

NFPA® 52

Vehicular Natural Gas Fuel Systems Code

2023 Edition



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NFPA® 52

Vehicular Natural Gas Fuel Systems Code

2023 Edition

This edition of NFPA 52, *Vehicular Natural Gas Fuel Systems Code*, was prepared by the Technical Committee on Vehicular Alternative Fuel Systems. It was issued by the Standards Council on March 20, 2022, with an effective date of April 9, 2022, and supersedes all previous editions.

This edition of NFPA 52 was approved as an American National Standard on April 9, 2022.

Origin and Development of NFPA 52

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

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

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

The first edition of NFPA 52, *Standard for Compressed Natural Gas (CNG) Vehicular Fuel Systems*, was issued in 1984, and it was revised in 1988, 1992, 1995, and 1998.

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

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

The 2010 edition of NFPA 52 revised the committee scope so that it better coordinated with the responsibilities of NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, with regard to hydrogen storage systems. A large number of changes were also made to the chapters concerning hydrogen to update to current material in NFPA documents, the *Manual of Style for NFPA Technical Committee Documents*, and acceptable performance criteria.

Paragraphs extracted from NFPA 55 were shown with the extract reference in brackets [] at the end of the paragraph. In some cases, modifications were made to the extracted text to use terminology appropriate for this standard, such as the term *cryogenic fluid* instead of *compressed gas*. In those instances, brackets encased the modified terms.

The 2013 edition removed the requirements for hydrogen systems, the responsibility for which were transferred to NFPA 2, *Hydrogen Technologies Code*. A chapter on general fueling requirements was added, and changes were made to the onboard gas detection requirements for LNG-fueled vehicles. The installation requirements for ASME tanks for LNG were updated to coordinate with NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)*.

The 2016 edition was completely reorganized for easier access to requirements. The title of the document was changed from *Vehicular Gaseous Fuel Systems Code* to *Vehicular Natural Gas Fuel Systems*

Code to coordinate with the removal of hydrogen systems from the scope of the document in 2013. New and revised definitions harmonized the code with the new CSA Group NGV 5.1 standard, *Residential Fueling Appliances*. Most notably, a new definition for *residential fueling appliances* was added and the definition for *vehicle fueling appliances* was revised.

For the 2019 edition, text reorganization and additions were made to address vehicle fueling applications (VFAs). A new chapter was added for nonresidential CNG fueling applications. Several terms were added and updated to align with current definitions and VFA updates to the document. For example, the term *qualified engineer* was changed to *qualified person*, and the definition *contiguous building volume* was added to Chapter 3. Sections of the residential CNG fueling chapter were removed because they were part of the certification of appliances covered in CSA Group NGV 5.1, *Residential Fueling Appliances*.

For the 2023 edition, bulk plant requirements extracted from NFPA 59A have been revised and in most cases are no longer extracted, since these requirements commonly do not apply to NFPA 52 installations. To provide additional clarity throughout the document, *defueling* and *manifold* have been added as defined terms in Chapter 3. Container protection requirements in Chapter 8 also have been revised where the requirements referred to ASME containers that utilize pressure relief valves instead of pressure relief devices.

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

Committee Scope: This Committee shall have primary responsibility for documents on fire and explosion hazards associated with compressed natural gas (CNG), liquefied natural gas (LNG) engine fuel systems, 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 the Liquefied Natural Gas Committee with respect to storage of LNG within its scope.

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Vehicular Natural Gas Fuel Systems Code

2023 Edition

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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.

A reference in brackets [] following a section or paragraph indicates material that has been extracted from another NFPA document. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

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

Chapter 1 Administration

1.1* Scope.

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

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

1.1.2 This code shall apply to the design, installation, operation, and maintenance of LNG engine fuel systems on vehicles of all types, to their associated fueling (dispensing) facilities, and to LNG-to-CNG facilities with LNG storage in ASME containers of 100,000 gal (379 m³) or less.

1.1.3 This code shall not apply to those aspects of vehicles and fuel supply containers that are covered by federal motor vehicle safety standards (FMVSSs).

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

1.1.5 Where conflicts occur between provisions of this code and referenced codes and standards, the provisions of this code shall apply.

1.1.6 Where, in any specific case, different sections of this code specify different materials, methods, or other requirements, the most restrictive shall govern.

1.1.7 Where there is a conflict between a general requirement and a specific requirement, the specific requirement shall be applicable.

1.1.8 Manufacturer specifications shall equal or surpass the applicable requirements of this code.

1.2 Purpose. The purpose of this code shall be to provide fundamental safeguards against 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.

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

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

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

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

1.4 Alternate Provisions. Site conditions, advancements in technology, and improvements in system design and equipment shall be permitted to allow for equipment fabrication methods, component design requirements, and installation and operating practices that differ from those specified in this code.

1.4.1 Such deviations or improvements shall be permitted to provide equivalent safety and compatible operation that meet the intent of this code.

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

1.5 Training. Persons engaged in the handling and storage of LNG, CNG, and LCNG shall be trained in the hazards and properties of these materials.

1.6 Units.

1.6.1 Metric units in this code are based on IEEE/ASTM SI 10, *American National Standard for Metric Practice*.

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

1.7 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, Quincy, MA 02169-7471.

NFPA 10, *Standard for Portable Fire Extinguishers*, 2022 edition.
NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, 2020 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2021 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*, 2022 edition.

NFPA 16, *Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems*, 2019 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems*, 2021 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*, 2021 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*, 2019 edition.

NFPA 54, *National Fuel Gas Code*, 2021 edition.

NFPA 56, *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*, 2017 edition.

NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)*, 2022 edition.

NFPA 70®, *National Electrical Code®*, 2023 edition.

NFPA 72®, *National Fire Alarm and Signaling Code®*, 2022 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives*, 2022 edition.

NFPA 101®, *Life Safety Code®*, 2021 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, 2018 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment*, 2021 edition.

NFPA 1221, *Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems*, 2019 edition.

2.3 Other Publications.

2.3.1 ACI Publications. American Concrete Institute, 38800 Country Club Drive, Farmington Hills, MI 48331-3439.

ACI 376, *Code Requirements for Design and Construction of Concrete Structures for the Containment of Refrigerated Liquefied Gases and Commentary*, 2011.

2.3.2 AMPP Publications. Association for Materials Protection and Performance (formerly NACE International and SSPC), 15835 Park Ten Place, Houston, Texas 77084.

NACE SP0169, *Control of External Corrosion of Underground or Submerged Metallic Piping Systems*, 2013.

SSPC-PA 1, *Shop, Field and Maintenance Painting of Steel*, 2016.

SSPC-PA 2, *Determining Compliance to Required DFT*, 2018.

SSPC-SP 6/NACE No. 3, *Commercial Blast Cleaning*, reaffirmed 2006.

2.3.3 API Publications. American Petroleum Institute, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001-5571.

API 510, *Pressure Vessel Inspection Code: In-service Inspection, Rating, Repair, and Alteration*, 2018.

API 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*, 2013.

API RP 576, *Inspection of Pressure-Relieving Devices*, 2017.

2.3.4 ASCE Publications. American Society of Civil Engineers, 1801 Alexander Bell Drive, Reston, VA 20191-4400.

ASCE 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, 2016.

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

ANSI/ASME B31.3, *Process Piping*, 2018.

ASME Boiler and Pressure Vessel Code, 2019.

2.3.6 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM A47/A47M, *Standard Specification for Ferritic Malleable Iron Castings*, 1999, reaffirmed 2018e1.

ASTM A395/A395M, *Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*, 1999, reaffirmed 2018.

ASTM A536, *Standard Specification for Ductile Iron Castings*, 1984, reaffirmed 2019e1.

ASTM D8080, *Standard Specification for Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG) Used as a Motor Vehicle Fuel*, 2021.

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 2021a.

ASTM E136, *Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C*, 2019a.

ASTM E2652, *Standard Test Method for Assessing Combustibility of Materials Using a Tube Furnace with a Cone-shaped Airflow Stabilizer, at 750°C*, 2018.

ASTM E2965, *Standard Test Method for Determination of Low Levels of Heat Release Rate for Materials and Products Using an Oxygen Consumption Calorimeter*, 2017.

2.3.7 CGA Publications. Compressed Gas Association, 8484 Westpark Drive, Suite 220, McLean, VA 22102.

CGA 341, *Standard for Insulated Cargo Tank Specification for Nonflammable Cryogenic Liquids*, 2017.

CGA C-6.4, *Methods for External Visual Inspection of Natural Gas Vehicle (NGV) and Hydrogen Vehicle (HGV) Fuel Containers and Their Installations*, 2012, reaffirmed 2018.

CGA S-1.1, *Pressure Relief Device Standards — Part 1 — Cylinders for Compressed Gases*, 2019.

CGA S-1.2, *Pressure Relief Device Standards — Part 2 — Portable Containers for Compressed Gases*, 2019.

CGA S-1.3, *Pressure Relief Device Standards — Part 3 — Stationary Storage Containers for Compressed Gases*, 2020.

▲ **2.3.8 CSA Group Publications.** CSA Group [corporate office:] 178 Rexdale Blvd., Toronto, ON M9W 1R3, Canada.

CSA B51, *Boiler, pressure vessel, and pressure piping code*, Part 3, 2019.

CSA/ANSI NGV 1, *Compressed natural gas vehicle (NGV) fueling connection devices*, 2017.

CSA/ANSI NGV 2, *Compressed natural gas vehicle fuel containers*, 2019.

CSA/ANSI NGV 3.1, *Fuel system components for compressed natural gas powered vehicles*, 2020.

CSA/ANSI NGV4.4, *Breakaway devices for natural gas dispensing hoses and systems*, 2021.

CSA/ANSI NGV 5.1, *Residential fueling appliances*, 2016.

CSA/ANSI NGV 5.2, *Vehicle fueling appliances (VFA)*, 2017.

CSA/ANSI NGV 6.1, *Compressed natural gas (CNG) fuel storage and delivery systems for road vehicles*, 2021.

CSA/ANSI PRD 1, *Pressure relief devices for natural gas vehicle (NGV) fuel containers*, 2020.

● **2.3.9 IEEE Publications.** IEEE Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-4141.

IEEE/ASTM SI 10, *American National Standard for Metric Practice*, 2016.

▲ **2.3.10 National Board Publications.** National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Avenue, Columbus, OH 43229.

NB-23, *National Board Inspection Code, Part 2, Inspection*, 2019.

NB-514, *Accreditation of "VR" Repair Organizations*, 2020.

● **2.3.11 UL Publications.** Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 723, *Test for Surface Burning Characteristics of Building Materials*, 2018.

UL 969, *Marking and Labeling Systems*, 2017.

2.3.12 US Government Publications. US Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001.

Title 29, Code of Federal Regulations, Part 1910.

Title 49, Code of Federal Regulations, Part 178.57, "Specification 4L Welded Insulated Cylinders."

Title 49, Code of Federal Regulations, Part 390.5, "Federal Motor Carrier Safety Regulations; General."

Title 49, Code of Federal Regulations, Part 390.21, "Marking of Commercial Motor Vehicles."

Title 49, Code of Federal Regulations, Part 571.304, "Compressed Natural Gas Fuel Container Integrity."

49 U.S.C. 5103, "General Regulatory Authority."

2.3.13 Other Publications.

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

2.4 References for Extracts in Mandatory Sections.

NFPA 30, *Flammable and Combustible Liquids Code*, 2021 edition.

NFPA 55, *Compressed Gases and Cryogenic Fluids Code*, 2020 edition.

NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)*, 2019 edition.

NFPA 96, *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations*, 2021 edition.

NFPA 101®, *Life Safety Code®*, 2021 edition.

NFPA 1901, *Standard for Automotive Fire Apparatus*, 2016 edition.

NFPA 1925, *Standard on Marine Fire-Fighting Vessels*, 2018 edition.

NFPA 5000®, *Building Construction and Safety Code®*, 2021 edition.

Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

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

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

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

standards or has been tested and found suitable for a specified purpose.

3.2.6 Shall. Indicates a mandatory requirement.

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

3.3 General Definitions.

3.3.1 Alterer. A person or business making changes to a certified vehicle. These changes do not include the addition, substitution, or removal of readily attachable components, such as mirrors or tire and rim assemblies. They also do not include minor finishing operations such as painting. The term *alterer* also means a person or business who alters a certified vehicle in such a manner that its stated weight ratings are no longer valid. All of these changes are made before the first purchase of the vehicle in good faith for purposes other than resale.

3.3.2 ANSI. American National Standards Institute.

3.3.3 Area.

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

△ **3.3.3.2 Indoor Area.** An area that is within a building or structure having overhead cover, other than a structure qualifying as “weather protection.” [55, 2020]

3.3.3.3 Outdoor Area. An area that is not an indoor area. [55, 2020]

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

3.3.5 Buildings. Structures, usually enclosed by walls and a roof, constructed to provide support or shelter for an intended occupancy. [5000, 2021]

3.3.5.1* Important Building. A building that is considered not expendable in an exposure fire. [30, 2021]

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

3.3.7* Cathodic Protection. A technique to resist the corrosion of a metal surface by making the surface the cathode of an electrochemical cell. [55, 2020]

3.3.8 Cathodic Protection Tester. A person who demonstrates an understanding of the principles and measurements of all common types of cathodic protection systems applicable to metal piping and container systems and who has education and experience in soil resistivity, stray current, structure-to-soil potential, and component electrical isolation measurements of metal piping and container systems. [55, 2020]

3.3.9 Certified. A formally stated recognition and approval of an acceptable level of competency, acceptable to the AHJ. [96, 2021]

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

3.3.10.1 Cargo Transport Container. A mobile unit designed to transport LNG or CNG.

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

3.3.10.3 Fuel Supply Container. A container mounted on a vehicle to store LNG or CNG as the fuel supply to the vehicle.

3.3.10.4 Fueling Facility Container. Primary storage for vehicular fueling.

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

3.3.12 Container Valve. See 3.3.66.1.

3.3.13 Contiguous Building Volume. The freely communicating volume of a building into which a release of flammable gas or vapor might accumulate from a single leak source and represent a flammability hazard.

3.3.14 Converter. An individual or organization that installs a natural gas fuel system on a vehicle after first sale and who is not required to certify compliance with federal motor vehicle safety standards.

3.3.15 Corrosion Expert. A person who, by reason of knowledge of the physical sciences and the principles of engineering acquired through professional education and related practical experience, is qualified to engage in the practice of corrosion control of container systems. [55, 2020]

3.3.16 Corrosion Protection. Protecting a container, piping, or system to resist degradation of the metal through oxidation or reactivity with the environment in which it is installed. [55, 2020]

3.3.17 Cylinder. A container constructed, inspected, and maintained in accordance with DOT regulations, the ASME *Boiler and Pressure Vessel Code*, or CSA/ANSI NGV 2, *Compressed natural gas vehicle fuel containers*.

■ **3.3.18 Defueling.** Depressurizing a fuel supply container(s) or system.

3.3.19 Device.

3.3.19.1 Emergency Shutdown Device (ESD). A device that brings all operations to a fail-safe condition within the fueling facility from either local or remote locations.

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

3.3.19.3 Pressure Relief Device (PRD). A device that, when activated under specified performance conditions, is used to vent the container contents.

3.3.19.4 Pressure Relief Valve (PRV) A reclosing device that opens to relieve pressure at the set pressure.

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

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

3.3.22 Dispensing Station. A natural gas installation that dispenses CNG or LNG from storage containers or a distribu-

tion pipeline into vehicular fuel supply containers, portable cylinders, or transportation vehicles by means of a compressor, vaporizer, or pressure booster.

3.3.23 DOT. U.S. Department of Transportation.

3.3.24 DOT Number. A number assigned by the U.S. Department of Transportation (DOT) to a motor carrier that is required to be marked on all power units of the motor carrier in accordance with 49 CFR 390.21.

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

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

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

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

3.3.28 Flame Spread Index. A comparative measure, expressed as a dimensionless number, derived from visual measurements of the spread of flame vs. time for a material tested in accordance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or with UL 723, *Test for Surface Burning Characteristics of Building Materials*.

3.3.29 Fuel Line. The pipe, tubing, or hose on a vehicle, including all related fittings, through which natural gas passes during normal vehicle fueling or operation.

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

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

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

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

3.3.34* LCNG. CNG formed by the vaporization of LNG followed by compression of the vapors.

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

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

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

3.3.37 Manifold. A system or device for connecting the inlets or outlets of one or more fuel containers or components to the central piping system for that specific gas.

3.3.38 Material.

3.3.38.1 Combustible Material. A building material that, in the form in which it is used and under the design conditions, will ignite and burn; a material that is neither noncombustible nor limited-combustible.

3.3.38.2* Limited-Combustible Material. See Section 4.2.

3.3.38.3 Noncombustible Material. See Section 4.2.

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

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

3.3.41 Mobile Refueling. The use of a DOT-approved vehicle or mobile equipment on site with tank(s) and/or pump(s) that dispenses engine fuel directly to vehicles, storage vessels/cylinders, or secondary refueling equipment.

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

3.3.42.1 Compressed Natural Gas (CNG). Mixtures of hydrocarbon gases and vapors consisting principally of methane in gaseous form and meeting the composition requirements of Section 5.2 that have been compressed for use as a vehicular fuel.

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

3.3.44 Original Component Manufacturer (OCM). One who provides components, performance data, and engineering specifications for individual components within a system.

3.3.45* Original Equipment Manufacturer (OEM). Any vehicle manufacturer that is subject to DOT regulations and first introduces a vehicle for sale, including any manufacturer that performs final stage manufacturer processes for the assembly and/or sale of natural gas vehicles.

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

3.3.47 Overpressure. The pressure in a blast wave above atmospheric pressure, a pressure within a containment structure that exceeds the maximum allowable working pressure of the containment structure, or 1.25 times the service pressure of the CNG vehicle component upstream of the first stage of pressure regulation.

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

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

3.3.50* Power Unit. A vehicle that contains a propulsion system.

3.3.51 Pressure.

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

3.3.51.2 Maximum Allowable Working Pressure (MAWP). The maximum pressure to which a component is designed to be

subjected when handling fluid or gas over the range of design temperature.

3.3.51.3 Operating Pressure. The varying pressure in a fuel system component during normal use.

3.3.51.4 Service Pressure. The settled pressure of the CNG fuel container at a uniform gas temperature of 21°C (70°F) and full gas content and for which the container, under normal conditions, has been constructed.

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

3.3.51.6* Working Pressure. The maximum pressure that a vehicle component can be expected to experience in actual service.

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

3.3.53 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.

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

3.3.55 Qualified Person. A person who, by possession of a recognized degree, certificate, professional standing, or skill, and who, by virtue of education, training, experience, or other special attributes, possesses expertise regarding a particular subject matter, work, or project. [1901, 2016]

3.3.56 Remotely Located, Manually Activated Shutdown Control. A control system that is designed to initiate shutdown of the flow of gases or liquids and that is manually activated from a point located some distance from the delivery system.

3.3.57 Residential Fueling Appliance (RFA). A self-contained CNG fueling appliance designed, listed, or approved, and intended to be installed as one system for fueling vehicles at residential (i.e., home) locations.

3.3.58 Room.

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

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

3.3.59 Space.

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

3.3.59.2 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.

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

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

3.3.59.5 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.

Δ 3.3.60 Standard Cubic Foot (scf) of Gas. An amount of gas that occupies one cubic foot at an absolute pressure of 14.7 psi (101 kPa) and a temperature of 70°F (21°C). [55, 2020]

3.3.61 System.

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

3.3.61.2 Fuel Dispenser System. The complete system, including controls used for the delivery of CNG or LNG fuel, and the removal of vapor from a vehicle.

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

3.3.61.4 Piping System. Interconnected piping consisting of mechanical components suitable for joining or assembly into pressure-tight fluid-containing system. Components include pipe, tubing, fittings, flanges, bolting, valves, and devices such as expansion joints, flexible joints, pressure hoses, in-line portions of instruments, and wetted components other than individual pieces or stages of equipment. [55, 2020]

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

3.3.63 TC. Transport Canada.

3.3.64 Temperature Compensation. A process that allows the pressure in a container at the actual present gas temperature to be calculated so that the quantity of gas contained is the same as will be in the container at a specified service pressure at 21°C (70°F).

3.3.65 Validation. Verification by responsible individuals as indicated in the code text where the requirement appears.

3.3.66 Valve.

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

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

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

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

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

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

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

3.3.68.1 Commercial Motor Vehicle. Any self-propelled or towed motor vehicle used on a highway in interstate commerce to transport passengers or property when the vehicle (1) has a gross vehicle weight rating or gross combination weight rating, or gross vehicle weight or gross combination weight, of 10,001 lb (4536 kg) or more, whichever is greater; or (2) is designed or used to transport more than eight passengers (including the driver) for compensation; or (3) is designed or used to transport more than 15 passengers, including the driver, and is not used to transport passengers for compensation; or (4) is used in transporting material found by the Secretary of Transportation to be hazardous under 49 U.S.C. 5103, "General Regulatory Authority," and transported in a quantity requiring placarding under regulations prescribed by the Secretary under 49 CFR 390.5, "Federal Motor Carrier Safety Regulations; General."

3.3.69 Vehicle Fueling Appliance (VFA). A listed appliance manufactured and certified for refueling CNG vehicles at fleet and public dispensing operations and that compresses and dispenses natural gas to a vehicle's engine fueling system.

3.3.70 Vehicular Fuel. Fuel stored on board a vehicle for powering vehicle systems.

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

3.3.72 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, 2018]

Chapter 4 Facility Management

4.1 General.

4.1.1 Application. This chapter shall apply to facilities containing CNG, LCNG, and LNG fuel supply systems that store and dispense fuel.

4.1.2 Buildings or Structures. 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.

4.1.2.1 Rooms Within Buildings.

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

4.1.2.1.2 Window glazing shall be permitted to be plastic.

4.1.2.1.3 Interior walls or partitions shall be continuous from floor to ceiling, be anchored in accordance with the requirements of the building code, and have a fire resistance rating of at least 2 hours.

4.1.2.1.4 At least one wall shall be an exterior wall.

4.1.2.1.5 Explosion venting shall be provided in accordance with 11.3.6.2.2.

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

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

4.1.2.2 Building Construction.

4.1.2.2.1 Buildings reserved exclusively for an LNG fueling facility shall be of Type I or Type II construction in accordance with NFPA 5000.

4.1.2.2.2 Windows and doors shall be located to permit ready egress in case of emergency.

4.2* Building Construction Materials.

Δ 4.2.1* Noncombustible Material. A material that complies with any of the following shall be considered a noncombustible material:

- (1)* 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.
- (2) A material that is reported as passing ASTM E136, *Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C*.
- (3) A material that is reported as complying with the pass/fail criteria of ASTM E136 when tested in accordance with the test method and procedure in ASTM E2652, *Standard Test Method for Assessing Combustibility of Materials Using a Tube Furnace with a Cone-shaped Airflow Stabilizer, at 750°C*.

[101:4.6.13.1]

4.2.2* Limited-Combustible Material. A material shall be considered a limited-combustible material where both of the following are met:

- (1) The material does not comply with the requirements for noncombustible material in accordance with 4.2.1.
- (2) The material, in the form in which it is used, exhibits a potential heat value not exceeding 3500 Btu/lb (8141 kJ/kg), when tested in accordance with NFPA 259.

[101:4.6.14]

Δ 4.2.2.1 The material shall have the structural base of a noncombustible material with a surfacing not exceeding a thickness of 1/8 in. (3.2 mm) where the surfacing exhibits a flame spread index not greater than 50 when tested in accord-

ance with ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, or UL 723, *Test for Surface Burning Characteristics of Building Materials*. [101:4.6.14.1]

- Δ 4.2.2.2 The material shall be composed of materials that, in the form and thickness used, neither exhibit a flame spread index greater than 25 nor evidence of continued progressive combustion when tested in accordance with ASTM E84 or UL 723 and are of such composition that all surfaces that would be exposed by cutting through the material on any plane would exhibit neither a flame spread index greater than 25 nor exhibit evidence of continued progressive combustion when tested in accordance with ASTM E84 or UL 723. [101:4.6.14.2]

4.2.2.3 Materials shall be considered limited-combustible materials where tested in accordance with ASTM E2965, *Standard Test Method for Determination of Low Levels of Heat Release Rate for Materials and Products Using an Oxygen Consumption Calorimeter*, at an incident heat flux of 75 kW/m² for a 20-minute exposure and both of the following conditions are met:

- (1) The peak heat release rate shall not exceed 150 kW/m² for longer than 10 seconds.
- (2) The total heat released shall not exceed 8 MJ/m². [101:4.6.14.3]

4.2.2.4 Where the term *limited-combustible* is used in this code, it shall also include the term *noncombustible*. [101:4.6.14.4]

4.3 Qualifications.

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

4.3.2 The installation of LNG and CNG systems shall be supervised by qualified personnel with reference to their construction and use.

