(2) A filling connection with a check valve to prevent gas from flowing back out of the connection
(3) A manual valve downstream from the container valve or valves
(4) A valve that automatically closes if the engine stops for any reason
(5) A pressure regulator to reduce the fuel supply container pressure to a low engine service pressure
(6) A gas–air mixer to produce a flammable mixture
(7) A pressure gauge to indicate the fuel supply container pressure

Systems are designed to operate at fuel supply container pressures of 2400 psi, 3000 psi, or 3600 psi (16.5 MPa, 20.6 MPa, or 25 MPa). Fueling connections are designed to accommodate compatible filling nozzles suitable only for the proper pressure.

Fuel supply containers are installed on either the outside of the vehicle or the inside of the vehicle. If inside, all connections to the containers are either external to a driver or passenger compartment or inside a compartment that is gastight with respect to a driver or passenger compartment. The compartment is vented to the outside of the vehicle. *(See Figure A.4.1.)*

A.4.2 For additional information on gas quality, see SAE J1616, *Recommended Practice for Compressed Natural Gas Vehicle Fuel*, and CGSB 3.513, *Natural Base for Vehicles*.

A.4.4 *Container Capacity.* Containers are described by their liquid capacity and their design and allowable service pressures. The liquid capacity [ft^3 (m^3) of water] is the volume of liquid that is required to fill the container. The gas storage capacity can be calculated from the liquid capacity and allowable service pressure.

The amount of gas stored in a container can be estimated by using the information in Table A.4.4 referenced to 70°F (21°C). The gas quantity, in standard cubic feet (Scf), can be estimated by multiplying the container water capacity [standard ft^3 (m^3)] by the stored volume [Scf/ft^3 (standard m^3/m^3)] factor at a given pressure. One Scf of natural gas weighs approximately 0.0456 lb (0.0207 kg) and has an energy content of about 930 Btu (2725 W) (on a lower heating value basis).

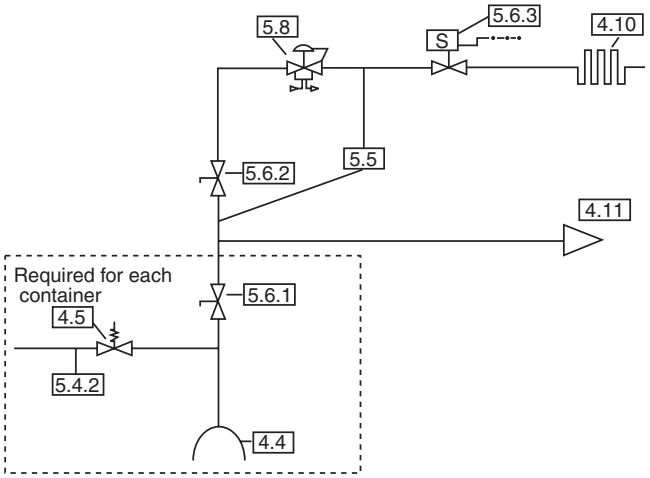

FIGURE A.4.1 Typical Vehicular Fuel System Components.

Table A.4.4 Natural Gas Storage Volume

Pressure		Stored Volume Ratio
psi	kPa	(volume/volume)
200	1.38	15
400	2.76	29
600	4.14	45
800	5.52	61
1000	6.89	78
1200	8.27	96
1400	9.65	114
1600	11.03	133
1800	12.41	152
2000	13.79	171
2200	15.17	189
2400	16.95	206
2600	17.93	223
2800	19.31	238
3000	20.68	252
3200	22.06	265
3400	23.44	278
3600	24.82	289
3800	26.20	299
4000	27.58	309
4200	28.96	318
4400	30.37	327
4600	31.72	335
4800	33.09	342
5000	34.47	349

Note: The above values may differ slightly for different gas compositions.

A.4.4.4 Current DOT and TC specifications, exemptions, and specified permits do not address the use of cylinders that are approved for the transportation of natural gas to be used in CNG service.

• The following Compressed Gas Association publications are four relevant cylinder inspection standards:

(1) CGA C-6, *Standards for Visual Inspection of Steel Compressed Gas Cylinders*
(2) CGA C-6.1, *Standards for Visual Inspection of High Pressure Aluminum Compressed Gas Cylinders*
(3) CGA C-6.2, *Guidelines for Visual Inspection and Requalification of Fiber Reinforced High Pressure Cylinders*
(4) CGA C-10, *Recommended Procedures for Changes of Gas Service for Compressed Gas Cylinders*

A.5.1 *Fueling Systems.* A typical fueling system consists of one or more compressors taking suction from a natural gas transmission or distribution pipeline or a building piping system connected to a transmission or distribution pipeline with the compressor discharging into either one or more storage containers or to a dispensing system along with a dispensing system consisting of a hose and nozzle and, sometimes, a meter. Where a storage container is present, it discharges to a dispensing system.