4.4 Equipment Security.

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

4.4.2 Storage and transfer equipment at unattended facilities shall be secured to prevent tampering.

4.4.3 The fueling facility shall provide protection to minimize unauthorized access and damage to the facility.

4.4.4 Security procedures shall be posted in readily visible areas near the fueling facility.

4.5 Operations and Maintenance.

4.5.1 Programs and Activities.

4.5.1.1* CNG Facility Maintenance.

4.5.1.1.1 The system maintenance requirements of 4.5.1.1 shall be retroactive and shall be applied to existing stations.

4.5.1.1.2 Containers and their appurtenances, piping systems, compression equipment, controls, and detection devices shall be maintained in safe operating condition and according to manufacturers' instructions.

4.5.1.2* LNG Facility Maintenance.

- Δ 4.5.1.2.1 Each facility shall have written maintenance procedures based on experience, knowledge of similar facilities, and conditions under which the facilities will be maintained.

4.5.1.2.2 The maintenance program shall be carried out by a qualified representative of the equipment owner.

4.5.1.2.3 Maintenance Manual.

- Δ 4.5.1.2.3.1 Each operating company shall prepare a written manual that sets out an inspection and maintenance program for identified components that are used in the facility.

- Δ 4.5.1.2.3.2 The maintenance manual for facility components shall include the following:

- (1) The manner of carrying out and the frequency of the inspections and tests referred to in 4.5.1.3
- (2) A description of any other action in addition to those referred to in 4.5.1.2.3.2(1) that is necessary to maintain the facility in accordance with this standard
- (3) All procedures to be followed during repairs on a component that is operating while it is being repaired, to ensure the safety of persons and property at the facility

- Δ 4.5.1.2.3.3 Each operating company shall conduct the facility's maintenance program in accordance with the written manual for facility components.

4.5.1.2.4 Maintenance shall be performed based on the component manufacturers' recommendations and not less than every six months.

4.5.1.2.5 Stationary LNG container relief valves shall be inspected and set-point tested at least once every 2 calendar years, with intervals not exceeding 30 months.

- N 4.5.1.2.6 All other relief valves protecting hazardous fluid components shall be inspected and set-point tested at the intervals specified in 4.5.1.2.6.1 and 4.5.1.2.6.2.

- N 4.5.1.2.6.1 Inspection intervals for in-service equipment shall be in accordance with either of the following:

- (1) Inspection intervals not exceeding 1 year plus 6 months in accordance with Section 2 of NB-23, *National Board Inspection Code, Part 2, Inspection*, for pressure relief devices, including listed conditions that can be observed on the valves externally
- (2) Inspection intervals in accordance with API 510, *Pressure Vessel Inspection Code: In-service Inspection, Rating, Repair, and Alteration*

- N 4.5.1.2.6.2 Set-point testing intervals shall be in accordance with either of the following:

- (1) Intervals not exceeding 5 years plus 3 months
- (2) A frequency in accordance with API RP 576, *Inspection of Pressure-Relieving Devices*

4.5.1.2.7 The refueling site shall have a maintenance program or process safety analysis program in place.

- Δ 4.5.1.2.8 Each operating company shall maintain for a period of not less than 5 years a record of the date and the type of each maintenance activity performed.

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- Δ 4.5.1.3 Each LNG operating company shall carry out periodic inspection, tests, or both on a schedule that is included in the maintenance plan on identified components and its support

system in service in the LNG facility, to verify that the components are maintained in accordance with the equipment manufacturer's recommendations and the following:

- (1) The support system or foundation of each component shall be inspected at least annually to ensure that the support system or foundation is sound.
- (2) Each uninterrupted power supply powering safety equipment at the LNG station shall be tested annually to ensure that it can perform at its intended operating capacity.
- (3) When a safety device serving a single component is taken out of service for maintenance or repair, the component shall also be taken out of service, except where the safety function is provided by an alternative means.
- (4) Where the operation of a component that is taken out of service could cause a hazardous condition, a tag bearing the words "Do Not Operate," or equivalent, shall be attached to the controls of the component, or the component shall be locked out.
- (5) Stop valves for isolating pressure or vacuum-relief valves shall be locked or sealed open and shall be operated only by a qualified person.
- (6) No more than one pressure or vacuum relief valve stop valve shall be closed at one time on an LNG container.

4.5.1.3.1 All maintenance and servicing shall be done in accordance with 29 CFR 1910 for energy control.

4.5.1.4 All LNG facilities shall be free of rubbish, debris, and other material that will present a fire hazard to the distance of at least 25 ft (7.6 m).

4.5.1.5 Grass areas on the LNG fueling facility grounds shall be maintained in a manner that does not present a fire hazard.

4.5.1.6 Safety and fire protection equipment shall be tested or inspected at intervals not to exceed six months.

4.5.1.7 Control systems that are used as part of the fire protection system at the LNG station shall be inspected and tested in accordance with the applicable fire codes and standards and conform to the following criteria:

- (1) Monitoring equipment shall be maintained in accordance with NFPA 72 and NFPA 1221.
- (2) Portable or wheeled fire extinguishers suitable for gas fires, preferably of the dry-chemical type, shall be available at strategic locations, as determined in accordance with Chapter 14, within an LNG facility and on tank vehicles, and shall be maintained in accordance with NFPA 10.
- (3) Where installed, fixed fire extinguishers and other fire-control systems shall be maintained in accordance with NFPA 11, NFPA 12, NFPA 12A, NFPA 16, and NFPA 17.

4.5.1.8 Maintenance activities on fire control equipment shall be scheduled so that a minimum of equipment is taken out of service at any one time, and fire prevention safety is not compromised.

4.5.1.9 LNG storage facilities and, in particular, the storage container and its foundation shall be externally inspected annually and after each major meteorological disturbance to ensure that the structural integrity of the LNG facility is intact.

4.5.1.10 Access routes for movement of fire control equipment to an LNG fueling facility shall be maintained at all times.

4.5.1.11 Operations and Maintenance.

4.5.1.11.1 Each facility shall have written operating, maintenance, and training procedures based on experience, knowledge of similar facilities, and conditions under which the facility will be operated.

4.5.1.11.1.1 Basic Operations Requirement. Each LNG facility shall meet the following requirements:

- (1) Have written procedures covering operation, maintenance, and training
- (2) Keep up-to-date drawings of LNG facility equipment showing all revisions made after installation
- (3) Revise the plans and procedures as operating conditions or facility equipment require
- (4) Establish a written emergency plan
- (5) Establish liaison with appropriate local authorities such as police, fire department, or municipal works and inform them of the emergency plans and their role in emergency situations
- (6) Analyze and document all safety-related malfunctions and incidents for the purpose of determining their causes and preventing the possibility of recurrence

4.5.1.11.1.2 Operating Procedures Manual.

(A) The operations manual shall contain procedures to ensure that the cool down of each system of components under its control and subjected to cryogenic temperatures is limited to a rate and a distribution pattern that maintain the thermal stresses within the design limits of the system during the cool down period, having regard for the performance of expansion and contraction devices.

(B) Each operations manual shall include purging procedures [in accordance with NFPA 56] that, when implemented, minimize the presence of a combustible mixture in LNG facility piping or equipment when a system is being placed into or taken out of operation.

(C) The operations manual shall contain procedures for loading or unloading operations applicable to all transfers, including the following:

- (1) Written procedures shall cover all transfer operations and shall cover emergency as well as normal operating procedures.
- (2) Written procedures shall be kept up-to-date and available to all personnel engaged in transfer operations.
- (3) Prior to transfer, gauge readings shall be obtained or inventory established to ensure that the receiving vessel cannot be overfilled.
- (4) Levels of the receiving vessel shall be checked during transfer operations.
- (5) The transfer system shall be checked prior to use to ensure that valves are in the correct position.
- (6) Pressure and temperature conditions shall be observed during the transfer operation.

(D) The manual shall be accessible to operating and maintenance personnel.

(E) The manual shall be updated when changes in equipment or procedures are made.

4.5.2 Manuals. (Reserved)

4.5.3 Record Requirements. A written record of maintenance shall be provided.

4.6 CNG Training. CNG maintenance personnel shall be trained in leak detection procedures and equipment in accordance with manufacturers' recommendations.

4.7* LNG Training.

4.7.1 All persons employed in handling and dispensing LNG shall be trained in handling and operating duties and procedures.

4.7.2 Protective clothing, face shield/goggles, and gloves shall be provided for all operators dispensing and handling LNG, except as provided in 4.7.3.

4.7.3 The requirements specified in 4.7.2 shall be permitted to be excluded where equipment is demonstrated to operate without exposing operators to the release of LNG or cold gases.

4.7.4* Training shall be conducted upon employment and every 2 years thereafter.

4.7.5 Training.

4.7.5.1 Training shall include the following:

- (1) Information on the nature, properties, and hazards of LNG in both the liquid and gaseous phases
- (2) Specific instructions on the facility equipment to be used
- (3) Information on materials that are compatible for use with LNG
- (4) Use and care of protective equipment and clothing
- (5) Standard first aid and self-aid instruction
- (6) Response to emergency situations such as fires, leaks, and spills
- (7) Good housekeeping practices
- (8) Emergency response plan as required in 5.3.2.4
- (9) Evacuation and fire drills

4.7.5.2 Each operator shall provide and implement a written plan of initial training to instruct all designated operating and supervisory personnel in the characteristics and hazards of LNG used or handled at the site, including low LNG temperature, flammability of mixtures with air, odorless vapor, boil-off characteristics, and reaction to water and water spray; the potential hazards involved in operating activities; and how to carry out the emergency procedures that relate to personnel functions and to provide detailed instructions on mobile LNG operations.

4.8 Special Hazard Requirements.

4.8.1 A hazard analysis of the proposed modification and the startup plan shall be required and prepared prior to the modification and operation of the facility.

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

Chapter 5 Facility Fire Protection

5.1 General.

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

5.1.1.1 Validation.

5.1.1.1.1 The validation shall address the following:

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

5.1.1.1.2 The refueling station and associated storage equipment shall be validated per the specifics of 5.1.1.1.1 upon initial installation and revalidated per 5.1.1.1.1 when a change is made to the last validated design, including, but not limited to, changes in the service pressure. The installation validation shall also be reviewed at least every 4 years to detect any undocumented changes.

5.1.1.1.3 The validation shall be conducted by a qualified person(s) with proven expertise in the specific fueling and supporting equipment being installed.

5.1.1.1.4 Validation shall be kept on site and provided to the AHJ.

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

5.1.2 Ignition Source Control.

5.1.2.1 Smoking. Smoking and ignition sources shall be prohibited, except in accordance with 5.1.2.2.

5.1.2.2 Welding, Oxygen-Acetylene Cutting, and Similar Operations. Welding, oxygen-acetylene cutting, and similar operations shall be conducted only when and where specifically authorized and in accordance with the provisions of NFPA 51B.

5.1.2.3 Vehicles.

5.1.2.3.1 Vehicles shall not be considered a source of ignition with respect to the provisions of this chapter, except as provided in 5.1.2.3.2.

5.1.2.3.2 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.

5.1.2.4 Nonelectrical sources of ignition shall not be permitted.

5.1.3 Signage.

5.1.3.1 The location of signs shall be determined by local conditions.

5.1.3.2 The lettering on signs shall be large enough to be visible and legible from each point of transfer.

5.1.3.3 A warning sign with the words "NO SMOKING, FLAMMABLE GAS" shall be posted in every compressor and storage area.

5.1.3.4 Access doors shall have warning signs with the words “WARNING — NO SMOKING — FLAMMABLE GAS.”

5.1.3.5 The wording shall be in plainly legible, bright red letters not less than 1 in. (25 mm) high on a white background.

5.2 CNG Supplemental Requirements.

5.2.1 Siting.

5.2.1.1 Setbacks.

5.2.1.1.1 Compression, storage, and dispensing equipment located outdoors shall be a minimum of 10 ft (3 m) from the nearest important building or line of adjoining property that is able to be built upon or from any source of ignition.

5.2.1.1.2 Compression, storage, and dispensing equipment located outdoors shall be not less than 10 ft (3 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.

5.2.1.1.3 Combustible material shall not be permitted within 10 ft (3 m) of any stationary container.

5.2.1.1.4 The minimum separation between containers and aboveground tanks containing flammable or combustible liquids shall be 20 ft (6 m).

5.2.1.1.5 Point of Transfer.

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

5.2.1.1.5.2 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 m) from any building openings.

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

5.2.2 Signage.

5.2.2.1 A warning sign(s) shall be posted at each dispensing point with the following words:

FLAMMABLE GAS — STOP MOTOR, NO SMOKING.

NATURAL GAS VEHICLE FUEL CYLINDERS SHALL BE
INSPECTED AT INTERVALS NOT EXCEEDING 3 YEARS TO
ENSURE SAFE OPERATION OF THE VEHICLE.

NATURAL GAS FUEL CYLINDERS PAST THEIR END-OF-
LIFE DATE SHALL NOT BE REFUELED AND SHALL BE
REMOVED FROM SERVICE.

5.3 LNG Supplemental Requirements.

5.3.1 Application. This section applies to LNG fire protection, personnel safety, security, LNG fueling facilities and training for LNG vehicles, and warning signs.

5.3.2 Fire Protection, Safety, and Security.

5.3.2.1 Fire protection shall be provided for all LNG fueling facilities.

5.3.2.1.1 The extent of such protection shall be determined by an evaluation based on sound fire protection and methane detection engineering principles, analysis of local conditions, vehicle operations, hazards within the facility, exposure to or from other property, and the size of the LNG containers.

5.3.2.1.2 Guidance factors for making such an evaluation shall include the following:

- (1) Type, quantity, and location of equipment necessary for the detection and control of fires, leaks, and spills of LNG, flammable refrigerants, and flammable gases or liquids
- (2) Methods necessary for the protection of vehicles, equipment, and structures from the effects of fire exposure
- (3) Equipment and processes to be incorporated within the ESD system
- (4) Type, quantity, and location of sensors necessary to initiate automatic operation of the ESD system
- (5) Availability and duties of individual facility personnel and the availability of external response personnel during an emergency
- (6) Protective equipment and special training required by personnel for emergency duties

5.3.2.2 The planning for emergency response measures shall be coordinated with the appropriate local emergency agencies.

5.3.2.3 All-weather accessibility to the site for emergency services equipment shall be provided.

5.3.2.4* An emergency response plan shall be prepared to cover foreseeable emergency conditions.

5.3.2.5 The fire protection and methane detection equipment shall be maintained in accordance with the manufacturer's instructions and the AHJ.

5.3.2.6 An operating, portable, flammable-gas detector shall be readily available.

5.3.3 Siting.

5.3.3.1 LNG tanks and their associated equipment shall not be located where exposed to failure of overhead electric power lines operating over 600 volts unless approved protection is provided.

5.3.3.2 Vaulted or underground installations shall be deemed to provide engineered protection from overhead power lines.

5.3.3.3 If other combustible or hazardous liquids are able to encroach on the LNG fueling facility, means shall be provided to protect the LNG facility.

5.3.3.4 Points of transfer shall be located not less than 25 ft (7.6 m) from the nearest important building not associated with the LNG facility, from the line of adjoining property that is able to be built upon, or from fixed sources of ignition.

5.3.3.5 Flammable liquid storage tanks shall not be located within an LNG container impounding area.

5.3.4 Ignition Source Control.

5.3.4.1 LNG fueling facilities shall be free from rubbish, debris, and other material that present a fire hazard to a distance of at least 25 ft (7.6 m).

5.3.4.2 Grass areas on the LNG fueling facility grounds shall be maintained in a manner that does not present a fire hazard.

5.3.4.3 Gas leak detection and fire detection shall be installed based on the evaluation required in 5.3.2.1.1.

5.3.4.4 LNG vehicles shall be permitted to be parked indoors, provided such facilities or vehicles are equipped to prevent an accumulation of gas in a combustible mixture or the onboard fuel storage tank and fuel system are drained of LNG and purged with inert gas or depressurized.

5.3.5 Vehicles.

5.3.5.1 Vehicles and other mobile equipment that constitute a potential ignition source shall be prohibited except where specifically authorized and under constant supervision or when at a transfer point specifically for the purpose of transfer.

5.3.5.2 Vehicles delivering LNG to the facility or vehicles being fueled from the facility shall not be considered sources of ignition.

5.3.5.3 Vehicles containing fuel-fired equipment (e.g., recreational vehicles and catering trucks) shall be considered a source of ignition unless all sources of ignition such as pilot lights, electric igniters, burners, electrical appliances, and engines located on the vehicle being refueled are shut off completely before entering an area where ignition sources are prohibited.

5.3.6 Electrical Classifications.

5.3.6.1 Fired equipment shall be located in accordance with Table 14.3.2.21.1 from any impounding area or container drainage system.

5.3.6.2 Buildings and rooms used for storage or dispensing shall be classified in accordance with Table 14.3.2.21.1 for installations of electrical equipment.

5.3.7 Signage. For all LNG fueling facilities, the following signs shall be displayed in bright red letters on a white background, with letters not less than 6 in. (152 mm) high:

- (1) "No Smoking" or "No Smoking within 25 ft (7.6 m)"
- (2) "Stop Motor"
- (3) "No Open Flames Permitted"
- (4) "Cryogenic Liquid or Cold Gas"
- (5) "Flammable Gas"
- (6) "Unodorized Gas"

▲ 5.3.8 Emergency Response Measures.

5.3.8.1 Safety and fire protection equipment shall be tested or inspected at intervals not to exceed 6 months.

5.3.8.2 Maintenance activities on fire control equipment shall be scheduled so that a minimum of equipment is taken out of service at any one time and fire prevention safety is not compromised.

5.3.8.3 Access routes for movement of fire control equipment to an LNG fueling facility shall be maintained at all times.

Chapter 6 Facility Gas Detection, Alarm, and Emergency Shutdown Systems

6.1 General.

6.1.1 Gas Detection. Gas detection equipment and alarms for dispensing station systems and dispensing station system components shall be listed or approved.

6.1.2 Flame Detection. (Reserved)

6.2 CNG Supplemental Requirements.

6.2.1 Gas Detection.

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

6.2.1.2 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 11.3.2.16.5.
- (2) A gas detection system equipped to sound a latched alarm and visually indicate when a maximum of one-fifth of the lower flammable limit is reached shall be installed.

6.2.1.3 The actuation of the gas detection system shall shut down the compressor and stop the flow of gas into the structure.

6.2.1.4 Odorized CNG. (Reserved)

6.2.1.5 Nonodorized CNG. (Reserved)

6.2.1.6 Flame Detection. (Reserved)

6.3 LNG Supplemental Requirements.

6.3.1 Gas Detection.

6.3.1.1 A gas detection system shall be provided in all buildings containing LNG.

6.3.1.2 The gas detection system shall activate a latched alarm when a maximum of 20 percent of the LFL is reached.

Chapter 7 Fuel Quality

- **7.1* CNG.** Natural gas composition dispensed to vehicles shall comply with ASTM D8080, *Standard Specification for Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG) Used as a Motor Vehicle Fuel*, or other nationally recognized consensus standard.

7.1.1 Natural gas introduced into any CNG system covered by this code shall have a distinctive odor potent enough for its presence to be detected down to a concentration in air of not over one-fifth of the lower limit of flammability.

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

7.2 LNG. (Reserved)

Chapter 8 Facility Equipment

8.1 Scope. This chapter shall apply to equipment used for storage and dispensing of CNG and LNG as an engine fuel in fleet and public dispensing operations.

8.2 Application. CNG and LNG equipment used shall be in accordance with Section 8.3 and the fuel-specific paragraphs of Section 8.4, as applicable. Where there is a conflict between general requirements and fuel-specific requirements, the fuel-specific requirements shall apply.

8.3 General.

8.3.1 System Component Qualifications. (Reserved)

8.3.2* System Approvals. The following subsystems or components associated with storage and dispensing of CNG and LNG as an engine fuel in fleet and public dispensing operations 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 (e.g., nozzle and receptacle)
- (7) Engine fuel systems
- (8) Electrical equipment related to storage or dispensing systems
- (9) Gas detection equipment and alarms
- (10) Fire protection and suppression equipment
- (11) Vehicle fueling appliances (VFAs)
- (12) Residential fueling appliances (RFAs)

8.3.3 Equal Level of Safety. Subsystems or components that are not listed in 8.3.2 shall provide a level of safety equal to that required of those listed in 8.3.2.

8.3.4 Equipment.

8.3.4.1 Pressure Regulators.

8.3.4.1.1 Regulators shall be designed, installed, or protected so that their operation is not affected by freezing rain, sleet, snow, ice, mud, insects, or debris.

8.3.4.1.2 Regulator protection of 8.3.4.1.1 shall be permitted to be integral with the regulator.

8.3.4.2 Pressure Relief Valves (PRVs).

8.3.4.2.1 PRVs shall not be fitted with lifting devices.

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

8.3.4.2.1.2 If at any time it is necessary to break such a seal as provided in 8.3.4.2.1.1, the valve shall be removed from service until it has been reset and sealed.

8.3.4.2.1.3 PRV 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.

8.3.4.2.1.4 The organization making such PRV adjustments shall attach a permanent tag with the setting, capacity, and date.

8.3.4.2.2 PRVs protecting ASME pressure vessels shall be repaired, adjusted, and tested in accordance with NB-23, *National Board Inspection Code*.

8.3.4.2.3 PRVs shall be maintained in safe operating condition.

8.3.4.2.4 PRVs shall have vent lines to convey escaping gas upward to prevent impinging on buildings, other equipment, or areas open to the public (e.g., sidewalks).

8.3.4.2.5 The PRV shall not have a setting greater than the maximum allowable working pressure of the line it protects.

8.3.4.3 Piping. (Reserved)

8.3.4.4 Piping Connections. (Reserved)

8.3.4.5 Hoses and Breakaway Devices. (Reserved)

8.3.4.6 Valves. (Reserved)

8.3.4.7 Electrical Equipment. (Reserved)

8.4 CNG Systems.

8.4.1 Compressor Systems.

8.4.1.1 Design Temperature and Pressure.

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

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

8.4.1.2 Installation of Pressure Gauges. Gauges or other read-out devices shall be installed to indicate compression discharge pressure, storage pressure, and dispenser discharge pressure.

8.4.1.3 Pressure Relief Valves. Compression equipment shall have PRVs that limit each stage pressure to the maximum allowable working pressure for the compression cylinder and piping associated with that stage of compression.

8.4.1.4 Shutdown Control.

8.4.1.4.1 CNG compression equipment shall be equipped with a high discharge and a low suction pressure automatic shutdown control.

8.4.1.4.2 Control circuits that shut down shall remain down until manually activated or reset after a safe condition is restored.

8.4.1.5 Engine Drives. Engine-driven compressor installations shall conform, where applicable, to NFPA 37.

8.4.2 Dispensing Systems and Dispensers.

8.4.2.1 Operation.

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

8.4.2.1.2 A fuel supply container shall not be charged in excess of the quantity of fuel that would result in a gas pressure equal to service pressure at a uniform temperature of 70°F (21°C).

8.4.2.1.3 Under no circumstances shall the fuel supply container be subjected to pressure in excess of 1.25 times the service pressure.

8.4.2.1.4 DOT, TC, and CSA/ANSI NGV 2 cylinders shall be charged in accordance with DOT, TC, and CSA/ANSI NGV 2 regulations.

8.4.2.2 Vehicle Fill Pressure Control.

8.4.2.2.1 CNG dispensing systems shall be equipped to stop fuel flow automatically when a vehicle fuel supply container reaches the maximum fill conditions of 8.4.2.1.2.

8.4.2.2.2 Malfunctions.

8.4.2.2.2.1 The dispenser shall be designed to detect any malfunction that fills the vehicle fuel container in excess of the limits specified, or causes the relief valve required in 11.3.2.3 to open.

8.4.2.2.2.2 If a malfunction is detected, the following shall occur:

- (1) The dispenser shall disable itself and provide clear visual annunciation until it is repaired, calibrated, or serviced.
- (2) The dispenser shall notify the vehicle operator or fueling technician shall be notified that the vehicle has been overfilled.
- (3) After any such malfunction, the dispenser shall be repaired and calibrated in accordance with 4.5.1.1 before continued operation.