Where storage containers are used, the system is known as a *fast-fill* system with a vehicle-filling time of about 3–5 minutes. Where storage containers are not used, the system is known as a *slow-fill* system with filling times that can last several hours.

The suction pressure for compressors ranges from approximately 2–500 psi (13.7 kPa to 3.4 MPa), with the suction pressure for most compressors under 60 psi (40 kPa). The delivery pressure is more than the vehicle system pressure but less than 5000 psi (35 MPa), with most at approximately 3600 psi (25 MPa).

CNG is stored in two types of storage systems: bulk storage and cascade storage. They differ in the manner in which the CNG is withdrawn.

A.5.4 *Natural Gas Vehicles Best Practices Manual* gives information on how to prevent blockages in the vent line.

A.5.4.1 It is not permitted to terminate the vent outlet in the engine compartment.

A.5.6.5 Electronic fuel injectors are considered to be automatic valves.

A.5.12.4 The following practices should be followed.

(1) Before a CNG vehicle is returned to service following an accident that caused damage or dislocation to the CNG fuel system, or following the repair or replacement of any part of a CNG fuel system that is subject to container pressure, the system should be tested in accordance with Section 5.12.
(2) Prior to maintenance or repair of a CNG fuel system, the following should be performed:
    (a) Before commencing the work, the supply of CNG should be shut off by closing the shutoff valves and operating the engine until the engine stops running, and it should be ensured that the valves remain shut off throughout the inoperative period.
    (b) CNG should be vented outdoors to a safe location and should not be vented indoors.
    (c) Upon completion of the work, the CNG fuel system should be leak tested in accordance with the requirements of Section 5.12.
(3) Prior to making repairs to gasoline-related equipment on a CNG vehicle, other than to the CNG fuel system, the following should be performed:
    (a) Prior to removal of the natural gas mixer, the supply of CNG should be shut off by closing the shutoff valves and operating the engine until the engine stops running, and it should be ensured that the valves remain off throughout the inoperative period.
    (b) Upon completion of the work, the natural gas mixer should be placed in its original location without any change or adjustment before the CNG shutoff valves are reopened.
(4) Prior to making collision repairs on a CNG vehicle, other than to the CNG fuel system, the following should be performed:
    (a) The shutoff valve at the outlet of the CNG container should be closed before commencing the work, and it should be ensured that the valve remains off throughout the inoperative period.
    (b) The CNG vehicle owner or operator should be instructed to take the vehicle to a vehicle conversion center for inspection of the CNG fuel system before the shutoff valve described in A.5.12.4(4)(a) is reopened.

A.6.1 Bulk storage of CNG can be accomplished using one large container or a number of smaller containers manifolded together. As vehicles draw CNG from bulk storage, all containers draw down (reduce in pressure) at the same rate.

Bulk storage provides less "available" CNG storage than the cascade system.

Storage containers arranged in a cascade can provide more "available" CNG storage than a bulk system for the same size containers. A brief description of the operation of a typical cascade system is as follows.

A cascade is usually arranged in at least three banks of containers with the containers in any one bank manifolded together so that each bank acts as one large container. The banks are separated by automatic switching valves. The valve sequencing is controlled automatically by a sequencing control panel.

The cascade banks are initially filled with CNG in sequence by the compressor to the normal service pressure of the system. The highest pressure bank is refilled first (bank 1), followed by successively lower pressure banks (bank 2, bank 3, etc.). This sequence is called *priority fill*.

Vehicles can then be fueled from the cascade, beginning with bank 3 (for a three-bank cascade).

If there is insufficient CNG in bank 3 to pressurize the vehicle fuel supply container(s), bank 3 is valved off and bank 2 "tops up" the vehicle container(s). Successive vehicles draw from banks 3 and 2, as previously described, until bank 1 has to top up the vehicle container(s). When bank 1 pressure is reduced to a preset value, the compressor bypasses the cascade and fills the vehicle directly. At the completion of the last vehicle fill, the compressor continues running and refills the cascade by priority fill.

Cascade valving can be arranged to provide more available storage than the system described.

CNG can be produced from liquefied natural gas (LNG). LNG storage containers and equipment upstream of CNG containers are not covered by this standard. For information on LNG containers and equipment, see NFPA 57, *Liquefied Natural Gas (LNG) Vehicular Fuel Systems Code*.

A.6.3.3 Methanol injection systems are not an approved control device.