8.4.2.3 Overpressure Protection.

8.4.2.3.1 Transfer systems shall be capable of depressurizing to facilitate disconnection.

8.4.2.3.2 The pressure relief valve shall be redundant to and independent from any operating control system used to control the supplied fuel pressure during dispenser operation.

8.4.2.3.3 The set pressure of the overpressure protection device shall not exceed 125 percent of the service pressure of the fueling nozzle it supplies.

8.4.2.4 Breakaway Protection.

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

(A) A breakaway device shall be arranged to separate using a force not greater than 150 lb (68 kg) when applied in any direction that the vehicle would move.

(B) Breakaway devices shall comply with *CSA/ANSI NGV 4.4, Breakaway devices for natural gas dispensing hoses and systems.*

8.4.2.5 Malfunction Control.

8.4.2.5.1 An emergency manual shutdown device shall be provided within 10 ft (3.0 m) of the dispensing area and also greater than 25 ft (7.6 m) from the dispensing area.

8.4.2.5.1.1 This device, when activated, shall shut off the power supply and gas supply to the compressor and the dispenser.

8.4.2.5.1.2 Control circuits shall be arranged so that, when an emergency shutdown device is activated, the systems that shut down shall remain off until manually activated or reset after a safe condition is confirmed.

8.4.2.5.1.3 When the electric power is cut off (i.e., blackout condition), the systems that shut down shall remain off until manually activated or reset after a safe condition is confirmed.

8.4.2.5.1.4 When the electric power is interrupted (i.e., brownout condition) or the station is equipped with backup power, the system that shut down should be allowed to reset after power is restored.

8.4.2.6 Electrical Classification. Electrical classification areas inside dispenser enclosures are determined by the requirements in Table 11.3.2.14.1.

8.4.2.7 System Testing.**8.4.2.7.1 Leak Testing.**

(A) 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 maximum operating pressure of that portion of the system. Compression equipment that has, by design, interstage air movement and ventilation through the crankcase shall not be subjected to leak testing as this design will give an erroneous test reading.

(B) Compression equipment that has, by design, interstage air movement and ventilation through the crankcase shall not be subjected to this system testing, as its inclusion will give an erroneous reading to the system test.

8.4.2.8 Hose Assemblies.

8.4.2.8.1 Dispensing station hose, metallic hose, flexible metal hose, tubing, and their connections shall be designed or selected for the most severe pressures and temperatures under normal operating conditions with a burst pressure of at least four times the maximum allowable working pressure.

8.4.2.8.2 Prior to use, hose assemblies shall be tested by the OEM or its designated representative at a pressure of at least twice the maximum allowable working pressure (MAWP).

8.4.3 Shutoff Valves.

8.4.3.1 Shutoff valves for dispensing stations shall have a rated maximum allowable working pressure not less than the rated operating pressure of the system.

8.4.3.2 Shutoff valves shall be capable of withstanding a hydrostatic test of at least four times the rated operating pressure without rupture.

8.4.4* Design and Construction of Containers.

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

8.4.4.2 The container shall be designed for CNG service.

8.4.4.3 The container shall be permanently marked "CNG" by the manufacturer.

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

8.4.4.5 ASME Compliance.

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

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

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

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

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

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

▲ 8.4.5* Pressure Relief Devices (PRDs).

▲ 8.4.5.1 Pressure vessels complying with 8.4.4.5 used in stationary storage shall be protected with one or more spring-loaded PRVs in accordance with the ASME *Boiler and Pressure Vessel Code*.

8.4.5.2 The minimum rate of discharge of PRDs on containers shall be in accordance with CGA S-1.3, *Pressure Relief Device Standards — Part 3 — Stationary Storage Containers for Compressed Gases*, or the ASME *Boiler and Pressure Vessel Code*, whichever is applicable.

8.4.5.3 PRVs for CNG service shall not be fitted with lifting devices.

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

8.4.5.5 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.

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

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

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

• 8.4.6 Pressure Gauges. A pressure gauge, if provided, shall be capable of reading at least 1.20 times the maximum allowable working pressure of the station.

• 8.4.7 Piping, Tubing, and Fittings.

▲ 8.4.7.1 The following components shall not be used for CNG service:

- (1) Fittings, street els, and other piping components of cast irons other than those complying with ASTM A47/A47M, *Standard Specification for Ferritic Malleable Iron Castings*; ASTM A395/A395M, *Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*; and ASTM A536, *Standard Specification for Ductile Iron Castings*
- (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

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

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

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

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

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

8.4.8 Valves.

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

8.4.8.1.1 Shutoff valves for dispensing stations shall have a rated maximum allowable working pressure not less than the rated operating pressure of the system and shall be capable of withstanding a hydrostatic test of at least 4 times the rated operating pressure.

8.4.8.1.2 Leakage shall not occur at less than 1.5 times the rated operating pressure.

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

8.4.8.3 Marking.

8.4.8.3.1 The manufacturer shall stamp or otherwise permanently mark the valve body to indicate the maximum allowable working pressure rating.

8.4.8.3.2 Container valves incorporating integral PRDs complying with 8.4.5.1 shall not require additional marking.

▲ 8.4.8.4 Valves of cast irons other than those complying with ASTM A47/A47M, *Standard Specification for Ferritic Malleable Iron Castings*; ASTM A395/A395M, *Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*; and ASTM A536, *Standard Specification for Ductile Iron Castings*, shall not be used as primary stop valves.

8.4.8.5 Hose and Hose Connections.

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

8.4.8.5.2 Hose Assemblies.

▲ 8.4.8.5.2.1 Metallic hose, flexible metal hose, tubing, and their connections shall be designed or selected for the most severe pressures and temperatures under normal operating conditions with a burst pressure of at least 4 times the operating pressure.

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

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

8.4.9 Vehicle Fueling Connection.

8.4.9.1 CNG vehicle fueling connection devices shall be listed in accordance with CSA/ANSI NGV 1, *Compressed natural gas vehicle (NGV) fueling connection devices*.

8.4.9.2 The use of adapters to defeat the pressure-specific nozzle and receptacle connections shall be prohibited.

Chapter 9 Outdoor Storage

9.1 Scope. This chapter shall apply to the outdoor storage of vehicular gas fuel systems in portable and stationary cylinders, containers, equipment, systems and tanks.

9.2 General. (Reserved)

9.3 CNG Supplemental Requirements.

9.3.1 Compression, Storage, and Dispensing Equipment Located Outdoors. A facility in which CNG compression, storage, and dispensing equipment are sheltered by weather protection constructed in accordance with the requirements of the building code and by a roof designed for ventilation and dispersal of escaped gas shall be considered to be located outdoors.

9.3.1.1 Compression, storage, and dispensing equipment located outdoors shall be above ground.

9.3.1.2 Compression, storage, and dispensing equipment shall not be located where exposed to failure of overhead electric power lines operating over 600 volts unless approved protection is provided.

9.3.1.3 Compression, storage, and dispensing equipment located outdoors shall be above ground.

9.3.1.4 Compression, storage, and dispensing equipment located outdoors shall be a minimum of 10 ft (3 m) from the nearest important building or line of adjoining property that is able to be built upon or from any source of ignition.

9.3.1.5 Compression, storage, and dispensing equipment located outdoors shall be not less than 10 ft (3 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.

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

9.3.2.1* Installation of Containers and Container Appurtenances (Other than Pressure Relief Devices).

9.3.2.1.1 Storage containers shall be installed above ground on stable, noncombustible foundations or in vaults with ventilation and drainage. (See Section 4.2 for noncombustible.)

9.3.2.1.2 Horizontal containers shall have no more than two points of support longitudinally.

9.3.2.1.3 In areas subject to flooding, container(s) shall be anchored to prevent floating.

9.3.2.2 Containers shall be protected by painting or other equivalent means where necessary to inhibit corrosion.

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

9.3.2.2.2 Horizontally installed containers shall not be in direct contact with each other.

9.3.2.2.3 Composite containers shall be protected from UV radiation as required by the manufacturer.

9.3.2.3 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.

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

9.3.4 Electrical Installations. Areas for compression, storage, and dispensing shall be classified in accordance with Table 11.3.2.14.1 for installations of electrical equipment.

9.3.5 Warning Signs. Warning signs for CNG outdoor storage shall follow the requirements in 5.1.3.

9.3.6 Connections.

9.3.6.1 Piping Connections.

9.3.6.1.1 Manifolds connecting fuel containers shall be fabricated to minimize vibration.

9.3.6.1.1.1 Manifolds shall be installed in a protected location or shielded to prevent damage from unsecured objects.

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

9.3.6.1.3 Threaded piping and fittings shall be clear and free from cutting or threading burrs and scales.

9.3.6.1.3.1 The ends of all piping shall be reamed.

9.3.6.1.4 A bend in piping or tubing shall be prohibited where such a bend weakens the pipe or tubing beyond its designed operating condition.

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

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

9.3.7 Separation Distances.

9.3.7.1 Sidewalks (and Rail). Pressure relief valves on storage systems shall have a pressure relief valve vent system 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).

9.3.7.1.1 Installation of PRVs. PRVs shall have vent lines to convey escaping gas to the outdoors and then upward to prevent impinging on buildings, other equipment, or areas open to the public (e.g., sidewalks).

9.4 LNG Supplemental Requirements.

9.4.1 Spill Containment. LNG outdoor storage spill containment shall follow the requirements of 14.3.2.15.2.

Δ 9.4.2 LNG ASME Tanks. ASME tanks for LNG shall follow the requirements of Chapter 17.

9.4.3 Separation Distances.

9.4.3.1 Adjacent Buildings. Separation distances between adjacent buildings shall align with the minimum distances in Table 17.5.

9.4.3.2 Power Lines.

9.4.3.2.1 LNG tanks and their associated equipment shall not be located where exposed to failure of overhead electric power lines operating over 600 volts unless approved protection is provided.

9.4.3.2.2 Vaulted or underground installations shall be deemed to provide engineered protection from overhead power lines.

9.4.3.3 Stationary Containers. Separation distances between stationary containers shall align with the minimum distances in Table 17.5.

9.4.3.4 Aboveground/Underground Storage Tanks. Separation distances between aboveground/underground storage tanks shall align with the minimum distances in Table 17.5 and Table 17.5.2.

9.4.3.5 Buildings, Highways, Streets, and Roads. Separation distances between buildings, highways, streets, and roads shall align with the minimum distances in Table 17.5.

9.4.4 Cargo Transport Unloading. Subsection 9.4.4 shall apply to the transfer of LNG between cargo transport containers and fueling facility containers.

9.4.4.1 When transfers are made into fueling facility containers, the LNG shall be transferred at a pressure that does not overpressurize the receiving tank.

9.4.4.1.1 Venting of on-site containers shall be done only under emergency conditions and in a manner acceptable to the authority having jurisdiction.

9.4.4.2 Isolation Valves.

9.4.4.2.1 The transfer piping shall have isolation valves at both ends.

9.4.4.2.2 On facility containers with a capacity greater than 2000 gal (7.6 m³), one remotely operated valve, automatic closing valve, or check valve shall be used to prevent backflow.

9.4.4.3 If the fueling facility tank or transfer equipment is located in a remote area, operating status indicators, such as those that indicate container level, shall be provided in the unloading area.

9.4.4.4 At least one qualified person shall be in continuous attendance with an unobstructed view of the transfer point while unloading is in progress.

9.4.4.5 Sources of ignition shall not be permitted in the unloading area while transfer is in progress.

9.4.4.6 Methane Detection.

9.4.4.6.1 Offloading site methane detection and fire protection shall be provided.

9.4.4.6.2 The methane detection system shall be capable of detection at multiple locations beyond the full radius of the transfer hose, measured at each point of transfer and receipt of LNG.

9.4.4.7 Bleed Connections.

9.4.4.7.1 Bleed or vent connections shall be provided so that loading arms and hoses can be drained and depressurized prior to disconnection if necessary.

9.4.4.7.2 The connections shall relieve to a safe area.

9.4.4.8 Prior to connection, a cargo transport vehicle's wheels shall be rendered immobile.

9.4.4.9 The cargo transport vehicle's engine shall be shut off while the transfer hose or piping is being connected or disconnected.

9.4.4.10 If required for LNG transfer, the engine shall be permitted to be started and used during the liquid transfer operations.

9.4.4.11 The LNG cargo transport unloading connection shall be at least 1.5 ft (0.46 m) from a storage container.

Chapter 10 Indoor Storage

10.1 Scope. This chapter shall apply to the indoor storage of vehicular gas fuel systems in portable and stationary cylinders, containers, equipment, systems and tanks.

10.2 General. (Reserved)

10.3 CNG Supplemental Requirements.

10.3.1 Indoors.

10.3.1.1 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.

10.3.1.2 Limits of Storage in Buildings.

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

10.3.1.2.2 CNG stored in vehicle-mounted fuel supply containers shall not be subject to 10.3.1.2.1.

10.3.1.3 Rooms Within Buildings.

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

10.3.1.3.2 Window glazing shall be permitted to be plastic.

10.3.1.3.3 Interior walls or partitions shall be continuous from floor to ceiling, be anchored in accordance with the requirements of the building code, and have a fire resistance rating of at least 2 hours.

10.3.1.3.4 At least one wall shall be an exterior wall.

10.3.1.3.5 Explosion venting shall be provided in accordance with 11.3.6.2.2.

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

10.3.1.3.7 If access to the room from outside the primary structure is not possible, access from within the primary structure shall be permitted where such access is made through a

barrier space having two vapor-sealing, self-closing fire doors rated for the location where installed.

10.3.1.4 Ventilation.

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

10.3.1.4.2 In either case in 10.3.1.4.1, the system shall immediately shut down the fueling system in the event of detection of an alarm condition or failure of the ventilation system, the detection system, or the controls.

10.3.1.4.3* The ventilation rate shall be at least 1 cfm/12 ft³ (1 m³/min/11.3 m³) of room volume.

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

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

10.3.1.4.6 Reactivation of the fueling system shall be by manual restart that is conducted by trained personnel.

10.3.1.4.7 Buildings and rooms used for compression, storage, and dispensing shall be classified in accordance with Table 11.3.2.14.1 for installations of electrical equipment.

10.3.1.4.8 Nonelectrical sources of ignition shall not be permitted.

10.3.1.4.9 Pressure relief valves on storage systems shall have a pressure relief valve vent system 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).

10.3.1.5 Ventilation Inlets and Outlets.

10.3.1.5.1 Indoor locations shall be ventilated utilizing air supply inlets and exhaust outlets arranged to provide uniform air movement throughout the space.

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

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

10.3.1.6 PRVs.

10.3.1.6.1 PRVs for CNG service shall not be fitted with lifting devices.

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

10.3.1.6.1.2 If at any time it is necessary to break such a seal as provided in 10.3.1.6.1.1, the valve shall be removed from service until it has been reset and sealed.

10.3.1.6.1.3 PRV 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.

10.3.1.6.1.4 The organization making such PRV adjustments shall attach a permanent tag with the setting, capacity, and date.

10.3.1.6.2 PRVs protecting ASME pressure vessels shall be repaired, adjusted, and tested in accordance with NB-23, *National Board Inspection Code*.

10.3.1.6.3* PRVs shall be maintained in safe operating condition.

10.3.1.6.4 PRVs shall have vent lines to convey escaping gas to the outdoors and then upward to prevent impinging on buildings, other equipment, or areas open to the public (e.g., sidewalks).

10.3.1.6.5 The PRV shall not have a setting greater than the maximum allowable working pressure of the line it protects.

10.3.1.7 Shutoff Valves.

10.3.1.7.1 Rating.

10.3.1.7.1.1 Shutoff valves shall have a rated pressure not less than the MAWP of the piping system on which it is installed.

10.3.1.7.1.2 Shutoff valves shall be capable of withstanding a hydrostatic test of at least four times the rated service pressure without rupture.

10.3.1.7.2 Access to an emergency manual shutoff valve(s) shall not require the use of any key or tool.

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

10.3.1.8 Interior Walls. Interior walls or partitions shall be continuous from floor to ceiling, be anchored in accordance with the requirements of the building code, and have a fire resistance rating of at least 2 hours.

10.3.1.9 Exterior Walls.

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

10.3.1.9.2 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

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

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

10.3.1.10 Ventilation.

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

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

10.3.1.10.3 The actuation of the gas detection system shall shut down the compressor and stop the flow of gas into the structure.

10.3.1.11 Reactivation. Reactivation of the fueling system shall be by manual restart that is conducted by trained personnel.

10.3.1.12 Residential Storage. (Reserved)

10.3.1.13 Maintenance.

10.3.1.13.1 Containers and their appurtenances, piping systems, compression equipment, controls, and detection devices shall be maintained in safe operating condition and according to manufacturers' instructions.

10.3.1.13.2 PRVs shall be maintained in safe operating condition.

10.3.1.13.3 Maintenance personnel shall be trained in leak detection procedures and equipment in accordance with manufacturers' recommendations.

10.4 LNG Supplemental Requirements. LNG container installation for indoor storage shall follow 17.5.7.

Chapter 11 CNG Fueling

11.1 Application. This chapter shall apply 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 other than residential fueling appliances (RFAs) and nonresidential fueling appliances or vehicle fueling appliances (VFAs), coverage of RFAs and VFAs is provided in Chapter 12 and Chapter 13 of this code, respectively.

11.2 General.

11.2.1 The installation of CNG systems shall be supervised by personnel familiar with proper practices with reference to their construction and use.

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

11.3* CNG Dispensing.

11.3.1 General System Requirements.

11.3.1.1 Where CNG dispensing systems are served by a gas utility, the gas utility shall be notified of this CNG installation.

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

11.3.1.3 The system shall be designed so that internal or external icing or hydrate formation does not cause vehicle or fueling station malfunction.

11.3.1.4 Sources of Ignition.

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

11.3.1.4.2 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.

11.3.1.5 A hazard analysis of the proposed modification and the startup plan shall be required and prepared prior to the modification and operation of the facility.

11.3.2 System Component Qualification. System components shall comply with the applicable provisions of Chapter 5 as well as 11.3.2.1 through 11.3.2.7.10 and 11.3.2.12 through 11.3.2.17.

11.3.2.1 Installation of Containers, Cylinders, and Tanks.

11.3.2.1.1 Installation of indoor tanks shall meet the requirements of Chapter 10.

11.3.2.1.2 Installation of outdoor tanks shall meet the requirements of Chapter 9.

11.3.2.2 Installation of Pressure Relief Devices.

11.3.2.2.1 Pressure relief valves shall be arranged so that they discharge to a location where escaping gas does not impinge on buildings, other equipment, or areas that are occupiable by the public (*see 10.3.1.4.9*).

11.3.2.2.2 Pressure relief valves on pressure vessels shall be installed so that any discharge is in a vertical position.

11.3.2.2.3 Pressure relief valve venting systems shall be designed to protect against the elements.

11.3.2.2.4 If approved, sized and lockable valves shall be permitted to be installed between the relief valves and the storage vessel or fueling transfer system.

11.3.2.2.5 The valves referenced in 11.3.2.2.4 shall be locked open under normal operating condition.

11.3.2.3 Installation of Pressure Relief Devices on Dispensing Systems. A pressure relief valve shall be installed in the fueling transfer system to prevent vehicle pressure from exceeding 125 percent of the vehicle service pressure.

11.3.2.3.1 The pressure relief valve shall be redundant to and independent from any operating control system used to control the supplied fuel pressure during dispenser operation.

11.3.2.3.2 The set pressure of the overpressure protection device shall not exceed 125 percent of the service pressure of the fueling nozzle it supplies.

11.3.2.4 Installation of Pressure Gauges. Gauges or other readout devices shall be installed to indicate compression discharge pressure, storage pressure, and dispenser discharge pressure.

11.3.2.5 Installation of Pressure Regulators.

11.3.2.5.1 Regulators shall be designed, installed, or protected so that their operation is not affected by freezing rain, sleet, snow, ice, mud, insects, or debris.

11.3.2.5.2 Regulator protection of 11.3.2.5.1 shall be permitted to be integral with the regulator.

11.3.2.6 Installation of Piping and Hoses.

11.3.2.6.1* Piping and hose shall be run directly with provisions for expansion, contraction, jarring, vibration, and settling.

11.3.2.6.1.1 Exterior piping shall be either buried or installed above ground and shall be supported and protected against mechanical damage.

11.3.2.6.1.2 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.

11.3.2.6.1.3 Underground and aboveground piping shall be protected from corrosion in compliance with recognized practices.

11.3.2.6.1.4 Threaded pipe and fittings shall not be used underground.

11.3.2.6.1.5* Piping installed in trench systems located below grade where the trench is open to above shall not be considered to be underground. [55:7.1.17.1.2]

11.3.2.7 Installation of Piping Connections.

11.3.2.7.1 Manifolds connecting fuel containers shall be fabricated to minimize vibration.

11.3.2.7.2 Manifolds shall be installed in a protected location or shielded to prevent damage from unsecured objects.

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

11.3.2.7.4 Threaded piping and fittings shall be clear and free from cutting or threading burrs and scales.

11.3.2.7.5 The ends of all piping shall be reamed.

11.3.2.7.6 A bend in piping or tubing shall be prohibited where such a bend is tighter than the minimum bend radius.

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

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

11.3.2.7.9 Natural gas shall be vented only to a safe point of discharge.

11.3.2.7.10 A vent pipe or stack shall have the open end protected to prevent entrance of rain, snow, and solid material.

11.3.2.7.11 Vertical vent pipes and stacks shall have provision for drainage.

11.3.2.8 Installation of Hose and Hose Connections. The use of hose for natural gas service shall be limited to the following:

- (1) Vehicle fueling hose
- (2) Inlet connection to compression equipment
- (3) Section of hose not exceeding 36 in. (910 mm) in length to provide flexibility where necessary

11.3.2.8.1 Each section shall be installed so that it is protected against mechanical damage and is visible for inspection.

11.3.2.8.2 The manufacturer's identification shall be retained in each section.

11.3.2.9 Installation of Valves.

11.3.2.9.1 Individual groups of manifolded ASME storage vessels without individual storage vessel valves shall be limited to a maximum of 10,000 scf (283 m³).

11.3.2.9.2 Manifolds serving each group of ASME storage vessels shall be provided with a manually operated shutoff valve.

11.3.2.9.3 Individual ASME pressure vessels of any size, not part of a manifold system, shall have a manual shutoff valve.

11.3.2.9.4 A manually operated shutoff valve shall be installed at the outlet from the manifold.

11.3.2.9.5 The valve in 11.3.2.9.4 shall be located downstream of the backflow check valve specified in 11.3.2.9.6.

11.3.2.9.6 Where there is a dedicated fill line on a storage container, it 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, fittings, or other equipment upstream of the storage containers.

11.3.2.9.7 Excess Flow Check Valve(s).

11.3.2.9.7.1 Where excess-flow check valves are used, the closing flow shall be greater than the maximum system design flow over the full range of operating pressures and less than the flow rating of the piping system that results from a complete line failure between the excess-flow valve and the equipment downstream of the excess-flow check valve.

11.3.2.9.7.2 Provisions shall be made for safe depressurization upstream of the device after it closes.

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

11.3.2.10 System Testing.

11.3.2.10.1 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 maximum operating pressure of that portion of the system.

11.3.2.10.2 Compression equipment that has, by design, inter-stage air movement and ventilation through the crankcase shall not be subjected to leak testing as its inclusion will give an erroneous test reading.

11.3.2.10.3 Pressure relief valves shall be tested and recertified at least every 3 years. ASME code pressure relief valves shall be tested in accordance with NB-514, *Accreditation of "VR" Repair Organizations*.

11.3.2.11 System Maintenance. The system maintenance requirements of 11.3.2.11 shall be retroactive and shall be applied to existing stations.

11.3.2.11.1 Containers and their appurtenances, piping systems, compression equipment, controls, and detection devices shall be maintained in safe operating condition and according to manufacturers' instructions.

11.3.2.11.2 Written instructions shall be provided for CNG dispensing systems to include the following:

- (1) Operating instructions
- (2) Emergency shutdown instructions
- (3) Maintenance and repair instructions
- (4) Instructions for pressure and temperature calibrations and functional checks to assure that the dispenser continues to satisfy the requirements of 11.3.2.13.

11.3.2.11.3 Dispensing System Maintenance.

11.3.2.11.3.1 Dispensing systems shall be maintained in accordance with the instructions required in 11.3.2.11.2 to verify pressure control and pressure relief valves

11.3.2.11.3.2 A written record of maintenance shall be provided.

11.3.2.11.4 After the original installation, vehicle fueling hoses shall be examined visually according to the manufacturers' recommendations or at least monthly to ensure that they are safe for use.

11.3.2.11.5 Hoses shall be tested for leaks in accordance with manufacturers' requirements.

11.3.2.11.5.1 Any leakage or surface cracks shall be reason for rejection and replacement.

11.3.2.11.6 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.

11.3.2.11.7* PRVs shall be maintained in safe operating condition.

11.3.2.11.8 Maintenance personnel shall be trained in leak detection procedures and equipment in accordance with manufacturers' recommendations.

11.3.2.12 Installation of Compression and Gas Processing Equipment.

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

11.3.2.12.2 Compression equipment shall have pressure relief valves that limit each stage pressure to the maximum allowable working pressure for the compression cylinder and piping associated with that stage of compression.

11.3.2.12.3 CNG compression equipment shall be equipped with a high discharge and a low suction pressure automatic shutdown control.

11.3.2.12.4 Control circuits that shut down shall remain down until manually activated or reset after a safe condition is confirmed.

11.3.2.12.5 Engine-driven compressor installations shall conform, where applicable, to NFPA 37.

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

11.3.2.12.7 A facility in which CNG compression, storage, and dispensing equipment are sheltered by weather protection constructed in accordance with the requirements of the building code and by a roof designed for ventilation and dispersal of escaped gas shall be considered to be located outdoors.

11.3.2.12.8 Location.

11.3.2.12.8.1 Compression, storage, and dispensing equipment located outdoors shall be above ground.

11.3.2.12.8.2 Compression, storage, and dispensing equipment located outdoors shall not be located where exposed to

failure of overhead electric power lines operating over 600 volts unless approved protection is provided.

11.3.2.12.8.3 Compression, storage, and dispensing equipment located outdoors shall be a minimum of 10 ft (3 m) from the nearest important building or line of adjoining property that is able to be built upon or from any source of ignition.

11.3.2.12.8.4 Compression, storage, and dispensing equipment located outdoors shall be not less than 10 ft (3 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.

11.3.2.12.9 Areas for compression, storage, and dispensing shall be classified in accordance with Table 11.3.2.14.1 for installations of electrical equipment.

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

11.3.2.12.11 An emergency manual shutdown device shall be provided both within 10 ft (3.0 m) of the dispensing area and greater than 25 ft (7.6 m) from the dispensing area.

11.3.2.13 Vehicle Fueling Dispensing Operation.

11.3.2.13.1 A vehicle fuel supply container shall not be charged in excess of the quantity of fuel that would result in a gas pressure equal to service pressure at a uniform temperature of 70°F (21°C).

11.3.2.13.2 Under no circumstances shall the vehicle fuel supply container be subjected to pressure in excess of 1.25 times the service pressure.

11.3.2.13.3 Title 49 CFR 571.304 or CSA/ANSI NGV 2 containers shall be charged in accordance with 49 CFR 571.304 regulations or CSA/ANSI NGV 2, *Compressed natural gas vehicle fuel containers*, requirements, as applicable.

11.3.2.13.4 The use of adapters to defeat the pressure-specific nozzle and receptacle connections shall be prohibited.

11.3.2.13.5 CNG dispensing systems shall be equipped to stop fuel flow automatically when a vehicle fuel supply container reaches maximum fill conditions of 11.3.2.13.

11.3.2.13.6 Malfunctions. The dispenser shall be designed to detect any malfunction that fills the vehicle fuel container in excess of the limits specified, or causes the relief valve required in 11.3.2.3 to open. If a malfunction is detected, it shall perform the following:

- (1) The dispenser shall disable itself and provide clear visual annunciation until repaired, calibrated, or serviced.
- (2) The dispenser shall notify the vehicle operator or fueling technician that the vehicle has been overfilled.
- (3) After any such malfunction, the dispenser shall be repaired and calibrated in accordance with 4.5.1.1 before continued operation.

11.3.2.13.6.1 Repairs.

(A) After any such malfunction, the dispenser shall be repaired and calibrated in accordance with 11.3.2.11 before continued operation.

(B)* The excess fuel shall be removed from the vehicle by qualified person(s) only.

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

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

11.3.2.13.9 CNG Transfer.

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

11.3.2.13.9.2 Personnel filling CNG bulk transport cylinders or vehicles shall be instructed and trained in accordance with DOT hazardous materials regulations.

11.3.2.13.10 Transfer systems shall be capable of depressurizing to facilitate disconnection.

11.3.2.13.11 Bleed connections shall lead to a safe point of discharge.

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

11.3.2.13.13* A warning sign(s) shall be posted at the dispensing points with the following words:

FLAMMABLE GAS — STOP MOTOR, NO SMOKING.

NATURAL GAS VEHICLE FUEL CYLINDERS SHALL BE INSPECTED AT INTERVALS NOT EXCEEDING 3 YEARS TO ENSURE SAFE OPERATION OF THE VEHICLE.

NATURAL GAS FUEL CYLINDERS PAST THEIR END-OF-LIFE DATE SHALL NOT BE REFUELED AND SHALL BE REMOVED FROM SERVICE.

11.3.2.13.13.1 Each fast- or slow-fill CNG dispenser shall display a sign stating the following:

THIS CNG DISPENSER HAS TEMPERATURE COMPENSATION.

11.3.2.13.13.2 The service pressure of each dispenser shall be posted in view of the operator.

11.3.2.14* Installation of Electrical Equipment.

11.3.2.14.1 Electrical Installations. Fixed electrical equipment and wiring within areas specified in Table 11.3.2.14.1 shall comply with Table 11.3.2.14.1 and be installed in accordance with NFPA 70.

11.3.2.14.1.1 Electrical equipment on internal combustion engines installed in accordance with NFPA 37 shall not be subject to 11.3.2.14.1.

11.3.2.14.2 With the approval of the AHJ, classified areas specified in Table 11.3.2.14.1 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.

11.3.2.14.3 Classified Areas.

11.3.2.14.3.1 Classified areas shall not extend beyond an unpierced wall, roof, or vaportight partition.

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

11.3.2.14.4 Space around welded pipe and equipment without flanges, valves, or fittings shall be a nonhazardous location.

Table 11.3.2.14.1 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
Compression and ancillary equipment	2	Up to 15 ft (4.6 m) from equipment
Dispensing equipment outdoors	1	Inside the dispenser enclosure gas compartment
Outdoors	2	From 0 to 5 ft (0 to 1.5 m) from the dispenser enclosure gas compartment
Indoors	1	Inside the dispenser enclosure gas compartment
Indoors	2	Entire room, with adequate ventilation (see 10.3.1.1)
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)

11.3.2.15 Stray or Impressed Current.

11.3.2.15.1* Where stray or impressed currents, such as those from cathodic protection, are used or present on dispensing systems, protective measures shall be taken to prevent ignition.

11.3.2.15.2* Static protection shall not be required where CNG is transferred by conductive hose, flexible metallic tubing, or pipe connections where both halves of the metallic couplings are in continuous contact.

11.3.2.16 Installation of Emergency Shutdown Equipment.

11.3.2.16.1 Manually Operated Container Valve.

11.3.2.16.1.1 Individual groups of manifolded ASME storage vessels without individual storage vessel valves shall be limited to a maximum of 10,000 scf (283 m³).

11.3.2.16.1.2 Manifolds serving each group of ASME storage vessels shall be provided with a manually operated shutoff valve.

11.3.2.16.1.3 Individual ASME pressure vessels of any size, not part of a manifold system, shall have a manual shutoff valve.

11.3.2.16.1.4 A manually operated shutoff valve shall be installed at the outlet from the manifold.

11.3.2.16.1.5 The valve in 11.3.2.16.1.3 shall be located downstream of the backflow check valve specified in 11.3.2.16.2.

11.3.2.16.2 Where there is a dedicated fill line on a storage container, it 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, fittings, or other equipment upstream of the storage containers.

11.3.2.16.3 Excess-Flow Valve(s).

11.3.2.16.3.1 Where excess-flow check valves are used, the closing flow shall be greater than the maximum system design flow over the full range of operating pressures and less than the flow rating of the piping system that results from a complete line failure between the excess-flow valve and the equipment downstream of the excess-flow check valve.

11.3.2.16.3.2 Provisions shall be made for safe depressurization upstream of the device after it closes.

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

11.3.2.16.5 An emergency manual shutdown device shall be provided within 10 ft (3.0 m) of the dispensing area and also greater than 25 ft (7.6 m) from the dispensing area.

11.3.2.16.5.1 This device, when activated, shall shut off the power supply and gas supply to the compressor and the dispenser.

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

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

11.3.2.16.6.1 A breakaway device shall be installed at every dispensing point.

11.3.2.16.6.2 A breakaway device shall be arranged to separate using a force not greater than 150 lb (68 kg) when applied in any direction that the vehicle would move.

11.3.2.16.6.3 Breakaway devices shall comply with **CSA/ANSI NGV 4.4**, *Breakaway devices for natural gas dispensing hoses and systems*.

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

11.3.2.16.8 Control circuits shall be arranged so that, when an electric power is cut off (i.e., blackout condition), systems that shut down remain off until manually activated or reset after a safe condition is confirmed.

11.3.2.16.9 Control circuits shall be arranged so that, when an electric power is interrupted (i.e., brownout condition) or a system is equipped with backup power, systems that shut down should be allowed to reset and resume operation.

11.3.2.16.10 Fast-Fill Station.

11.3.2.16.10.1 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.

11.3.2.16.10.2 A fast-closing, "quarter turn" manual shutoff valve shall be provided at a fast-fill station upstream of the breakaway device specified in 11.3.2.16.6, where it is accessible to the person dispensing natural gas, unless one of the following occurs:

- (1) The self-closing valve referred to in 11.3.2.16.10.1 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.

11.3.2.16.11 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 compressor is switched to the OFF position.

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

11.3.3 Indoor Dispensing to Non-Public Users.

11.3.3.1 Indoor Non-Public Fast-Fill Fueling.

11.3.3.1.1 Indoor Fast-Fill Fueling, Outdoor Storage, and Compression. Fast-fill fueling indoors shall be permitted where storage and compression equipment is located outdoors complying with 5.2.1.1.1 through 5.2.1.1.4, 9.3.1, 9.3.2, 9.3.6.1, 11.3.4.1.5, and 11.3.4.1.7.

11.3.3.1.1.1 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 11.3.2.16.5.

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

11.3.3.1.1.2 The actuation of the indoor gas detection system shall shut down the compressor and stop the flow of gas into the structure.

11.3.3.1.1.3 Reactivation of the fueling system shall be by manual restart that is conducted by trained personnel and in accordance with a process safety analysis.

11.3.3.1.2 Equipment Location. (Reserved)

11.3.3.1.3 Ventilation. (Reserved)

11.3.3.1.4 Electrical Classification. (Reserved)

11.3.3.1.5 Fire Detection. (Reserved)

▲ 11.3.3.1.6 Fire Alarm System. (Reserved)

11.3.3.1.7 Emergency Shutdown System. (Reserved)

11.3.3.1.8 Dispensing Equipment. (Reserved)

11.3.3.2 Indoor Non-Public Slow-Fill Fueling. (Reserved)

11.3.4 Outdoor Non-Public Fueling.

11.3.4.1 General.

11.3.4.1.1 A facility in which CNG compression, storage, and dispensing equipment are sheltered by weather protection constructed in accordance with the requirements of the building code and by a roof designed for ventilation and dispersal of escaped gas shall be considered to be located outdoors.

11.3.4.1.2 Compression, storage, and dispensing equipment located outdoors shall be above ground.

11.3.4.1.2.1 Compression, storage, and dispensing equipment located outdoors shall not be beneath electric power lines or where exposed by their failure.

11.3.4.1.2.2 Compression, storage, and dispensing equipment located outdoors shall be a minimum of 10 ft (3 m) from the nearest important building or line of adjoining property that is able to be built upon or from any source of ignition.

11.3.4.1.3 Compression, storage, and dispensing equipment located outdoors shall be not less than 10 ft (3 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.

11.3.4.1.4 Combustible material shall not be permitted within 10 ft (3 m) of any stationary container.

11.3.4.1.5 The minimum separation between containers and aboveground tanks containing flammable or combustible liquids shall be 20 ft (6 m).

11.3.4.1.6 Point of Transfer.

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

11.3.4.1.6.2 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 m) from any building openings.

11.3.4.1.7 Areas for compression, storage, and dispensing shall be classified in accordance with Table 11.3.2.14.1 for installations of electrical equipment.

11.3.4.2 Outdoor Non-Public Fueling from Transport Vehicles Including Marine Vessels.

11.3.4.2.1 Mobile Refueling Stations.

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

11.3.4.2.1.2 Mobile refueling equipment shall be in accordance with DOT regulations for transportation of hazardous materials.

(A) The mobile refueling equipment shall prevent overfilling of vehicles or storage containers.

(B) The connections to and from the refueling equipment shall incorporate a breakaway device in accordance with 11.3.2.16.6.

11.3.5 Storage. CNG storage shall be in accordance with Chapters 9 and 10.

11.3.6 Dispensing to the Public.

11.3.6.1 General.

11.3.6.1.1 CNG compression, storage, and dispensing shall be located and conducted in compliance with this section.

11.3.6.1.2 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.

11.3.6.2 Indoor Public Fueling.

11.3.6.2.1 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.

11.3.6.2.1.1 Nonelectrical sources of ignition shall not be permitted.

11.3.6.2.1.2 Pressure relief valves on storage systems shall have a pressure relief valve vent system 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).

11.3.6.2.2* Deflagration Venting. Deflagration (explosion) venting shall be provided in exterior walls or roof only.

11.3.6.2.3 Vents. 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

11.3.6.2.4 Snow Loads. Where applicable, snow loads shall be considered.

11.3.6.2.5 Rooms Within Buildings.

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

11.3.6.2.5.2 Window glazing shall be permitted to be plastic.

11.3.6.2.5.3 Interior walls or partitions shall be continuous from floor to ceiling, be anchored in accordance with the requirements of the building code, and have a fire resistance rating of at least 2 hours.

11.3.6.2.5.4 At least one wall shall be an exterior wall.

11.3.6.2.5.5 Explosion venting shall be provided in accordance with 11.3.6.2.2.

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

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

11.3.6.2.6 Ventilation.

11.3.6.2.6.1 Indoor locations shall be ventilated utilizing air supply inlets and exhaust outlets arranged to provide uniform air movement throughout the space.

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

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

11.3.6.2.6.4 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.

11.3.6.2.6.5 In either case in 11.3.6.2.6.4, the system shall immediately shut down the fueling system in the event of detection of an alarm condition or failure of the ventilation system, the detection system, or the controls.

11.3.6.2.6.6* The ventilation rate shall be at least 1 cfm/min/12 ft³ (1 m³/min/11.3 m³) of room volume.

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

11.3.6.2.6.8 Buildings and rooms used for compression, storage, and dispensing shall be classified in accordance with Table 11.3.2.14.1 for installations of electrical equipment.

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

11.3.6.2.8 Reactivation. Reactivation of the fueling system shall be by manual restart that is conducted by trained personnel.

11.3.6.2.9 Warning Signs.

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

11.3.6.2.9.2 The wording shall be in plainly legible, bright red letters not less than 1 in. (25 mm) high on a white background.

11.3.6.3 Indoor Fast-Fill Fueling, Outdoor Storage, and Compression. Fast-fill fueling indoors shall be permitted where storage and compression equipment is located outdoors complying with 5.2.1.1.1, 5.2.1.1.2, 5.2.1.1.3, 5.2.1.1.4, 9.3.1, 9.3.2, 11.3.4.1.5, and 11.3.4.1.7.

11.3.6.3.1 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 11.3.2.16.5.
- (2) A gas detection system equipped to sound a latched alarm and visually indicate when a maximum of one-fifth of the lower flammable limit is reached shall be installed.

11.3.6.3.2 The actuation of the gas detection system shall shut down the compressor and stop the flow of gas into the structure.

11.3.7 Outdoor Public Fueling.

11.3.7.1 General.

11.3.7.1.1 A facility in which CNG compression, storage, and dispensing equipment are sheltered by weather protection constructed in accordance with the requirements of the building code and by a roof designed for ventilation and dispersal of escaped gas shall be considered to be located outdoors.

11.3.7.1.2 Compression, storage, and dispensing equipment located outdoors shall be above ground.

11.3.7.1.3 Dispensing Equipment Location.

11.3.7.1.3.1 Compression, storage, and dispensing equipment located outdoors shall not be beneath electric power lines or where exposed by their failure.

11.3.7.1.3.2 Compression, storage, and dispensing equipment located outdoors shall be a minimum of 10 ft (3 m) from the nearest important building or line of adjoining property that is able to be built upon or from any source of ignition.

11.3.7.1.3.3 Compression, storage, and dispensing equipment located outdoors shall be not less than 10 ft (3 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.

11.3.7.1.4 Point of Transfer.

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

11.3.7.1.4.2 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 m) from any building openings.

Chapter 12 Residential CNG Fueling Appliances

12.1 Application.

12.1.1 This chapter applies to the design, construction, installation, and operation of residential fueling appliances (RFA) listed to ANSI/CSA NGV 5.1, *Residential fueling applications*, or its equivalent.

12.1.2 The capacity of a residential fueling appliance (RFA) listed or approved for indoor refueling shall not exceed an inlet flow rate of 5 scf/min (0.14 scm/min) of natural gas.

12.1.3 The capacity for an RFA listed or approved for outdoor fueling shall not exceed an inlet flow rate of 10 scf/min (0.28 scm/min) of natural gas.

12.1.4 For indoor units, the total volume of contained gas by the RFA package shall not exceed 9.0 scf (0.25 scm).

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

12.1.4.2 For outdoor units, the total volume of gas contained by the RFA package shall not exceed 750 scf (21 scm) and any single storage container shall not exceed 433 scf (12.3 scm).

12.2 System Component Qualifications.

12.2.1 System components not part of a listed RFA shall comply with the appropriate provisions in Chapters 8 and 11.

12.2.2 The installation of RFAs shall be exempt from the requirements of 5.1.1 as well as 15.4.3.2 through 15.4.3.4, 11.3.1, 11.3.2, 9.3.3, 11.3.2.4, 11.3.2.6, 11.3.2.10, 11.3.2.11, and 11.3.2.13 through 11.3.2.16.

12.3 General Safety Requirements.

12.3.1 All equipment related to an RFA installation shall be protected to minimize the possibility of physical damage and vandalism.

12.3.2 The use of an enclosure for the compressor package, similar to that of a central air conditioner, shall be permitted to satisfy 12.3.1.

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

12.3.4 Vehicle Equipment and Classification.

12.3.4.1 Vehicles shall be unclassified electrically with respect to Article 500 of *NFPA 70*.

12.3.4.2 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 are not permitted.

12.3.5 Natural Gas Venting.

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

12.3.5.2 Release of gas to the atmosphere during disconnection of the refueling hose connector from the vehicle receptacle shall be permitted in accordance with CSA/ANSI NGV 1, *Compressed natural gas vehicle (NGV) fueling connection devices*.

12.3.6 In a residential installation, RFAs shall not be installed in series or shall not be manifolded together on the discharge side.

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

12.3.8 RFAs shall not be installed within 10 ft (3.0 m) of any other flammable gas or liquid storage.

12.4 Installation.

12.4.1 General.

12.4.1.1 All RFA equipment shall be installed in accordance with the equipment manufacturer's instructions.

12.4.1.2 The RFA shall have a nameplate marked with minimum and maximum gas inlet pressures, gas outlet maximum pressure, and electrical requirements.

12.4.2 Indoors.

12.4.2.1 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.

12.4.2.2* Where the RFA or the vehicle being fueled is located indoors, a gas detector set to operate at one-fifth the lower flammable limit (LFL) of natural gas shall be installed in the room.

12.4.2.2.1 The detector shall be located within 6 in. (150 mm) of the ceiling or the highest point in the room.

12.4.2.2.1.1 An RFA that is listed shall be permitted to utilize a combination of ventilation or gas detection to ensure that the room is maintained at a level below one-fifth of the lower limit of flammability of natural gas.

12.4.2.2.1.2 Meeting the provisions of 12.4.2.2.1 shall be deemed to be equivalent to a gas detector located within 6 in. (150 mm) of the ceiling or the highest point in the room.

12.4.2.2.2 The detector shall stop the compressor and operate an audible and a visual alarm.

12.4.3 Outdoors. The RFA shall be installed on a firm, noncombustible support to prevent undue stress on piping and conduit. (*See Section 4.2 for noncombustible.*)

12.5 Installation of PRVs. PRVs shall have PRD vents or vent lines to convey escaping gas to the outdoors and then upward to prevent impinging on buildings, other equipment, or areas open to the public (e.g., sidewalks).

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

12.7 Pressure Regulation. An RFA shall be equipped to stop fuel flow automatically when the container(s) reaches the maximum fill conditions of 11.3.2.13.1.

12.8 Piping and Hose.

12.8.1 All gas piping to the RFA shall be installed in accordance with NFPA 54 and manufacturers' installation instructions.

12.8.2 Bleed connections shall lead to a safe point of discharge.

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

12.10 Operation.

12.10.1 An RFA shall be operated in accordance with the manufacturer's instructions.

12.10.2 DOT and TC containers shall be charged in accordance with DOT and TC regulations.

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

12.11 Maintenance and Inspection.

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

12.11.2 After installation, all hose shall be examined visually as part of this inspection.

12.11.3 Hose that are kinked or worn shall be replaced.

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

Chapter 13 Nonresidential CNG Fueling Appliances**13.1 General.**

13.1.1 This chapter shall apply to the installation and operation of a vehicle fueling appliance (VFA) listed to CSA/ANSI NGV 5.2, *Vehicle fueling appliances (VFA)*, or its equivalent, and to residential fueling appliances (RFAs) installed at nonresidential occupancies.

13.1.2 VFAs shall not exceed the following flow rates:

- (1) For VFAs listed for indoor installation or indoor fueling, inlet flow rates shall not exceed 5.0 scf/min (0.14 scm/min).
- (2) For VFAs listed for outdoor installation and outdoor fueling, inlet flow rates shall not exceed 10 scf/min (0.28 scm/min).

▲ **13.1.3*** VFAs shall be listed to CSA/ANSI NGV 5.2, *Vehicle fueling appliances (VFA)*, or its equivalent, and installed in accordance with their listing and installation instructions.

13.1.4 System components not part of a listed VFA shall comply with the appropriate provisions in Chapters 8 and 11.

▲ **13.1.5** The installation of VFAs listed to CSA/ANSI NGV 5.2, *Vehicle fueling appliances (VFA)*, that do not contain more than 9.0 scf (0.25 scm) of gas shall be exempt from the requirements of Section 4.2 as well as 5.2.1.1.1 through 5.2.1.1.5, 9.3.1, 9.3.2, 10.3.1.1 through 10.3.1.5, 11.3.1, 11.3.2.2, 11.3.2.4, 11.3.2.6, 11.3.2.10, 11.3.2.11, 11.3.2.13 through 11.3.2.17, 11.3.6.2.2, 15.4.3.2 through 15.4.3.6, and 15.4.3.8.

13.1.6 The installation of VFAs listed to CSA/ANSI NGV 5.2, *Vehicle fueling appliances (VFA)*, that contain more than 9.0 scf (0.25 scm) of gas shall be exempt from the requirements of Section 4.2 as well as 11.3.1, 11.3.2.2, 11.3.2.4, 11.3.2.6, 11.3.2.10, 11.3.2.11, 11.3.2.13 through 11.3.2.17, 11.3.6.2.2, 15.4.3.2 through 15.4.3.6, and 15.4.3.8.

13.1.7* An RFA installed in a nonresidential setting shall be exempt from the requirements of Section 4.2, 5.2.1.1.1 through 5.2.1.1.5, 9.3.1, 9.3.2, 10.3.1.1 through 10.3.1.5, 11.3.1, 11.3.2.2, 11.3.2.4, 11.3.2.6, 11.3.2.10, 11.3.2.11, 11.3.2.13

through 11.3.2.17, 11.3.6.2.2, 15.4.3.2 through 15.4.3.6, and 15.4.3.8.

13.1.8 VFAs shall not be installed at residential occupancies.

13.1.9 Spacing.

13.1.9.1 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.

13.1.9.2* VFAs shall not be installed in series.

13.1.10 VFAs shall not be installed within 10 ft (3 m) of any other flammable gas or liquid storage, except for the following:

- (1) Storage in the vehicle fuel supply container
- (2) Gas contained within the VFA for outdoor installation

13.1.11 Public Assembly and Educational Occupancies.

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

13.1.11.2 Where installed indoors in public assembly and educational occupancies, and a VFA is located outdoors, the dispensing point shall be permitted to be located indoors without the need for a separate room.

13.1.12 VFAs and Stationary Containers.

13.1.12.1 VFAs shall be permitted to be used to fill stationary containers and to be connected to dispensing equipment at vehicle fueling locations.

13.1.12.2 The method of connecting the VFA to such storage and dispensing equipment shall comply with the provisions of Chapters 5, 7, and 8 and shall be approved.

13.1.12.3 The design, siting, and installation of the storage in 13.1.12.1 shall comply with the provisions of Chapters 8 and 9.

13.1.12.4 Subsection 13.1.4 shall apply to the VFA when connected to stationary containers at vehicle fueling locations.

13.1.12.5 The exemptions contained in 13.1.4 shall not apply to the stationary containers and dispensing equipment in 13.1.12.

13.1.13 VFA Containers.

13.1.13.1 Containers used in a VFA shall comply by design with one of the following, as applicable:

- (1) Department of Transportation (DOT) or Transport Canada (TC) regulations, exemptions, or special permits
- (2) CSA B51, *Boiler, pressure vessel, and pressure piping code*, Part 3
- (3) ASME *Boiler and Pressure Vessel Code*, Section VIII or X
- (4) CSA/ANSI NGV 2, *Compressed natural gas vehicle fuel containers*

13.1.13.2 Inspection requirements for any container shall be per the applicable container design standard.

13.1.14 VFA Storage Limits.**13.1.14.1 VFAs Installed Indoors.**

▲ **13.1.14.1.1** The aggregate quantity of gas contained within VFAs listed to CSA/ANSI NGV 5.2, *Vehicle fueling appliances (VFA)*, shall not exceed 9.0 scf (0.25 scm) per every 1000 ft³

(28.3 m³) of contiguous building volume of nonresidential buildings.

13.1.14.1.2 For contiguous building volumes exceeding 28.3 m³ (1000 ft³), one combustible gas detector shall be mounted on the VFA and additional gas detection shall be installed in proximity to the VFA and located in accordance with good engineering practice.

Δ 13.1.14.2 VFAs Installed Outdoors. Storage contained within a VFA listed to CSA/ANSI NGV 5.2, *Vehicle fueling appliances (VFA)*, shall conform to all of the following:

- (1) Shall not exceed 3000 scf (85 scm) total volume
- (2) Shall not contain gas at pressure above the VFA's outlet service pressure rating
- (3) Shall have no single container with capacity more than 750 scf (21.3 scm)

13.1.15 Gas Detectors.

13.1.15.1 Where the VFA or the vehicle being fueled is located indoors, a gas detector set to operate at one-fifth the lower flammable limit (LFL) of natural gas shall be installed in the room.

13.1.15.2 Gas detectors shall be located and installed in accordance with manufacturers' installation instructions and good engineering practices.

13.2 Installation.

13.2.1 All VFA equipment shall be installed in accordance with the equipment manufacturer's instructions.

13.2.2 All equipment related to a VFA installation shall be protected to minimize the possibility of physical damage and vandalism.

13.2.3 The VFA shall be installed on a firm noncombustible support to prevent undue stress on piping and conduit.

13.2.4 All gas piping to the VFA shall be installed in accordance with NFPA 54 and the manufacturer's installation instructions.

13.2.5 All piping and tubing to the VFA shall be tested for leaks after installation at a pressure equal to the maximum operating pressure of that portion of the system.

13.2.6 Where a VFA is installed indoors the unit shall be mounted or otherwise located such that the unit is vented to the outdoors.

13.2.7 Pressure relief valves (PRVs) shall have pressure relief devices (PRD) vents or vent lines to convey escaping gas to the outdoors and then upward to prevent impinging on buildings, other equipment, or areas open to the public (e.g., sidewalks).

13.2.8 An electrical disconnection means shall be provided at least 5 ft (1.5 m) from the VFA and in view of the VFA.

13.3 Operation.

13.3.1 A VFA shall be operated in accordance with the manufacturer's instructions.

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

13.4 Maintenance and Inspection.

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

13.4.2 After installation, all hose shall be examined visually as part of this inspection.

13.4.3 Hose that are kinked or worn shall be replaced.

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

Chapter 14 LNG Fueling

14.1 Application. This chapter applies to the design, siting, construction, installation, spill containment, and operation of containers, pressure vessels, pumps, vaporization equipment, buildings, structures, and associated equipment used for the storage and dispensing of LNG and LCNG as engine fuel for vehicles of all types.

14.2 General.

14.2.1 Designers, fabricators, and constructors of LNG fueling facilities shall be competent in the design, fabrication, and construction of LNG containers, cryogenic equipment, loading and unloading systems, fire protection equipment, methane detection, and other components of the facility.

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

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

14.2.4 Supervision shall be provided for the fabrication, construction, and acceptance tests of facility components to the extent necessary to ensure that facilities are structurally sound, suitable for the service, and otherwise in compliance with this code.

14.3* LNG Dispensing.

14.3.1 General.

14.3.1.1 LNG refueling sites utilizing or dispensing saturated LNG with personnel in the immediate vicinity shall provide barrier walls or equal protection in order to protect the refueling operator and vehicle.

14.3.1.2 All facility piping other than the refueling hose to the vehicle shall be behind a barrier, which in the case of an equipment or device malfunction deflects the saturated LNG upward.

14.3.2 System Component Qualification.

14.3.2.1 Design and Construction of Stationary Tanks. The installation of stationary ASME tanks for LNG shall be in accordance with Chapter 17.

14.3.2.2 Pressure Relief Devices.

14.3.2.2.1 Pressure relieving safety devices shall be so arranged that the possibility of damage to piping or appurtenances is reduced to a minimum.

14.3.2.2.2 The means for adjusting relief valve set pressure shall be sealed.

14.3.2.2.3 Stationary LNG containers shall be equipped with pressure relief devices in accordance with CGA S-1.3, *Pressure Relief Device Standards — Part 3 — Stationary Storage Containers for Compressed Gases*.

14.3.2.2.4 A thermal expansion relief valve shall be installed as required to prevent overpressure in any section of a liquid or cold vapor pipeline that can be isolated by valves.

(A) Thermal expansion relief valves shall be set to discharge above the maximum pressure expected in the line but less than the rated test pressure of the line it protects.

(B) Discharge from thermal expansion relief valves shall be directed so as to minimize hazard to personnel and other equipment.

14.3.2.3 Pressure Gauges. Pressure gauges shall be installed on each pump and compressor discharge.

14.3.2.4 Pressure Regulators. (Reserved)

14.3.2.5 Temperature Instruments.

14.3.2.5.1 Vaporizers and Heaters.

14.3.2.5.1.1 Vaporizers and heaters shall be provided with instrumentation to monitor outlet temperatures.

14.3.2.5.1.2 Ambient pressure–building coil vaporizers that are fed with liquid from, and return vapor to, a container shall not be subject to 14.3.2.5.1.1.

14.3.2.5.2 Temperature monitoring systems shall be provided where the foundations supporting cryogenic containers and equipment are subject to adverse effects by freezing or frost heaving of the ground.

14.3.2.6 Fuel Lines and Piping Systems.

14.3.2.6.1 Piping shall be in accordance with Chapter 17.

14.3.2.6.2 Piping Connections.

14.3.2.6.2.1 Bleed or vent connections shall be provided so that loading arms and hose can be drained and depressurized prior to disconnection if necessary.

14.3.2.6.2.2 Bleed or vent connections shall lead to a safe point of discharge.

14.3.2.7 Corrosion Control.

14.3.2.7.1 Underground and submerged piping shall be protected and maintained in accordance with the principles of NACE SP0169, *Control of External Corrosion of Underground or Submerged Metallic Piping Systems*.

14.3.2.7.2 Austenitic stainless steels and aluminum alloys shall be protected to minimize corrosion and pitting from corrosive atmospheric and industrial substances during storage, construction, fabrication, testing, and service.

(A) These substances shall include, but not be limited to, chlorides and compounds of sulfur or nitrogen.

(B) Tapes or other packaging materials that are corrosive to the pipe or piping components shall not be used.

(C) Where insulation materials cause corrosion of aluminum or stainless steels, inhibitors or waterproof barriers shall be utilized.

▲ **14.3.2.7.3** Corrosion protection of all other materials shall be in accordance with the requirements of SSPC-PA 1, *Shop, Field and Maintenance Painting of Steel*, SSPC-PA 2, *Determining Compliance to Required DFT*; and SSPC-SP 6/NACE No. 3, *Commercial Blast Cleaning*.

14.3.2.8* Maintenance.

14.3.2.8.1 The maintenance program shall be carried out by a qualified representative of the equipment owner.

• **14.3.2.8.2** Maintenance shall be performed based on the component manufacturers' recommendations and not less than every 6 months.

• **14.3.2.8.3** The refueling site shall have a maintenance program or process safety analysis program in place.

• **14.3.2.8.4** Maintenance records shall be kept for the duration of the fueling operation.

• **14.3.2.9 Inspection, Tests, and Maintenance.** All maintenance and servicing shall be done in accordance with 29 CFR 1910 for energy control.

• **14.3.2.10** All LNG facilities shall be free from rubbish, debris, and other material that will present a fire hazard to the distance of at least 25 ft (7.6 m).

14.3.2.11 Grass areas on the LNG fueling facility grounds shall be maintained in a manner that does not present a fire hazard.

14.3.2.12 Safety and fire protection equipment shall be tested or inspected at intervals not to exceed six months.

• **14.3.2.13** Maintenance activities on fire control equipment shall be scheduled so that a minimum of equipment is taken out of service at any one time and fire prevention safety is not compromised.

• **14.3.2.14** Access routes for movement of fire control equipment to an LNG fueling facility shall be maintained at all times.

• 14.3.2.15 Compression and Gas Processing.

14.3.2.15.1 Siting.

14.3.2.15.1.1 LNG tanks and their associated equipment shall not be located where exposed to failure of overhead electric power lines operating over 600 volts.

14.3.2.15.1.2 Vaulted or underground installations shall be deemed to provide engineered protection from overhead power lines.

14.3.2.15.1.3 If other combustible or hazardous liquids are able to encroach on the LNG fueling facility, means shall be provided to protect the LNG facility.

14.3.2.15.1.4 Fired equipment shall be located in accordance with Table 14.3.2.21.1 from any impounding area or container drainage system.

14.3.2.15.1.5 Points of transfer shall be located not less than 25 ft (7.6 m) from the nearest important building not associated with the LNG facility, from the line of adjoining property that is able to be built upon, or from fixed sources of ignition.

14.3.2.15.2 Spill Containment.

14.3.2.15.2.1 Site preparation shall include provisions for retention of spilled LNG within the limits of plant property and for surface water drainage.

14.3.2.15.2.2 Saturated LNG in an ASME container [50 psi (345 kPa) and above] shall only have to meet the requirements of 14.3.2.15.2.1 with respect to construction of the impounding area.

14.3.2.15.2.3 Enclosed drainage channels for LNG shall be prohibited.

14.3.2.15.2.4* Impounding areas, if provided to serve LNG transfer areas, shall have a minimum volumetric capacity equal to the greatest volume of LNG or flammable liquid that could be discharged into the area during a 10-minute period from any single accidental leakage source or a lesser time period based on demonstrable surveillance and shutdown provisions acceptable to the AHJ.

14.3.2.15.2.5 Flammable liquid storage tanks shall not be located within an LNG container impounding area.

▲ 14.3.2.15.2.6* Impounding areas serving aboveground and mounded LNG containers shall have a minimum volumetric holding capacity, including any useful holding capacity of the drainage area and with allowance made for the displacement of snow accumulation, other containers, and equipment, in accordance with 14.3.2.15.2.7 and 14.3.2.15.2.8.

▲ 14.3.2.15.2.7 Where containers in the dike area are constructed or protected to prevent failure from spilled LNG and fire in the dike, the minimum holding of the dike shall be the volume of the largest container in the dike.

▲ 14.3.2.15.2.8 Where containers in the dike area are not constructed or protected to prevent failure from spilled LNG and fire in the dike, the minimum holding of the dike shall be equal to the total volume of the containers in the dike area.

14.3.2.15.2.9 The containment design shall include calculations and shall be installed to prevent overflow due to spill wave action.

14.3.2.15.2.10 The containment design shall prevent projecting LNG or cold gas beyond the containment area.

14.3.2.15.2.11 Provisions shall be made to clear rain or other water from the impounding area.

14.3.2.15.2.12 Automatically controlled sump pumps shall be permitted if equipped with an automatic cutoff device that prevents their operation when exposed to LNG temperatures.

14.3.2.15.2.13 Piping, valves, and fittings whose failure permits liquid to escape from the impounding area shall be designed for continuous exposure to LNG temperatures.

14.3.2.15.2.14 If gravity drainage is employed for water removal, provisions shall be made to prevent the escape of LNG by way of the drainage system.

14.3.2.15.2.15 The spacing of LNG dispensing equipment relative to other equipment, activities, nearby property lines, and other exposures in a fuel dispensing forecourt shall be approved by the AHJ.

14.3.2.16 Stationary Pumps and Compressors.

14.3.2.16.1 Valves shall be installed such that each pump or compressor can be isolated for maintenance.

14.3.2.16.2 Where pumps or centrifugal compressors are installed for operation in parallel, each discharge line shall be equipped with a check valve.

14.3.2.16.3 Foundations and sumps for cryogenic pumps shall be designed and constructed to prevent frost heaving.

14.3.2.16.4 Operation of all pumps and compressors shall cease when the facility's ESD system is initiated.

14.3.2.16.5 Each pump shall be provided with a vent or relief valve that prevents overpressurizing of the pump case under all conditions, including the maximum possible rate of cool down.

14.3.2.16.6 Compression equipment handling flammable gases shall be provided with vent line connections from all points, including distance pieces of packing for piston rods, where gases escape.

14.3.2.16.7 Vents shall be piped outside of buildings to a point of safe disposal.

14.3.2.17 Vaporizers.

14.3.2.17.1 Multiple vaporizers shall be manifolded such that both inlet and discharge block valves are installed on each vaporizer.

14.3.2.17.2 If the intermediate fluid used with a remote heated vaporizer is flammable, shutoff valves shall be provided on both the hot and cold lines of the intermediate fluid system.

14.3.2.17.3 A low temperature switch or other accepted means shall be installed on the vaporizer discharge to eliminate the possibility of LNG or cold natural gas entering CNG containers and other equipment not designed for LNG temperatures.

14.3.2.17.4 Relief valves on heated vaporizers shall be located so that they are not subjected to temperatures exceeding 140°F (60°C) during normal operation unless they are designed to withstand higher temperatures.

14.3.2.17.5 The combustion air required for the operation of integral heated vaporizers or the primary heat source for remote heated vaporizers shall be taken from outside an enclosed structure or building.

14.3.2.17.6 Vaporizers for purposes other than pressure building coils or LNG-to-CNG (LCNG) systems shall be in accordance with NFPA 59A.

14.3.2.17.7 Installation of internal combustion engines or gas turbines shall conform to NFPA 37.

14.3.2.17.8 The vaporizer shall be anchored and its connecting piping shall be sufficiently flexible to provide for the effect of expansion and contraction due to temperature change.

14.3.2.18 LNG-to-CNG (LCNG) Systems.

14.3.2.18.1 Paragraph 14.3.2.18 shall apply to the design, construction, installation, and operation of equipment used to produce CNG from LNG.

14.3.2.18.2 The process shall be permitted to be accomplished by pumping LNG to high pressure and vaporizing it or by compressing vapor from an LNG tank.

14.3.2.18.3 In addition to the emergency shutdown systems described in 14.3.2.19, the emergency shutdown system also shall shut off the liquid supply and power to the LNG transfer equipment necessary for producing CNG from LNG.

14.3.2.18.4 Compressors, Vaporizers, and CNG Storage Cylinders.

14.3.2.18.4.1 Compressors, vaporizers, and CNG storage cylinders shall not be located inside the facility impounding area.

14.3.2.18.4.2 Ambient and remotely heated vaporizers shall be permitted to be located inside the facility impounding area.

14.3.2.18.5 Transfer piping, pumps, and compressors shall be protected from vehicle collision damage.

14.3.2.18.6 LCNG natural gas refueling site and automotive applications shall not be required to utilize an odorant if an engineered and validated methane detection system is in place.

14.3.2.18.7 Unodorized LCNG natural gas shall not be dispensed at public refueling stations.

14.3.2.18.8 Refueling stations dispensing odorant shall have safety measures in place to automatically and completely shut down all dispensing of LCNG if the odorant supply is inadequate.

14.3.2.18.9 Refueling station odorant dispensing equipment shall be certified by the dispenser OEM for automotive refueling station applications.

14.3.2.18.10 Dispensing of odorant for automotive natural gas applications shall conform to the federal standards for natural gas pipeline percentages of odorant within the gaseous mixture.

14.3.2.18.11 Onboard methane detection shall be required for vehicles that utilize unodorized natural gas or that do not meet the federal standards for pipeline gas odorization.

14.3.2.19 Vehicle Fueling Dispensing.

14.3.2.19.1 The dispensing device shall be protected from vehicle collision damage.

14.3.2.19.2 An ESD shall be provided that includes a shutoff valve for stopping liquid supply and shutting down transfer equipment.

14.3.2.19.3 An ESD actuator, distinctly marked for easy recognition with a permanently affixed, legible sign, shall be provided within 10 ft (3.1 m) of the dispenser and also at a safe, remote location.

14.3.2.19.4 The maximum delivery pressure at the fueling nozzle shall not exceed the maximum allowable working pressure of the vehicle fuel tanks.

14.3.2.19.5 Hose and arms shall be equipped with a shutoff valve at the fuel end and a breakaway device to minimize

release of liquid and vapor in the event that a vehicle pulls away while the hose remain connected.

(A) Such a device shall be installed and maintained in accordance with the OEM component manufacturer's maintenance/safety instructions.

(B) A breakaway device shall be arranged to separate using a force not less than 225 lb and not greater than 275 lb where applied in any direction that the vehicle would move.

14.3.2.19.6 When not in use, hose shall be secured to protect it from damage.

14.3.2.19.7 Where a hose or arm of nominal 3 in. (76 mm) diameter or larger is used for liquid transfer or where one of nominal 4 in. (100 mm) diameter or larger is used for vapor transfer, an emergency shutoff valve shall be installed in the piping of the transfer system within 10 ft (3.1 m) from the nearest end of the hose or arm.

(A) Where the flow is away from the hose, a check valve shall be permitted to be used as the shutoff valve.

(B) Where either a liquid or vapor line has two or more legs, an emergency shutoff valve shall be installed either in each leg or in the feed line before the legs.

14.3.2.19.8 The OEM manufacturer's instructions shall be posted at the dispensing device.

14.3.2.19.9 Operating instructions identifying the location and operation of emergency controls shall be posted conspicuously in the facility area.

14.3.2.19.10 LNG fueling facilities transferring LNG during the night shall have permanent, adequate lighting at points of transfer and operation.

14.3.2.19.11 The transfer of LNG into vehicular onboard fuel containers shall be performed in accordance with the onboard tank and refueling component OEM manufacturer's instructions.

14.3.2.20 Vehicle Fueling Connector.

14.3.2.20.1 A fueling connector and mating vehicle receptacle shall be used for reliable, safe, and secure transfer of LNG or gas vapor to or from the vehicle, with minimal leakage.

14.3.2.20.2 The fueling connector either shall be equipped with an interlock device that prevents release while the line is open or have self-closing ends that automatically close upon disconnection.

14.3.2.21 Installation of Electrical Equipment.

14.3.2.21.1 Buildings and rooms used for storage or dispensing shall be classified in accordance with Table 14.3.2.21.1 for installations of electrical equipment.

14.3.2.21.2 Electrical equipment and wiring shall be as specified by and installed in accordance with *NFPA 70* meeting the requirements of Class I, Group D, Division or Zone as specified in Table 14.3.2.21.1.

(A) Electrical equipment on internal combustion engines installed in accordance with *NFPA 37* shall not be subject to 14.3.2.21.2.

(B) The LNG container and associated piping shall be electrically bonded and grounded.

Table 14.3.2.21.1 LNG Fueling Facility Electrical Area Classification

Part	Location	Class I, Group D Division or Zone ^a	Extent of Classified Area ^b
A	LNG Fueling Facility Container Area		
	Indoors	1	Entire room
	Outdoor, aboveground containers (other than portable)	1	Open area between a high-type dike and container wall where dike wall height exceeds distances between dike and container walls
		2	Within 15 ft (4.6 m) in all directions from container, plus area inside a low-type diked or impounding area up to the height of the dike impoundment wall
	Outdoor, belowground containers	1	Within any open space between container walls and surrounding grade or dike
		2	Within 15 ft (4.6 m) in all directions from roof and sides above grade
B	Nonfired LNG Process Areas Containing Pumps, Compressors, Heat Exchangers, Piping, Connections Vessels, etc.		
	Indoors with adequate ventilation	2	Entire room and any adjacent room not separated by a gastight partition, and 15 ft (4.6 m) beyond any ventilation discharge vent or lower
	Outdoors in open air at or above grade	2	Within 15 ft (4.6 m) in all directions from this equipment
C	Pits, Trenches, or Sumps Located in or Adjacent to Division 1 or 2 Areas	1	Entire pit, trench, or sump
D	Discharge from Relief Valves, Drains	1	Within 5 ft (1.5 m) from point of discharge
		2	Beyond 5 ft (1.5 m) but within 15 ft (4.6 m) in all directions from point of discharge
E	Vehicle/Cargo Transfer Area		
	Indoors with adequate ventilation ^c	1	Within 5 ft (1.5 m) in all directions from point of transfer
		2	Beyond 5 ft (1.5 m) of entire room and 15 ft (4.6 m) beyond ventilation vent
	Outdoors in open air at or above grade	1	Within 5 ft (1.5 m) in all directions from point of transfer
		2	Beyond 5 ft (1.5 m) but within 15 ft (4.6 m) in all directions from the point of transfer

^aSee Article 500, Hazardous (Classified) Locations, in *NFPA 70* for definitions of classes, groups, and divisions.

^bThe classified area shall not extend beyond an unpierced wall, roof, or solid vaportight partition.

^cVentilation is considered adequate when provided in accordance with the provisions of this code.

14.3.2.21.3 Each interface between a flammable fluid system and an electrical conduit or wiring system, including process instrumentation connections, integral valve operators, foundation heating coils, canned pumps, and blowers, shall be sealed or isolated to prevent the passage of flammable fluids to another portion of the electrical installation.

14.3.2.21.4 Each seal, barrier, or other means used to comply with 14.3.2.21.3 shall be designed to prevent the passage of flammable fluids or gases through the conduit, stranded conductors, and cables.

14.3.2.21.5 Primary Seal.

14.3.2.21.5.1* A primary seal shall be provided between the flammable fluid and gaseous systems and the electrical conduit wiring system.

14.3.2.21.5.2 If the failure of the primary seal would allow the passage of flammable fluids and gases to another portion of the conduit or wiring system, an additional approved seal, barrier, or other means shall be provided to prevent the passage of the flammable fluid beyond the additional device or means in the event that the primary seal fails.

14.3.2.21.6 Seals or Barriers.

14.3.2.21.6.1 Each primary seal shall be designed to withstand the service conditions to which it is expected to be exposed.

14.3.2.21.6.2 Each additional seal or barrier and interconnecting enclosure shall meet the pressure and temperature requirements of the condition to which it could be exposed in the event of failure of the primary seal, unless other approved means are provided to accomplish this purpose.

14.3.2.21.7 Unless specifically designed and approved for the purpose, the seals specified in 14.3.2.21.3 through 14.3.2.21.5 shall not be permitted to replace the conduit seals required by Section 501.15 of *NFPA 70*.

14.3.2.21.8 Where primary seals are installed, drains, vents, or other devices shall be provided for monitoring purposes to detect flammable fluids and leakage.

14.3.2.21.9 Static protection shall not be required when cargo transport vehicles or marine equipment are loaded or unloaded by conductive or nonconductive hose, flexible metallic tubing, or pipe connections through or from tight (top or bottom) outlets where both halves of metallic couplings are in contact.

14.3.2.22 Installation of Emergency Shutdown Device (ESD).

14.3.2.22.1 Instrumentation for LNG fueling facilities shall be designed so that, in the event of a power or instrumentation failure, the system goes into a fail-safe condition until the operators either reactivate or shut down the system.

14.3.2.22.2 All ESDs shall be manually reset.

14.3.2.23 Outdoor Non-Public Fueling from Transport Vehicles Including Marine Vessels.

14.3.2.23.1 Mobile Refueling Stations. All dispensing of LNG, including mobile refueling, into vehicle onboard fuel systems shall comply with the requirements of a permanent LNG refueling installation at the point of dispensing fuel.

(A) Refueling from Vehicle Mounted Tank at Commercial and Industrial Facilities. The provisions of 14.3.2.19 shall not apply to dispensing from vehicle-mounted tanks located at commercial and industrial facilities used in connection with their business where the following conditions are met:

- (1) An inspection of the premises and operations shall have been made and approval granted by the AHJ.
- (2) The vehicle-mounted container shall comply with requirements of DOT.
- (3) The dispensing hose shall not exceed 50 ft (15 m) in length.
- (4) Nighttime deliveries shall be made only in lighted areas.

14.3.2.23.2 Marine Vessel Transfer. (Reserved)

14.4 LNG Storage.

14.4.1 Dispensing to the Public.

14.4.1.1 General.

14.4.1.1.1 LNG fueling facilities that are permitted to be unattended shall be designed to secure all equipment from tampering.

14.4.1.1.2 Storage and transfer equipment at unattended facilities shall be secured to prevent tampering.

14.4.1.2 Indoor Public Fueling.

14.4.1.2.1 Building Construction.

14.4.1.2.1.1 Buildings reserved exclusively for an LNG fueling facility shall be of Type I or Type II construction in accordance with *NFPA 5000*.

14.4.1.2.1.2 Windows and doors shall be located so as to permit ready egress in case of emergency.

14.4.1.2.1.3 LNG piping entering a building shall be provided with shutoff valves located outside the building.

14.4.1.2.2 Dispensing.

14.4.1.2.3* Deflagration Venting.

14.4.1.2.3.1 Deflagration venting shall be provided only in the exterior walls or the roof.

14.4.1.2.3.2 Vents shall consist of any one or a 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 roof

14.4.1.2.4 Snow Loads.

14.4.1.2.5 Rooms Within Buildings.

14.4.1.2.5.1 Dispensing equipment located inside or attached to buildings used for other purposes shall comply with the following:

- (1) The dispensing room shall have a minimum of one external wall.
- (2) Interior walls or partitions shall be continuous from floor to ceiling, be anchored in accordance with the building code, and have a fire resistance rating of at least 2 hours.
- (3) The interior finish of the dispensing room shall be constructed of noncombustible or limited-combustible materials. (See Section 4.5 for noncombustible or limited-combustible.)
- (4) In the interior walls of the dispensing room, doors shall be listed as 1-hour self-closing fire doors that are installed in accordance with NFPA 80.
- (5) A ventilation system for a dispensing room within or attached to another building shall be separated from any ventilation system for the other building.
- (6) Access to the dispensing room shall be from outside the primary structure only.

14.4.1.2.5.2 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 a fire resistance rating equal to that of the wall.

14.4.1.2.5.3 Access doors or fire doors shall be kept unobstructed at all times.

14.4.1.2.6 Ventilation.

14.4.1.2.6.1 Ventilation shall be by a continuous mechanical ventilation system or by a mechanical ventilation system activated by a continuously monitoring natural gas detection system when a gas concentration of not more than one-fifth of the LFL is present.

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

14.4.1.2.6.3 Failures of any controllers used by the system shall result in a safe condition.

14.4.1.2.6.4* The ventilation rate shall be at least 1 cfm/12 ft³ (1 m³/min/11.3 m³) of room volume.

14.4.1.2.7 Gas Detection. A gas detection system shall be provided in all buildings containing LNG.

14.4.1.2.7.1 The gas detection system shall activate a latched alarm when a maximum of 20 percent of the LFL is reached.

14.4.1.2.7.2 The alarm shall be clearly audible and visible both inside and outside the whole building and potential affected area.

14.4.1.2.7.3 The gas detection system shall not be shut down during fueling operations.

14.4.1.2.8 Warning Signs. Signs and markings and the words “WARNING — NO SMOKING” shall be in red letters at least 1 in. (25 mm) high on a white background.

14.4.2 Outdoor Public Fueling — Dispensing Equipment Location. The spacing of LNG dispensing equipment relative to other equipment, activities, nearby property lines, and other exposures in a fuel dispensing forecourt shall be approved by the AHJ.

14.5 Piping Systems and Components. Piping shall be in accordance with Chapter 16.

Chapter 15 Automotive Equipment (Onboard)

15.1 Scope. This chapter shall apply to equipment used in CNG and LNG fuel supply systems serving vehicular internal combustion engines.

15.2 Application.

15.2.1 CNG and LNG equipment used shall be in accordance with Section 15.3 and the fuel-specific sections of Section 15.4 or Section 15.5, as applicable.

15.2.2 Where there is a conflict between general requirements and fuel-specific requirements, the fuel-specific requirements shall apply.

15.3 General.

15.3.1 System Component Qualifications. (Reserved)

15.3.2 System Approvals.

Δ 15.3.2.1 Original Equipment Manufacturer (OEM) Approved Equipment. The following CNG and LNG fuel supply subsystems and components, if used, shall be recommended by the OEM for the intended service and shall be listed or approved:

- (1) Fuel supply containers
- (2) Fuel quantity gauging systems
- (3) Pressure relief devices, including pressure relief valves
- (4) Pressure measurement devices
- (5) Pressure regulators
- (6) Valves
- (7) Hose and hose connections
- (8) Vehicle fueling connections
- (9) Vaporizers
- (10) Pumps
- (11) Electrical equipment related to engine fuel systems
- (12) Gas detection equipment and alarms
- (13) Fire protection and suppression equipment

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

15.3.3 Equipment.

15.3.3.1 Pressure Relief Valves (PRVs). PRVs shall not be fitted with lifting devices.

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

15.3.3.1.2 If at any time it is necessary to break such a seal as provided in 15.3.3.1.1, the valve shall be removed from service until it has been reset and sealed.

15.3.3.1.3 PRV adjustments shall be made only by the manufacturer or other companies having qualified person(s) and facilities for the repair, adjustment, and testing of such valves.

15.3.3.1.4 The organization making such PRV adjustments shall attach a permanent tag with the setting, capacity, and date.

15.4 CNG Supplemental Requirements.

15.4.1 Application. This section applies only to pressurized system components handling CNG.

Δ 15.4.2 All systems for CNG-fueled, on-road vehicles, where stored CNG is used as the fuel for propulsion, shall meet the requirements of CSA/ANSI NGV 6.1, *Compressed natural gas (CNG) fuel storage and delivery systems for road vehicles*.

N 15.4.2.1 All other vehicles shall comply with CSA/ANSI NGV 6.1, *Compressed natural gas (CNG) fuel storage and delivery systems for road vehicles*, or 15.4.3 through 15.4.3.8.4.

15.4.3 System Component Qualifications.

15.4.3.1* Design and Construction of Containers.

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

15.4.3.1.2 The container shall be designed for CNG service.

15.4.3.1.3 The container shall be permanently marked “CNG” by the manufacturer.

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

15.4.3.1.5* Cylinders.

15.4.3.1.5.1 Fuel supply containers shall be manufactured in accordance with one of the following:

- (1) CSA/ANSI NGV 2, *Compressed natural gas vehicle fuel containers*, specifically for CNG service
- (2) U.S. Federal Motor Vehicle Safety Standard, 49 CFR 571.304, *Compressed Natural Gas Fuel Container Integrity*

15.4.3.1.5.2* Removing Cylinders from Service.

(A) Cylinders that have reached the labeled expiration date shall be removed from service.

(B) Cylinders that are disconnected, depressurized, and permanently disabled shall be permitted to be left on the vehicle.

15.4.3.1.5.3* Composite reinforced cylinders or other cylinders marked with exemption or special permit numbers shall be removed from service.

15.4.3.2 Pressure Relief Devices (PRDs). See Annex C.

15.4.3.2.1 Container Protections. Each cylinder complying with 15.4.3.1.5 shall be fitted with one or more thermally activated pressure relief devices (PRDs) with the number, location, and part number as specified by the cylinder manufacturer and shall be marked and certified in accordance with CSA/ANSI PRD 1, *Pressure relief devices for natural gas vehicle (NGV) fuel containers*. Container shall be permitted to be protected using a combination of fire-resistant barriers and PRDs.

15.4.3.2.1.1 Containers shall be permitted to be protected using a combination of fire-resistant barriers and PRDs.

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

15.4.3.3 Pressure Gauges. A pressure gauge, if provided, shall be capable of reading at least 1.5 times the service pressure for the vehicle.

15.4.3.4 Pressure Regulators. A pressure regulator inlet and each chamber upstream of the first stage of regulation shall be designed with a pressure safety factor of at least 250 percent of the service pressure of the vehicle.

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

- Δ **15.4.3.4.2** A vehicle pressure regulator shall comply with the requirements of CSA/ANSI NGV 3.1, *Fuel system components for compressed natural gas powered vehicles*.

15.4.3.5 Piping, Tubing, and Fittings.

- Δ **15.4.3.5.1** The following components shall not be used for CNG service:

- (1) Fittings, street els, and other piping components of cast irons other than those complying with ASTM A47/A47M, *Standard Specification for Ferritic Malleable Iron Castings*; ASTM A395/A395M, *Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*; and ASTM A536, *Standard Specification for Ductile Iron Castings*
- (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

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

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

- Δ **15.4.3.5.4** Natural gas piping shall be fabricated and tested in accordance with CSA/ANSI NGV 3.1, *Fuel system components for compressed natural gas powered vehicles*.

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

15.4.3.6 Valves.

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

- Δ **15.4.3.6.1.1** Shutoff valves for vehicles shall have a service pressure not less than the maximum vehicle service pressure of the fuel container and comply with the requirements in CSA/ANSI NGV 3.1, *Fuel system components for compressed natural gas powered vehicles*.

15.4.3.6.1.2 Leakage shall not occur at less than 1.5 times the rated operating pressure.

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

15.4.3.6.3 Marking.

15.4.3.6.3.1 The manufacturer shall stamp or otherwise permanently mark the valve body to indicate the service pressure rating.

15.4.3.6.3.2 Container valves incorporating integral PRDs complying with 15.4.3.2.1 shall not require additional marking.

15.4.3.7 Vehicle Fueling Connection.

- **15.4.3.7.1** Vehicle fueling connection devices shall be listed in accordance with CSA/ANSI NGV 1, *Compressed natural gas vehicle (NGV) fueling connection devices*.

- **15.4.3.7.2** The use of adapters to defeat the pressure-specific nozzle and receptacle connections shall be prohibited.

15.4.3.7.3 Service Pressure.

15.4.3.7.3.1 The service pressure of the fueling connection receptacle shall not exceed the service pressure of the fuel supply cylinders.

15.4.3.7.3.2 The service pressure of the fueling receptacle shall not exceed 80 percent of the set pressure of any relief valves installed on fuel supply containers in the vehicle.

15.4.3.8 Hose and Hose Connections.

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

15.4.3.8.2 Hose Assemblies.

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

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

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

▲ **15.4.3.8.4** Vehicle hoses, metallic hose, flexible metal hose, and their connections shall comply with **CSA/ANSI NGV 3.1, *Fuel system components for compressed natural gas powered vehicles***, and be marked accordingly.

15.5 LNG Supplemental Requirements.

15.5.1 Application. This section applies only to vehicular engine fuel system components handling LNG.

15.5.2 Materials of Construction.

15.5.2.1 Metallic materials used in construction of the fuel system, except fusible links, shall have a minimum melting point of 1000°F (538°C).

15.5.2.2 Metallic material used in construction of the fuel system shall be listed in accordance with ANSI/ASME B31.3, *Process Piping*, and the ASME *Boiler and Pressure Vessel Code*, or API 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*, Appendix Q, and shall not be used below the minimum design temperature established in these codes or standards.

15.5.2.3 The use of dissimilar metal junctions shall be minimized, but if such a junction cannot be avoided, good corrosion protection practice shall be employed to reduce the effect of such a material combination on the long-term corrosion behavior of the junction.

15.5.2.4 All materials shall be selected or installed to minimize corrosion or to protect the material from corrosion.

15.5.2.4.1 Stainless steels that do not resist chloride-induced pitting/corrosion cracking and sensitization-induced corrosion resistance reduction shall not be used.

15.5.2.4.2 The use of all copper–zinc and copper–tin alloy families shall be restricted to those alloys that are metallurgically inhibited to prevent accelerated metallurgical deterioration from external environmental sources.

15.5.2.5 Brazing filler material shall have a melting point exceeding 1000°F (538°C).

15.5.2.6 Oxy–fuel gas welding shall not be permitted.

15.5.2.7 Furnace butt-welded steel products shall not be used.

15.5.2.8 Engine Compartment.

15.5.2.8.1 Onboard fuel system components inside the engine compartment shall be compatible with the liquids and gases throughout the full range of temperatures [–260°F to 248°F (–162°C to 120°C)].

15.5.2.8.2 Onboard fuel system components that are in contact with LNG shall be designed for service over a temperature range of –260°F to 248°F (–162°C to 120°C).

15.5.2.9 Outside Engine Compartment.

15.5.2.9.1 Components outside the engine compartment that are in contact with LNG shall be designed for service over a temperature range of –260°F to 185°F (–162°C to 85°C).

15.5.2.9.2 Other components that are not in contact with LNG shall be designed for service over a temperature range of –40°F to 185°F (–40°C to 85°C).

15.5.2.10 Components that are not fuel system components and are located within the operational area of LNG or LNG

liquid or gaseous leaks shall also be protected or maintain a service range equal to the onboard fuel system.

15.5.3 Fuel Supply Containers.

15.5.3.1 Design. Fuel supply containers shall be designed, fabricated, tested, and marked (or stamped) in accordance with the regulations of DOT Specification 4L, 49 CFR 178.57, or the “Rules for the Construction of Unfired Pressure Vessels,” in the ASME *Boiler and Pressure Vessel Code*, applicable at the date of manufacture.

15.5.3.1.1 LNG containers that are in contact with LNG or cold LNG vapor shall be physically and chemically compatible with LNG and designed for service at –260°F (–162°C).

15.5.3.1.2 Container appurtenances shall have a rated working pressure not less than the maximum allowable working pressure of the container.

15.5.3.1.3 For vacuum insulation, the inner tank, outer tank, and internal lines shall be tested for vacuum leaks prior to installation on the vehicle.

15.5.3.2* Hold Time. The manufacturer shall identify the maximum operating design pressure of the container.

15.5.3.2.1 The construction of the container shall be such that the unrelieved pressure inside the container will not exceed the maximum allowable working pressure of the container within a 72-hour period after the container has been filled to its maximum filling volume with LNG stabilized at the designed operating pressure and temperature equilibrium has been established.

15.5.3.2.2 The ambient temperature during the 120-hour period shall be 70°F (21°C).

15.5.3.3 Design and Construction of Containers.

15.5.3.3.1 ASME Compliance.

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

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

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

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

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

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

15.5.3.4 Pressure Relief Devices (PRDs).

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

15.5.3.4.2 PRDs shall be located so that the temperature to which they are subjected is representative of the temperature to which the fuel supply container is subjected.

15.5.3.4.3 The minimum rate of discharge of PRDs on containers shall be in accordance with CGA S-1.3, *Pressure Relief Device Standards — Part 3 — Stationary Storage Containers for Compressed Gases*, or the ASME Boiler and Pressure Vessel Code, whichever is applicable.

15.5.3.4.4 PRVs protecting ASME pressure vessels shall be repaired, adjusted, and tested in accordance with NB-23, *National Board Inspection Code*.

15.5.3.4.5 Containers and pressure vessels not constructed in accordance with 15.4.3.1.4 or 15.5.3.3.1 shall be provided with PRDs approved by the authority having jurisdiction.

15.5.3.5 Container Filling.

15.5.3.5.1 Containers shall be equipped with a device or devices that provide an indication of when the container is filled to the maximum allowable liquid level.

15.5.3.5.2 The function shall allow for the ullage volume to be determined by the manufacturer to be that which maintains the required hold time as required by 15.5.3.2.

15.5.3.6* Vehicular Fuel Container Shutoff Valves.

15.5.3.6.1 The container shall be equipped with shutoff valves that allow for its complete isolation from the rest of the vehicular fuel system.

15.5.3.6.1.1 Container shutoff valves shall be labeled as to their function.

15.5.3.6.1.2 Decals or stencils shall be acceptable.

15.5.3.6.2 Normally closed automatic shutoff valves that are held open by electric current, pneumatic or hydraulic pressure, or a combination thereof, or manually operated shutoff valves shall be permitted to be used to meet this requirement.

15.5.3.7 Vehicular Fuel Container Pressure Relief Devices (PRDs). Containers shall be equipped with the PRDs required by the code under which the containers were designed and fabricated.

15.5.3.7.1 PRDs shall be sized for simultaneous conditions of fire and loss of vacuum.

15.5.3.7.2 PRDs shall be sized in accordance with one of the following:

- (1) CGA S-1.1, *Pressure Relief Device Standards — Part 1 — Cylinders for Compressed Gases*
- (2) CGA S-1.2 *Pressure Relief Device Standards — Part 2 — Portable Containers for Compressed Gases*
- (3) CGA S-1.3, *Pressure Relief Device Standards — Part 3 — Stationary Storage Containers for Compressed Gases*

15.5.3.8 Fuel Supply Container Pressure Gauges.

15.5.3.8.1 Pressure gauges shall be designed for the maximum pressure and temperature conditions to which they can be subjected, with a minimum burst pressure safety factor of 4.

15.5.3.8.2 Dials shall be graduated to indicate at least 1.2 times the pressure at which the pressure relief device incident to the pressure gauge is set to function.

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

15.5.4 Fuel System Pressure Regulators. The engine pressure regulator inlet and each chamber shall have a design operating pressure not less than the MAWP of the upstream pressure source.

15.5.5 Piping, Tubing, and Fittings. Piping, tubing, and fittings shall be designed, installed, inspected, and tested in accordance with ANSI/ASME B31.3, *Process Piping*.

15.5.6 Valves. Valves, valve packing, gaskets, and seats shall be designed for the intended service.

15.5.6.1 All parts of container shutoff valves shall be stainless steel, brass, or copper except gaskets, packing, and seats.

15.5.6.2 All parts of container shutoff valves shall be designed for temperatures of -260°F (-162°C).

15.5.7 Fueling Receptacle. The fueling receptacle on the vehicular fuel system shall be supported and meet all of the following conditions:

- (1) Receive the fueling connector and be designed by the MAWP of the fuel supply container
- (2) Incorporate a means to minimize the entry of dust, water, and other foreign material
- (3) Be designed for any corrosive conditions that are anticipated

15.5.8 Onboard Pumps and Compressors.

15.5.8.1 Pumps and compressors shall be provided with a PRD to limit the discharge pressure to the maximum working pressure of the casing and downstream piping and equipment, unless these are designed for the maximum discharge pressure of the pumps or compressors.

15.5.8.2 Pumps shall be provided with a vent, a relief valve, or both that prevent overpressuring the pump case.

15.5.8.3 Pumps used for transfer of LNG shall be provided with means for precooling to reduce the effect of thermal shock and overpressure.

15.5.9 Onboard Vaporizers.

15.5.9.1 Vaporizers shall have the capacity to vaporize the LNG completely and heat the vapor to the design temperature of the downstream components prior to entry of the vapor into the pressure regulator when the vaporizer is subjected to the maximum vehicular fuel flow rate.

15.5.9.2 Vaporizers shall be marked permanently at a readily visible point to indicate the maximum allowable working pressure of the fuel-containing portion of the vaporizer.

15.5.9.3 Vaporizers shall be designed for a working pressure at least equal to the maximum discharge pressure of the pump or the pressurized system that supplies them, whichever is greater.

15.5.9.4 The discharge valve of each vaporizer, if provided, its piping components, the relief valves installed upstream of the discharge valve, the vaporizer piping, and related components shall be designed for operation at an LNG temperature of -260°F (-162°C).

15.5.9.5 Engine exhaust gases shall not be used as a direct source of heat to vaporize fuel.

15.5.9.6 Where engine exhaust is used to vaporize fuel, it shall be used via an indirect heating system.

Chapter 16 Automotive Fuel and Safety Systems (Onboard)

16.1 Application.

16.1.1 This chapter shall apply to the design, installation, inspection, and testing of CNG and LNG fuel supply systems serving vehicle internal combustion engines.

16.1.2 The installation, testing, maintenance, and repair of gaseous vehicle fuel systems shall be in accordance with Section 16.2 and the fuel-specific requirements of Sections 16.3 or 16.4, as applicable.

16.2 General.

16.2.1 Modifications. Modifications of a vehicle gaseous fuel system shall conform with, when available, the engineering recommendations of the original specifications of the original chassis vehicle manufacturer.

Δ 16.2.2 OEM Approved Equipment. The subsystems and components, if used, shall meet the general and applicable fuel-specific equipment requirements of Chapter 16.

16.2.3* Responsibilities of the OEM, Final-Stage Vehicle Integrator/Manufacturer, or Vehicle Alterer or Converter.

16.2.3.1 All those listed in 16.2.3 shall obtain, when available, documented approval of the chassis original equipment and component manufacturers of the onboard fuel and detection systems components, and verify proper installation and application for each of the following:

- (1) Vehicle
- (2) Chassis
- (3) Engine
- (4) Gas detection
- (5) Fuel system

16.2.3.2 Modifications of a vehicle gaseous fuel system shall conform with, when available, the engineering recommendations of the original specifications of the original chassis vehicle manufacturer.

16.2.4* Integration. All those listed in 16.2.3 shall be responsible for integration of the engine, fuel system, and gaseous detection system, where required, onto the vehicle chassis and for the operation of the vehicle.

16.2.5 System Component Qualifications. In addition to the requirements of 16.2.2, system components shall comply with the applicable requirements of 16.2.5.1.

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

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

16.2.6 Installation of Fuel Supply Containers.

16.2.6.1 Locations of Fuel Supply Containers. 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.

16.2.6.2 Containers Mounted in the Interior of Vehicles. Containers shall be installed and fitted so that no gas from fueling operations can be released inside the passenger compartment, by permanently installing the fueling receptacle outside the driver or passenger compartment of the vehicle in a location protected from physical damage and dislodgment.

16.2.6.3 Installation of Containers. Fuel supply containers shall be installed in accordance with the instructions of the container manufacturer and the fuel-specific requirements for CNG and for LNG.

16.2.6.4 Securing Containers.

16.2.6.4.1 Containers shall be mounted to prevent their jarring loose, slipping, or rotating.

16.2.6.4.2 Containers shall be secured to the vehicle body, bed, or frame by means capable of withstanding the loads defined in 16.3.3.1.6 and 16.4.2.2.

16.2.7 Installation of Venting Systems.

16.2.7.1 Enclosures, structures, seals, and conduits used to vent enclosures shall be fabricated of materials designed to resist damage, blockage, or dislodgment caused by the movement of articles carried in the vehicle or by the closing of luggage compartment enclosures or vehicle doors.

16.2.7.2 Enclosures shall require the use of tools for removal.

16.2.8 Installation of Fuel Lines.

16.2.8.1 Manifolds.

16.2.8.1.1 Manifolds connecting fuel containers shall be fabricated and installed to minimize vibration.

16.2.8.1.2 Manifolds shall be installed in a protected location or shielded to prevent damage from unsecured objects.

16.2.8.2 Manifolds connecting containers or container pressure relief devices shall be designed to vent gas from the individual container(s) exposed to a fire to meet the requirements of 15.4.3.2 and 15.5.3.4.

16.2.9 Installation of Valves.

16.2.9.1 Valves shall be mounted securely and shielded or installed in a protected location to prevent damage from vibration, shock, and unsecured objects.

16.2.9.2 Valves shall be installed so that their weight is not placed on, or supported by, the attached lines.

16.2.10 Installation of Electrical Wiring.

16.2.10.1 Wiring shall be installed, supported, and secured in a manner to prevent damage due to vibration, shock, strains, wear, or corrosion.

16.2.10.2 All conductors shall be sized for the maximum anticipated load and shall be protected by overcurrent protection devices.

16.2.10.3 Wiring Installation.

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

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

16.2.11 Labeling.

16.2.11.1 Each CNG or LNG vehicle shall be identified with a permanent, diamond-shaped label located on the exterior vertical surface or near-vertical surface on the lower right rear of the vehicle and inboard from any other markings.

16.2.11.1.1 The labels for vehicles less than 19,500 lb (8863 kg) GVWR shall be a minimum of 4.72 in. long × 3.27 in. high (120 mm × 83 mm).

16.2.11.1.2 The labels for vehicles with a GVWR of 19,500 lb (8863 kg) or greater shall be a minimum of 5.7 in. long × 4.2 in. high (145 mm × 107 mm).

16.2.11.1.3 The marking in the label required by 16.2.11.1.1 shall consist of a border and the letters “CNG or LNG,” as appropriate [1 in. (25 mm) minimum height centered in the diamond] of silver or white reflective luminous material on a blue background.

16.2.11.1.4 The marking in the label required in 16.2.11.1.2 shall consist of a border and the letters “CNG” or “LNG,” as appropriate [1.2 in. (30 mm) minimum height centered in the diamond] of silver or white reflective luminous material on a blue background.

16.2.11.1.5 Affixing Labels.

16.2.11.1.5.1 In addition to the requirement in 16.2.11.1.2 for placement of the diamond-shaped label on the lower right rear of the vehicle, labels shall be affixed to each side of the power unit.

16.2.11.1.5.2 If a DOT number is required to be displayed in accordance with 49 CFR 390.21, then the labels shall be affixed near the DOT numbers on each side of the power unit.

16.2.11.1.6 Vehicles with roof-mounted CNG fuel supply containers shall include a permanent label in the driver's compartment, clearly visible to a seated operator, which includes the maximum total height of the unladen vehicle.

16.3* CNG Engine Fuel Systems.**16.3.1 Scope.**

16.3.1.1 In addition to the general requirements of Section 16.2, the fuel-specific requirements of Section 16.3 apply to fuel systems serving CNG-fueled vehicles.

Δ 16.3.1.2 All systems for CNG-fueled, on-road vehicles, where stored CNG is used as the fuel for propulsion, shall meet the requirements of CSA/ANSI NGV 6.1, *Compressed natural gas (CNG) fuel storage and delivery systems for road vehicles*.

N 16.3.1.2.1 All other vehicles shall comply with CSA/ANSI NGV 6.1, *Compressed natural gas (CNG) fuel storage and delivery systems for road vehicles*, or 16.3.2 through 16.3.9.7.

16.3.1.3 Where there is a conflict between a general requirement and a fuel-specific requirement, the fuel-specific requirement shall apply.

16.3.2 System Component Qualifications.

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

16.3.2.2 Temperature Range.

16.3.2.2.1 Components in the engine compartment shall be designed or selected for a minimum temperature range of –40°F to 248°F (–40°C to 120°C).

16.3.2.2.2 All other components shall be designed or selected for service for a minimum temperature range of –40°F to 185°F (–40°C to 85°C).

16.3.3 Installation of Fuel Supply Containers.**16.3.3.1 Containers.**

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

16.3.3.1.2 Shields, if present, shall not interfere with the ability of the PRD to protect the fuel container. Shields shall be installed in a manner that prevents damage to the container or its coating in the following occurrences:

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

16.3.3.1.3 The fuel supply container shall be positioned to prevent contact with vehicle components such as, but not limited to, frame members, body panels, or brake lines that leads to container fretting or abrasion over time.

16.3.3.1.4 Vehicle fuel supply containers shall be mounted in a location or shielded to minimize damage to the container, or its valves and PRDs.

16.3.3.1.4.1 Containers shall be protected by covers from accidental contact with overhead electrical wiring.

16.3.3.1.4.2 The fuel system, including fuel supply containers, when installed, shall not intrude into the original vehicle's approach, departure, or breakover angles, without further engineering evaluation and protection as necessary.

16.3.3.1.4.3 The ground clearance shall be sufficient such that with the vehicle loaded to its gross vehicle weight rating, it would not allow any component to touch the road surface in the event of a flat tire or the removal of any tire.

16.3.3.1.4.4 No portion of a fuel supply container or container appurtenance mounted on the undercarriage of the vehicle shall be located ahead of the front axle or behind the point of attachment of the rear bumper to the vehicle.

16.3.3.1.4.5 Any portion of the fuel supply container or its appurtenances on the exterior of the vehicle shall be provided with a protective cover.

16.3.3.1.5 Each fuel supply container shall be secured to the vehicle in a manner that minimizes the risk of damage from road hazards, slippage, loosening, or transfer of vehicle chassis loads to the container due to frame flexing.

16.3.3.1.6 Each fuel supply container, together with valves, enclosures, and all other items that are mounted and attached, shall be secured in such a manner that it is capable of withstanding a static force, applied in the six principal directions shown in Figure 16.3.3.1.6 of eight times the weight of the fully pressurized container.

16.3.3.1.7 The container, the plumbing, and the mounting attachments shall withstand the effects of shock, vibration, and acceleration encountered in normal service.

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

16.3.3.1.9 Fuel supply containers shall be shielded against direct heat from any vehicle- or cargo-related source that would result in normal operating container or PRD surface temperatures exceeding 185°F (85°C).

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

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

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

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

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

16.3.3.1.13 Where parts of the vehicular fuel container are exposed to higher temperatures than the PRD during a localized fire, the fuel container shall be protected by any of the following:

- (1) Noncombustible heat-insulating shielding to retard localized heating of the container
- (2) Installation of a thermally sensitive “fusing” system to trigger the PRD in a fire situation
- (3) Other design for venting of the fuel container in a fire situation

16.3.3.2 Installation of Relief Devices. PRDs shall be located so that the temperature to which they are subjected is representative of the temperature to which the fuel supply container is subjected.

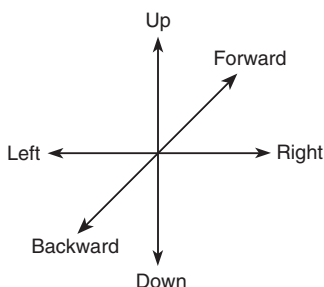


FIGURE 16.3.3.1.6 The Six Principal Directions.

16.3.3.3 Installation of Pressure Gauges.

16.3.3.3.1 Pressure gauges located within a driver or passenger compartment shall be installed in such a manner that no gas flows into the passenger compartment in the event of failure.

16.3.3.3.2 Pressure gauges installed outside a driver or passenger compartment shall be equipped with a limiting orifice, a shatterproof lens, and a body relief.

16.3.3.3.3 Pressure gauges shall be mounted, shielded, and installed in a protected location to prevent damage from vibration and unsecured objects.

16.3.3.4 Installation of Pressure Regulators.

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

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

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

16.3.3.5 Installation of Fuel Lines.

16.3.3.5.1 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.

16.3.3.5.2 Metallic Tubing.

16.3.3.5.2.1 Metallic tubing and fittings shall be clear and free from cutting or threading burrs and scales.

16.3.3.5.2.2 The ends of all metallic tubing shall be deburred or prepared in accordance with the fitting manufacturer's recommendations.

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

16.3.3.5.3 Fuel Lines.

16.3.3.5.3.1 Fuel lines shall be mounted, braced, and supported to minimize vibration.

16.3.3.5.3.2 Fuel lines shall be protected against damage, corrosion, or breakage due to strain or wear.

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

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

16.3.3.5.3.5 Mechanical joints on fuel line systems shall be located in an accessible location and shall not be located where natural gas leakage can accumulate undetected.

16.3.3.5.4 Bends.

16.3.3.5.4.1 A bend in metallic tubing shall not be in excess of the recommended minimum bend radius for the diameter of the tubing.

16.3.3.5.4.2 A crimp resulting from a bend shall be prohibited.

16.3.3.6 Fuel-Subsystem Isolation.

16.3.3.6.1 Container Isolation.

16.3.3.6.1.1 Every fuel container shall be equipped with either of the following:

- (1) A manual shutoff valve
- (2) A normally closed, remotely actuated shutoff valve connected directly to the container

16.3.3.6.1.2 For vehicles with more than one fuel supply container, where each container is equipped with a normally closed remotely actuated shutoff valve, the OEMs, FSVIMs, and converters shall provide guidance, as part of the maintenance procedures, on how to check that the solenoid valve is operating as intended.

16.3.3.6.1.3 When shut-off valves are attached directly to fuel containers, there shall be a means for the technician to determine if there is still pressure in the container, regardless of the valve position.

16.3.3.6.1.4 If an interconnected PRD system is protecting a group of containers installed in accordance with 16.3.3.8.3, a single valve shall be permitted that will isolate the group of containers.

16.3.3.6.1.5 A means shall be provided to bleed the container manually even in the event that a remote actuated shutoff valve fails or an excess flow device should remain closed.

16.3.3.6.2 Fuel System Isolation.

Δ **16.3.3.6.2.1** In addition to the valve required by 16.3.3.6.1, a normally closed, automatically actuated shutoff valve shall be installed between the fuel storage and the first-stage pressure regulator that allows isolation of the container(s) from the remainder of the fuel system.

N **16.3.3.6.2.2** The valve in 16.3.3.6.2.1 shall not be opened unless the engine is rotating or in a start-up sequence.

N **16.3.3.6.2.3** The valve in 16.3.3.6.2.1 shall be permitted to be opened for onboard diagnostics (OBD).

N **16.3.3.6.2.4** In addition to the valves in 16.3.3.6.1 and 16.3.3.6.2.1, a manual fuel system isolation valve shall be installed downstream of the valve in 16.3.3.6.2.1 and upstream of the first-stage pressure regulator.

Δ **16.3.3.6.2.5** An additional manual valve in 16.3.3.6.2.4 shall not be required on vehicles that are not normally operated on public streets and that have only a single fuel supply container equipped with an accessible manual container valve.

16.3.3.6.2.6 The manual valve in 16.3.3.6.2.4 shall be mounted and shielded or installed in a protected location to minimize damage from vibration and unsecured objects.

Δ **16.3.3.6.2.7** The manual valve in 16.3.3.6.2.4 shall not have more than 90 degrees rotation (quarter turn fuel delivery valve) from the open to the closed positions.

16.3.3.6.2.8 Access to the manual valve in 16.3.3.6.2.4 shall not require the use of any key or tool.

16.3.3.6.2.9 The location of the manual valve in 16.3.3.6.2.4 shall be indicated by means of a weather-resistant decal or label

with red, blue, or black letters on a white or silver reflective background containing the words "MANUAL SHUTOFF VALVE."

Δ **16.3.3.6.3 Engine Isolation.** A valve fuel injector or other means shall be provided that automatically prevents the flow of gaseous fuel to the engine when the engine is not running, even if the ignition is switched on.

N **16.3.3.6.3.1** This device shall be installed downstream of the first-stage pressure regulator.

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

16.3.3.6.5 Fuel Backflow Prevention. 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.

16.3.3.6.5.1 The backflow check valve shall be mounted to withstand the breakaway force specified in 8.4.2.4.

16.3.3.6.5.2 A second check valve shall be located between the fueling receptacle and the fuel supply containers.

16.3.3.7 Installation of Fueling Connectors.

16.3.3.7.1 Fueling connections installed on vehicles less than 10,000 lb (4500 kg) gross vehicle weight rating (GVWR) shall be in accordance with 15.4.3.7.

16.3.3.7.2 The fueling connection receptacle shall be mounted to withstand the breakaway force specified in 8.4.2.4.

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

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

16.3.3.8* Installation of PRD Systems.

16.3.3.8.1 All PRDs shall be in direct communication with the fuel.

16.3.3.8.2 Each cylinder complying with 15.4.3.1.5.1 shall be protected by one or more PRDs as specified by the cylinder manufacturer and OEM for CNG service.

16.3.3.8.3 Additional PRDs connecting two or more containers shall be permitted if in accordance with the container manufacturer's instructions.

16.3.3.8.4 PRD Venting.

16.3.3.8.4.1* The discharge from the PRD shall be vented to the outside of the vehicle.

16.3.3.8.4.2 Vent tube or hose shall be electrically conductive.

16.3.3.8.4.3 Vent tube or hose shall be 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.

16.3.3.8.4.4 Vent tube or hose shall have a burst pressure of at least 1.5 times the pressure in the vent that results from activation of the PRD.

16.3.3.8.4.5 Vent(s) shall not discharge:

- (1) Into or toward the passenger or luggage compartment
- (2) Into or toward wheel wells
- (3) Toward CNG storage systems
- (4) Toward the front of the vehicle
- (5) Toward exhaust systems
- (6) Into an engine compartment
- (7) Toward a vehicle exit

▲ **16.3.3.8.5*** The vent opening shall be designed to prevent blockage by debris thrown up from the road or otherwise affected by the elements.

16.3.3.8.6 Vent opening(s) shall resist accumulation of water due to rain, vehicle washing, and moisture due to condensation.

16.3.3.8.7 Vent opening(s) shall not restrict the operation of a container pressure relief device or pressure relief device channel.

16.3.3.9 Vent Outlet Protection.

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

16.3.3.9.2 Protective devices in 16.3.3.9.1 shall not restrict the flow of gas.

16.3.3.10* Vent Location and Signage. For vehicles with GVWR in excess of 19,500 lb (8863 kg), the following shall apply:

- (1) Vent outlets shall be located vertically near the top of the vehicle.
- (2) Vent outlets shall be orientated to direct the vent gas upward.

▲ **16.3.3.10.1** A label shall indicate the PRD(s) vent location(s) with the following language:

ATTENTION: CNG Vent Location

16.3.3.10.2* Each safety sign shall be 3 in. (76 mm) tall by 5 in. (127 mm) wide and shall use 18-point sans serif font for the message text.

16.3.3.10.3 One safety sign shall be located near each vent area.

16.3.3.11 Gastight Enclosures.

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

16.3.3.11.2 The gastight enclosure shall not be constructed of fire-resistant material if the thermally reactive portion of the PRD is contained within the gastight enclosure.

16.3.4 Defueling of Vehicle Containers.

16.3.4.1 Defueling shall be performed only by a qualified person using written procedures.

16.3.4.1.1 The gas from a defueled container shall be discharged into a closed transfer system, flared, or vented by an approved method.

16.3.4.1.2 A manual valve shall be used to control defueling discharge.

16.3.4.2* Defueling procedures shall include all of the following:

- (1) Perform container defueling only in accordance with the manufacturer's instructions.
- (2) Use grounding to prevent static electrical charge buildup
- (3) Limit the rate of gas release from plastic-lined containers to a value not greater than that specified by the container manufacturer
- (4) Restrain containers during defueling to prevent container movement

16.3.4.3 Direct gas venting to atmosphere shall be done through a vent tube that directs the gas flow upwards and away from vehicle or ignition sources.

▲ **16.3.4.3.1** The vent tube shall have a gastight connection prior to venting.

16.3.4.3.2 All components of the vent tube shall be grounded.

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

16.3.4.4* All vehicles shall be provided with a defueling system to allow the high-pressure portion of the CNG fuel system to be defueled for service.

16.3.4.4.1 Connections.

16.3.4.4.1.1 It shall not be required to break any connections while under pressure in order to defuel the high-pressure portion of the CNG fuel system.

16.3.4.4.1.2 A connection for an external defueling system shall be provided.

16.3.4.4.2 The defueling function shall be manually controlled.

16.3.4.4.3 All high-pressure portions of the CNG fuel system shall be capable of being defueled.

▲ **16.3.4.4.4** The vehicle manufacturer or system installer shall provide written instructions and specify any special tools needed for defueling.

16.3.5 Container Inspections.**16.3.5.1* Accidents or Damage to CNG Containers.**

16.3.5.1.1 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, inspected, or retested in accordance with the vehicle or container manufacturer's instructions.

16.3.5.1.2 The qualified person performing the replacement, removal, inspection, and/or retesting shall prepare a document certifying that the cylinder is acceptable for return to service and present the document to be retained by the vehicle's owner/operator and a copy to be retained by the qualified person.

16.3.5.1.3 The document shall identify the vehicle — by license plate number or vehicle identification number — and the cylinder (by serial number); describe the work done and

the dates of work; and provide the **qualified person's** name and contact information.

16.3.5.2 Accidents or Damage to CNG Fuel Systems.

16.3.5.2.1 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 16.3.8*) before being returned to service.

16.3.5.2.2 The **qualified person** performing the repair and retesting shall prepare a document certifying that the CNG fuel system is acceptable for return to service and present the document to be retained by the vehicle's owner/operator and a copy to be retained by the **qualified person**.

16.3.5.2.3 By license number or vehicle identification number, the document shall identify the vehicle CNG fuel system parts worked on, describe the work done and dates of work, and provide the **qualified person's** name and contact information.

16.3.5.3 Where a CNG container is removed from a vehicle to be installed within a different vehicle, it shall be inspected or retested in accordance with the vehicle or container manufacturer's inspection or requalification procedures before it is reinstalled.

16.3.6 Labeling.

16.3.6.1 CNG Labels.

16.3.6.1.1 A vehicle equipped with a CNG fuel system shall bear the following permanent labels:

- (1) A label(s) readily visible and located in the engine compartment shall include the following:
 - (a) Identification as a CNG-fueled vehicle
 - (b) System designed and installed in conformance with NFPA 52-XXXX (insert the edition year of the code)
 - (c) Service pressure
 - (d) Installer/converter's name or company and contact information (i.e., address, telephone number, and email)
- (2) A label(s) located at the primary fueling connection receptacle shall include the following:
 - (a) Identification as a CNG-fueled vehicle
 - (b) System service pressure
 - (c) Fuel container life expiration (insert date for limited-life fuel containers. This label item is not required for containers with unlimited life.)
 - (d) "Fuel containers are to be inspected by (insert date) and each (insert number) months thereafter."
- (3) Label(s) located at each auxiliary fueling connection receptacle shall include the following:
 - (a) Identification as a CNG-fueled vehicle
 - (b) Service pressure

16.3.6.1.2 The fuel container inspection dates shall be changed after each required container inspection to denote the next required inspection date. (*See 16.3.9 for inspections.*)

16.3.6.2 In addition to the label(s) required by 16.3.6.1, each vehicle shall be identified with a permanent, diamond-shaped label located on the exterior vertical surface or near-vertical surface on the lower right rear of the vehicle other than on the bumper of the vehicle.

16.3.6.2.1 The labels for vehicles less than 19,500 lb (8863 kg) GVWR shall be a minimum of 4.72 in. long × 3.27 in. high (120 mm long × 83 mm high).

16.3.6.2.2 The labels for vehicles with a GVWR of 19,500 lb (8863 kg) or greater shall be a minimum of 5.7 in. long × 4.2 in. high (145 mm long × 107 mm high).

16.3.6.2.3 The marking in the label required by 16.2.11.1.1 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.

16.3.6.2.4 CNG Labeling.

16.3.6.2.4.1 The marking in the label required by 16.2.11.1.2 shall consist of a border and the letters "CNG" [1.2 in. (30 mm) minimum height centered in the diamond] in silver or white reflective luminous material on a blue background.

16.3.6.2.4.2 In addition to placement of the "CNG" diamond label on the right rear of the vehicle, the "CNG" diamond label shall also be affixed to both sides of the power unit.

16.3.6.2.4.3 If a DOT number is required to be displayed in accordance with 49 CFR 390.21, then the labels shall be affixed near the DOT numbers on each side of the power unit.

16.3.6.2.5 Vehicles with roof-mounted CNG fuel containers shall include a permanent label in the driver's compartment, clearly visible to a seated operator, which includes the maximum total height of the unladen vehicle.

16.3.6.3 Each assembly of CNG containers shall be permanently labeled near the container valve as follows:

DANGER. Venting of the pressure from this system requires the use of special instructions or tools that can be obtained from the manufacturer [Insert the name, telephone number, and email address of the vehicle manufacturer or system installer].

▲ **16.3.7** Permanent labels shall meet the requirements of UL 969, *Marking and Labeling Systems*.

16.3.8 System Testing.

16.3.8.1* The completed fuel system assembly shall be leak tested using natural gas or inert gas.

16.3.8.2 Before use, every connection not previously tested in subassemblies shall be inspected for leaks with a noncorrosive leak detector solution or a leak detector instrument after the equipment is connected and pressurized to its service pressure. Passing inspection shall require the following:

- (1) Each connection shall have no bubbles in 3 minutes.
- (2) Any leakage as noted in 16.3.8.2(1) shall be corrected.
- (3) The system shall be leak-checked again after any corrections, modifications, disassembly, repairs or replacement of components of the natural gas system.

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

16.3.9 System Inspection, Maintenance, and Repair.

16.3.9.1 Damaged fuel lines shall be replaced and not repaired.

16.3.9.2 All containers, container appurtenances, piping systems, venting systems, and other components shall be maintained in accordance with the manufacturer's requirements.

▲ 16.3.9.3* Vehicle supply containers shall be inspected in accordance with the schedule in the vehicle label required in 16.3.6 and one of the following:

- (1) Vehicle manufacturer's instructions
- (2) Container manufacturer's instructions
- (3) The instructions in CGA C-6.4, *Methods for External Visual Inspection of Natural Gas Vehicle (NGV) and Hydrogen Vehicle (HGV) Fuel Containers and Their Installations*. Personnel inspecting vehicle fuel supply containers shall be trained on CGA C-6.4.

16.3.9.3.1* Fuel containers whose service life has expired shall be removed from service and rendered unusable.

16.3.9.3.2 After periodic container inspection, a label showing the next required inspection date shall be affixed as required in 16.3.6.1.

16.3.9.4 Pressure relief devices on fuel containers shall be maintained in accordance with the following:

- (1) Pressure relief device channels or other parts that 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) No pressure relief valve that has been in service shall be repaired or reworked without the written authorization of the pressure relief device manufacturer, valve manufacturer, fuel container manufacturer, or vehicle manufacturer. Any device that has been activated shall not be reworked or reused and shall be removed from service.
- (4) No pressure relief device that has been in service shall be reinstalled on another fuel cylinder.

16.3.9.5 The following shall be done during vehicle maintenance:

- (1) Ensure the engine is isolated from the fuel supply unless engine operation is required. If a manual isolation valve is used, it shall comply with 16.3.3.6.2.
- (2) Prohibit torches, welding, or grinding equipment on or near high-pressure fuel lines and containers.
- (3) Prevent damage to containers, including actions such as dropping, dragging, or rolling of the container.
- (4) Prevent exposure of containers to strong chemicals such as battery acid or metal-cleaning solvents.
- (5) Store CNG containers in a manner to avoid damage.
- (6) Protect stored containers from sunlight.
- (7) Containers shall be stored in accordance with manufacturers' instructions.
- (8) The openings in all stored cylinders shall be closed to prevent the entry of moisture and other contaminants.
- (9) Reinstall containers to their original configuration using approved gaskets, bolts, nuts, washers, and parts in accordance with the recommendations of the vehicle or container manufacturer or system installer.
- (10) Prevent hoists or jacks from coming into direct contact with containers.
- (11) Prohibit personnel from walking on containers unless permitted by the container manufacturer.

16.3.9.6 OEMs, FSVIMs, alterers, and converters shall make available instructions for system maintenance and repair.

16.3.9.7 Qualified Person(s).

16.3.9.7.1 All personnel engaged in activities in 16.3.4, 16.3.8, and 16.3.9, discharging CNG fuel containers or the inspection, maintenance, repair, replacement, removal, or testing of a CNG fuel system or its components, shall be qualified person(s).

16.4 LNG Engine Fuel Systems.

16.4.1 Scope.

16.4.1.1 In addition to the general requirements of Section 16.2, the fuel-specific requirements of Section 16.4 shall apply to fuel systems serving LNG-fueled vehicles.

16.4.1.2 This subsection shall not apply to LNG railroad fuel tenders required to comply with applicable DOT (Federal Railroad Administration) regulations.

16.4.1.3 Where there is a conflict between a general requirement and a fuel-specific requirement, the fuel-specific requirement shall apply.

16.4.2 Installation of Vehicular Fuel Supply Containers and Container Appurtenances.

16.4.2.1 Vehicular Fuel Supply Containers and Container Appurtenances.

16.4.2.1.1 Vehicular components or subsystems that can fail on exposure to LNG temperature shall be protected from exposure to LNG.

16.4.2.1.2 Fuel supply containers shall be located in a place and in a manner so as to minimize the possibility of damage to the fuel supply container and its appurtenances.

16.4.2.1.2.1 Fuel supply containers located in the rear of vehicles, where protected by bumpers or vehicular structure, shall be considered to be in conformance with 16.4.2.1.2.

16.4.2.1.2.2 If fuel or fuel supply container vent piping containing fuel is installed within 8 in. (200 mm) of engine or exhaust system components that exceed 248°F (120°C), it shall be shielded against direct heating.

16.4.2.1.3 Fuel supply container valves, appurtenances, and connections shall be protected to prevent damage due to incidental contact with foreign objects.

16.4.2.2 Structural Integrity.

16.4.2.2.1 The fully pressurized fuel supply container, when filled to its maximum filling volume with LNG, together with valves, enclosures, and all other items that are mounted and attached, shall be capable of withstanding a static force, in the six principal directions, equal to eight times the weight of the fuel supply container plus its contents, without loss of contents.

16.4.2.2.2* The fuel supply container, the plumbing, and the mounting attachments shall withstand the effects of shock, vibration, and acceleration encountered in normal service.

16.4.2.3 Reuse.

16.4.2.3.1 Fuel supply containers complying with 15.5.3.1 shall be permitted to be reused, reinstalled, or continued in use.

16.4.2.3.2 A fuel supply container shall be determined to be suitable for continued service prior to reuse by means of periodic validation.

16.4.2.3.3 Validation shall be performed during normal revacuum or repair of the fuel supply container.

16.4.2.4 Repair or alteration of fuel supply containers shall comply with the code or original container manufacturer's design under which the fuel supply container was fabricated.

16.4.2.5* Position.

16.4.2.5.1 No part of the fuel supply container or its appurtenances shall protrude beyond the sides or top of any vehicle to prevent the fuel supply container from being struck or punctured.

16.4.2.5.2 Non-roof-mounted fuel supply containers shall not be mounted ahead of the front axle or beyond the rear bumper on motor vehicles.

16.4.2.6 Fuel supply containers shall be installed to provide as much road clearance as practical.

16.4.2.6.1 The minimum clearance from the road to the fuel supply container, its housing, or its fittings, whichever is lowest, shall not, with the vehicle loaded to its gross weight rating, be less than that defined by the vehicle manufacturer's design, or allow any component to touch the surface should the vehicle have a flat tire or require the removal of any tire.

16.4.2.6.2 Further requirements for clearances shall be measured as follows:

- (1) Fuel supply containers installed between axles shall comply with 16.4.2.6.2(3) or shall not be lower than the lowest point on a structural component of the body; frame or subframe, if any; engine; or transmission; including the clutch housing or torque converter housing, forward of the fuel supply container measured as if the wheel rims were on the ground.
- (2) Fuel supply containers installed behind the rear axle and extending below the frame shall comply with 16.4.2.6.2(3) or shall not be lower than both of the following:
 - (a) The lowest point of a structural component of the body, engine, or transmission, including clutch housing or torque converter housing, forward of the fuel supply container.
 - (b) The lowest point of those lines extending rearward from each wheel at the point where the wheel rims contact the ground directly below the center of the rearmost axle — where there are more than two rear axles — to the lowest and most rearward structural interference (e.g., bumper, frame).
- (3) Where an LNG fuel supply container is substituted for the fuel supply container installed by the original chassis manufacturer of the vehicle, the LNG fuel supply container shall meet both of the following:
 - (a) The LNG fuel supply container shall either fit within the space in which the original fuel supply container was installed or comply with 16.4.2.6.2(1) or 16.4.2.6.2(2).
 - (b) The LNG fuel supply container shall meet, when available, the specifications of the chassis and fuel system OEMs.

16.4.2.7 The fuel supply container weight shall not be supported by outlet valves, manifolds, fuel lines, and other fuel-related components or connections.

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

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

16.4.2.10 Vehicular fuel systems shall be equipped with at least one manual or automatic fuel shutoff valve.

16.4.2.11 Manual fuel shutoff valves shall be readily accessible, operable without tools, and labeled as to their function.

16.4.2.12 Where a fuel supply container is roof mounted or installed above the operator or passenger compartment of a vehicle, the following requirements shall apply:

- (1) The fuel supply 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/hr (8 km/hr)
 - (b) A shield designed to absorb impacts that can occur during loading, unloading, or use of the vehicle
- (2) The top of the fuel supply container and any related piping, fitting, valve, housing, guardrail, or shield shall not be more than 13.5 ft (4.1 m) above the road surface.
- (3) The cylinder shall be protected from accidental contact with overhead electrical wiring by metallic or nonmetallic covers.
- (4) The vehicle shall include a permanent label in the driver's compartment, clearly visible to a seated operator, which includes the maximum total height of the unladen vehicle.

16.4.2.12.1 The guard rail or similar device shall be free of projections that could damage the fuel supply container or its valves and fittings.

16.4.2.12.2 The shield shall be free of projections that subject the fuel supply container or its valves and fittings to damage.

16.4.3 Installation of Fuel System Equipment.

16.4.3.1 Installation of Pressure Relief Device.

16.4.3.1.1 All discharge lines and outlets shall be installed in accordance with 16.4.3.1.1.1 through 16.4.3.1.1.13.

16.4.3.1.1.1 Pressure relief discharge lines shall be designed for the pressure and temperature of the discharged LNG.

16.4.3.1.1.2 Components shall be designed for operation at an LNG temperature of -260°F (-162°C).

16.4.3.1.1.3 Individual discharge lines and adapters shall be sized, located, and secured so as to permit the maximum required relief discharge capacity in order to minimize the possibility of physical damage.

16.4.3.1.1.4 The discharge lines shall be able to withstand the pressure of the relief vapor discharge when the PRD is in the full-open position.

16.4.3.1.1.5 A means shall be provided (e.g., loose-fitting caps) to minimize the possibility of the entrance of water or dirt into either the PRD or its discharge line and to drain any water that accumulates in the discharge line.

16.4.3.1.1.6 The means of protection shall remain in place except when the PRD operates.

16.4.3.1.1.7 In this event, the means of protection shall permit the PRD to operate at maximum required capacity.

16.4.3.1.1.8 The outlet of the discharge line shall be fitted with a device or configured to prevent the formation or accumulation of any ice or frozen LNG that prevents the PRD from operating at required capacity.

16.4.3.1.1.9 The PRV discharge shall be directed away from the refueling operator and not hinder manually shutting off any fuel system devices.

16.4.3.1.1.10 PRV Discharge.

(A) The discharge line from the fuel supply container primary PRV shall be directed upward near the highest point on the vehicle.

(B) Discharge outlets shall be located such that venting gas will not enter a wheel well, the engine compartment, the passenger compartment, or the cargo compartment of the vehicle.

(C) Discharge outlets shall not be directed toward the engine exhaust or components that are normally hot during vehicle use, or toward any other ignition source.

16.4.3.1.1.11 The PRV discharge line shall be secured at intervals in such a manner so as to minimize the possibility of damage, corrosion, breakage, or dislocation due to gas flow forces during venting, expansion, contraction, vibration, strains, or wear and tear and to prevent any loosening while in operation.

16.4.3.1.1.12 If the outlet of a discharge line from a PRV is located behind a shield or screen or is obscured from the view of a person approaching the exterior side of the vehicle on which the outlet is located, a label shall be affixed to that exterior side of the vehicle as close as possible to the outlet to point out the location of the outlet.

16.4.3.1.1.13 A secondary PRD, designed to prevent rupture of the fuel supply container upon failure of the primary PRD, shall not be required to be piped away from the fuel supply container.

16.4.3.1.2 PRDs shall be so designed that the possibility of tampering is minimized.

16.4.3.1.3 Externally set or adjusted PRVs shall be provided with a means of sealing the adjustment.

16.4.3.2 Installation of Pressure Gauges.

16.4.3.2.1 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 gauge failure.

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

16.4.3.3 Installation of Pressure Regulators.

16.4.3.3.1 On fuel delivery systems that have operating pressures that exceed the engine operating pressure requirements, automatic pressure regulating equipment shall be installed

between the vehicular fuel container and the engine to regulate the pressure of the fuel delivered to the engine.

16.4.3.3.2 Pressure regulating equipment shall be installed so that its weight is not placed on, or supported by, the attached lines.

16.4.3.4 Piping, Tubing, and Fittings.

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

16.4.3.4.2 Piping and tubing 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 transit.

16.4.3.4.3 Piping and tubing passing through a panel or structural member shall be protected by grommets or similar devices that shall snugly fit the piping or tubing and the hole in the panel or structural member.

16.4.3.4.4 Piping or Tubing and Connections.

16.4.3.4.4.1 Piping or tubing passing through the floor of a vehicle shall be installed to enter the vehicle through the floor directly beneath, or adjacent to, the container.

16.4.3.4.4.2 If a branch line is required, the tee connection shall be located in the main fuel line under the floor and outside the vehicle.

16.4.3.4.5 A fuel connection between a tractor and trailer or other over-the-road vehicle units shall not be permitted.

16.4.3.4.6 A PRV shall be installed in each section of piping or tubing in which LNG can be isolated between shutoff valves so as to relieve the trapped fuel pressure to a safe atmosphere.

16.4.3.4.7 The PRV shall not have a setting greater than the maximum allowable working pressure of the line it protects.

16.4.3.5 Installation of Valves.

16.4.3.5.1 Extended bonnet valves shall be installed with their stem packing seals in such a position as to prevent leakage or malfunction due to freezing.

16.4.3.5.2 Where the extended bonnet in a cryogenic liquid line is installed at an angle greater than 4 degrees from the upright vertical position, evidence of satisfactory service in the installed position shall be demonstrated and engineering validation shall be provided by the original equipment (bonnet valve) manufacturer.

16.4.3.5.3 Valves.

16.4.3.5.3.1 A positive shutoff valve shall be installed in the fuel supply line.

16.4.3.5.3.2 The shutoff valve shall close automatically and prevent the flow of fuel to the engine when the ignition switch is off or in the accessory position and when the engine is not running and the ignition switch is on.

16.4.3.5.3.3 Where multiple fuel systems or containers are installed on a vehicle, automatic valves shall be provided to shut off the container that is not being utilized.

16.4.3.5.3.4 The vehicular fueling system shall be equipped with a backflow check valve to prevent the return flow of LNG from the container(s) to the filling connection.

16.4.3.5.3.5 The check valve in 16.4.3.5.3.4 shall be permitted to be integral to another component in the system, such as the vehicular fueling connector.

16.4.3.6 Fueling Receptacle.

16.4.3.6.1 The fueling receptacle shall be mounted to withstand a breakaway force such that the breakaway device specified in 14.3.2.19.5 operates before the receptacle separates from the vehicular fuel system.

16.4.3.6.2 The receptacle shall be installed in accordance with the original component manufacturer's instructions.

16.4.4 Labeling.

16.4.4.1 A vehicle equipped with an LNG fuel system shall bear the following durable labels.

16.4.4.1.1 A label(s) readily visible and located in the engine compartment shall include the following:

- (1) Identification as an LNG-fueled vehicle
- (2) System designed and installed in conformance with NFPA 52-XXXX (insert the edition year of the code)
- (3) Maximum allowable working pressure of the LNG tank
- (4) Installer/converter's name or company and contact information (i.e., address, telephone number, and email)

16.4.4.1.2 A label(s) located at the fueling connection receptacle shall include the following:

- (1) Identification as an LNG-fueled vehicle
- (2) Primary PRV relief set pressure

16.4.4.2 Vehicle Fuel Container Markings.

16.4.4.2.1 Container markings shall be visible after the container's permanent installation on a vehicle.

16.4.4.2.2 A portable lamp and mirror shall be permitted to be used when reading markings.

16.4.4.2.3 The container shall have the following permanent identification markings:

- (1) Total water capacity of the container in gallons (liters)
- (2) Label or labels placed in a visible location near the vehicle fill connection identifying it as an LNG connection, indicating the maximum allowable working pressure of the LNG tank
- (3) Markings to designate whether all inlets and outlets, except the relief valves and gauging devices, communicate with vapor or liquid space

16.4.4.2.4 Decals or stencils shall be acceptable.

16.4.4.2.5 Penetrations marked with the function of the penetration and identification shall not be obscured by frost.

16.4.5 Electrical Wiring.

16.4.5.1 Wiring shall be installed, supported, and secured in a manner to prevent damage due to vibration, shock, strains, wear, or corrosion.

16.4.5.2 All conductors shall be sized for the maximum anticipated load and shall be protected by overcurrent protection devices.

16.4.6 Fuel System Testing.

16.4.6.1 Cold Test and Pressure Test.

16.4.6.1.1 After the system has been completely assembled, all fittings and connections shall be tested for leaks while pressurized to the maximum allowable working pressure.

16.4.6.1.2 Liquid nitrogen or LNG shall flow through the system at least as far as LNG flows when the system is in operation, to validate minimum temperature [-260°F (-162°C)] and maximum tank venting pressure.

16.4.6.2 Accident or Damage. When a vehicle is involved in an accident or fire causing damage to the LNG tank, the LNG fuel system, or both shall be replaced or inspected by a qualified person(s) in accordance with the vehicle manufacturer's instructions.

16.4.6.2.1 The facility performing the inspection, repair, replacement, and/or retesting shall prepare a document stating that the LNG tank, LNG fuel system or both are acceptable for return to service and present the document to be retained by the vehicle's owner/operator and retain a copy.

16.4.6.2.2 The document shall identify the vehicle by vehicle identification number, parts of the LNG fuel system worked on, the work done and dates of work, and provide the facility's name and contact information.

16.4.6.3 Qualified Person(s). All personnel engaged in inspection, maintenance, repair, replacement, removal, and testing of an LNG fuel system or its components shall be a qualified person(s).

16.4.7 Onboard Gas Detection.

16.4.7.1 Gas Detection. A fully engineered LNG onboard application methane detection system shall be validated and installed for each vehicle configuration and application and shall be certified by a qualified person with expertise in fire safety and gaseous fuels.

16.4.7.1.1 Motor vehicles equipped with an LNG fuel system or fueled with an unodorized LCNG shall be provided with a methane detection system that will warn of the presence of methane in the engine compartment, driver's compartment, and any passenger compartment.

16.4.7.1.2 The methane gas detection system shall provide a warning before the methane gas concentration exceeds the limits specified by 16.4.7.1.5.

16.4.7.1.3 Gas Detection Systems.

16.4.7.1.3.1 The gas detection system shall function continuously at all times when the engine is operating and for at least 15 minutes after the engine is turned off.

16.4.7.1.3.2 Gas detection systems shall be permitted to be disconnected during maintenance where detection is provided within the service area.

16.4.7.1.4 Warnings shall be plainly audible and visible to the driver prior to entering the vehicle and while seated in the normal driving position.

16.4.7.1.5 The detection system shall activate a visual alarm within the driver's compartment of the vehicle at a gas concentration not exceeding 20 percent to 30 percent of the LFL and

sound an audible and visual alarm at a gas concentration not greater than 50 percent to 60 percent of the LFL.

16.4.7.1.5.1 Sensor locations shall include at a minimum the engine and driver's compartment and any enclosed fuel container or installation within a compartment.

16.4.7.1.5.2 Motor vehicles equipped with a gas detection system shall provide warnings at two different levels in accordance with 16.4.7.1.5 and the following:

- (1) At the 50 percent to 60 percent LFL level, a warning that is audible and visible to the driver outside the vehicle
- (2) An 87 dBA warning that is audible outside the vehicle with windows up and doors closed
- (3) A visual warning that is visible in direct sunlight

16.4.7.1.6 Onboard methane detection, fire suppression, and fire protection systems shall be installed, inspected, validated, and maintained in accordance with the system OEM written recommendations and shall be maintained as a permanent vehicle record.

16.4.7.1.6.1 Periodic testing shall be done at a minimum of three times per year.

16.4.7.1.6.2 The gas detection testing procedure shall simulate the same gas and operating environment in which the vehicle is used for daily use of individual components and systems in accordance with the levels in 16.4.7.1.5.

16.4.7.1.6.3 Validation shall conform to the specifics of the component OEM recommendations and shall be maintained as a permanent vehicle record.

16.4.8 Fire Suppression Systems.

16.4.8.1 When provided, onboard fire suppression systems shall be operable at all times, whether or not the vehicle is operated or parked.

16.4.8.1.1 The suppression system shall provide a fire sensing system for detection, actuating, and dispensing of the appropriate agent in accordance with the OEM or FSVIM recommendation.

16.4.8.1.2 The fire suppression system shall be independent of all other systems and not share common components for recognition or automatic actuation.

16.4.8.1.3 Independent manual actuation shall be included as part of the fire suppression system and accessible to the driver when seated.

Chapter 17 Installation Requirements for ASME Tanks for LNG

17.1* Application.

17.1.1 This chapter provides requirements for the installation, design, fabrication, and siting of LNG containers of 100,000 gal (378,000 L) capacities and less and their associated equipment for use in applications such as vehicle refueling facilities that are designed and constructed in accordance with ASME *Boiler and Pressure Vessel Code*.

17.1.2 The maximum aggregate storage capacity at a single fueling facility shall be 280,000 U.S. gal (1060 m³).

Δ 17.2 General. Storage and transfer equipment at unattended facilities shall be secured to prevent tampering.

17.2.1 Site preparation shall include provision for retention of spilled LNG within the limits of the facility and for surface drainage.

17.2.2 The maximum allowable working pressure shall be specified for all pressure-containing components with an MAWP of 15 psi (103 kPa) or more.

17.3 Containers.

Δ 17.3.1 Piping that is part of an ASME LNG container, including piping between the inner and outer containers, shall be in accordance with either Section VIII of the ASME *Boiler and Pressure Vessel Code*, or ANSI/ASME B31.3, *Process Piping*.

Δ 17.3.2 Compliance of piping that is part of the ASME container shall be stated on or appended to Appendix W, Form U-1, "Manufacturer's Data Report for Pressure Vessels," of the ASME *Boiler and Pressure Vessel Code*.

Δ 17.3.3 Internal piping between the inner container and the outer container within the insulation space shall be designed for the maximum allowable working pressure of the inner container, with allowance for the thermal stresses.

Δ 17.3.4 Bellows shall not be permitted within the insulation space.

17.3.5 ASME containers used for the storage of LNG shall be double-walled, with the inner container holding the LNG surrounded by insulation contained in the outer container as specified in 17.3.6.

Δ 17.3.6 The inner container shall be of welded construction and in accordance with the ASME *Boiler and Pressure Vessel Code*, Section VIII, and shall be ASME-stamped and registered with the National Board of Boiler and Pressure Vessel Inspectors or other agency that registers pressure vessels.

Δ 17.3.6.1 The outer tank shall be of welded construction using any of the following materials:

- (1) Any of the carbon steels in Section VIII, Part UCS of the ASME *Boiler and Pressure Vessel Code* at temperatures at or above the minimum allowable use temperature in Section II, Part D, Table 1A of the ASME *Boiler and Pressure Vessel Code*
- (2) Materials with a melting point below 2000°F (1093°C) where the container is buried or mounded

Δ 17.3.7 The inner tank supports shall be designed for shipping, seismic, and operating loads.

Δ 17.3.8 The expansion and contraction of the inner container shall be included in the stress calculations, and the support system shall be designed so that the resulting stresses imparted to the inner and outer containers are within allowable limits.

Δ 17.3.9 Where vacuum is used for insulation purposes, the outer tank shall be designed by either of the following:

- (1) Section VIII, Parts UG-28, UG-29, UG-30, and UG-33 of the ASME *Boiler and Pressure Vessel Code*, using an external pressure of not less than 15 psi (103 kPa)
- (2) Paragraph 3.6.2 of CGA 341, *Standard for Insulated Cargo Tank Specification for Nonflammable Cryogenic Liquids*

▲ **17.3.10** Heads and spherical outer containers that are formed in segments and assembled by welding shall be designed in accordance with Section VIII, Parts UG-28, UG-29, UG-30, and UG-33 of the ASME *Boiler and Pressure Vessel Code*, using an external pressure of 15 psi (103 kPa).

17.3.11 Any portion of the outer tank surface exposed to LNG temperatures shall be designed for such temperatures or protected from the effects of such exposure.

17.3.12 The outer container shall be equipped with a relief device or other device to release internal pressure, as follows:

- (1) The discharge area shall be at least 0.00024 in.²/lb (0.34 mm²/kg) of the water capacity of the inner container, but the area of any individual device shall not exceed 300 in.² (0.2 m²).
- (2) The relief device shall function at a pressure not exceeding the internal design pressure of the outer container or 25 psi (172 kPa), whichever is least.

• ▲ **17.3.13** Thermal barriers shall be provided to prevent the outer container from falling below its design temperature.

17.3.14 Seismic Design.

17.3.14.1 Shop-built containers designed and constructed in accordance with the ASME *Boiler and Pressure Vessel Code* and their support systems shall be designed for the dynamic forces associated with horizontal and vertical accelerations as follows:

- (1) For horizontal force:

$$V = Z_c \times W \quad [17.3.14.1a]$$

- (2) For vertical force:

$$P = \frac{2}{3} Z_c \times W \quad [17.3.14.1b]$$

where:

Z_c = seismic coefficient equal to 0.60 S_{DS} where S_{DS} is the maximum design spectral acceleration determined in accordance with the provisions of ASCE 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, using an importance factor, I , of 1.0 for the site class most representative of the subsurface conditions where the LNG facility is located

W = total weight of the container and its contents

[59A:8.5.2.1]

17.3.14.2 Usage.

▲ **17.3.14.2.1** The method of design described in 17.3.14.1 shall be used only where the natural period, T , of the shop-built container and its supporting system is less than 0.06 second.

17.3.14.2.2 For periods of vibration greater than 0.06 seconds, the method of design in 8.4.1.4 of NFPA 59A shall be followed. [59A:8.5.2.1.2]

▲ **17.3.14.3** The container and its supports shall be designed for the resultant seismic forces in combination with the operating loads, using the allowable stresses increase shown in the code or standard used to design the container or its supports.

▲ **17.3.14.4** The requirements of Section 17.3 shall apply to ASME containers built prior to July 1, 1996, when reinstalled.

▲ **17.3.15** ASME containers shall be identified by the attachment of a corrosion-resistant nameplate as required by Section VIII of the ASME *Boiler and Pressure Vessel Code*.

▲ **17.3.16** Storage tank systems shall have all penetrations marked with the function of the penetration.

17.3.17 Markings shall be legible under all conditions.

▲ **17.3.18 Filling Volume.** Containers designed to operate at a pressure in excess of 15 psi (103 kPa) shall be equipped with a device(s) that prevents the container from becoming liquid-full or from covering the inlet of the relief device(s) with liquid when the pressure in the container reaches the set pressure of the relieving device(s) under all conditions.

17.4 Container Foundations and Supports.

▲ **17.4.1** Tank system foundations shall be in accordance with ACI 376, *Code Requirements for Design and Construction of Concrete Structures for the Containment of Refrigerated Liquefied Gases and Commentary*.

▲ **17.4.1.1** Saddles and legs shall be designed to withstand loads anticipated during shipping, installation, seismic, wind, and thermal loads.

17.4.1.2 Foundations and supports shall be protected to have a fire resistance rating of at least 2 hours.

■ **17.4.1.2.1** Insulation shall be resistant to dislodgment by hose streams where used to achieve the fire resistance rating of 17.4.1.2.

▲ **17.4.2** LNG storage containers installed in an area subject to flooding shall be secured to prevent the release of LNG or flotation of the container in the event of a flood.

▲ **17.5 Container Installation.** The minimum distance from the edge of an impoundment or container drainage system serving aboveground and mounded containers larger than 1000 gal (3.8 m³) shall be in accordance with Table 17.5 for each of the following:

- (1) Nearest offsite building
- (2) The property line that can be built upon
- (3) Spacing between containers

▲ **17.5.1** The distance from the edge of an impoundment or container drainage system to buildings or walls of concrete or masonry construction shall be reduced from the distance in Table 17.5 with the approval of the authority having jurisdiction with a minimum of 10 ft (3 m).

• **17.5.2** Underground LNG tanks shall be installed in accordance with Table 17.5.2.

▲ **17.5.3** Buried and underground containers shall be provided with means to prevent the 32°F (0°C) isotherm from penetrating the soil.

▲ **17.5.4** Where heating systems are used, they shall be installed such that any heating element or temperature sensor used for control can be replaced.

▲ **17.5.5** All buried or mounded components in contact with the soil shall be constructed from material resistant to soil corrosion or protected to minimize corrosion.

Table 17.5 Distances from Containers and Exposures

Container Water Capacity		Minimum Distance from Edge of Impoundment or Container Drainage System to Offsite Buildings and Property Lines That Can Be Built Upon		Minimum Distance Between Storage Containers	
gal	m ³	ft	m	ft	m
1000–2000	3.8–7.6	15	4.6	5	1.5
2001–18,000	≥7.6–56.8	25	7.6	5	1.5
18,001–30,000	≥56.8–114	50	15	5	1.5
30,001–70,000	≥114–265	75	23	¼ of the sum of the diameters of adjacent containers [5 ft (1.5 m) minimum]	
>70,000	>265	0.7 times the container diameter [100 ft (30 m) minimum]			

Table 17.5.2 Distances from Underground Containers and Exposures

Container Water Capacity		Minimum Distance from Buildings and Adjoining Property Line That Can Be Built Upon		Distance Between Containers	
gal	m ³	ft	m	ft	m
<18,000	<15.8	15	4.6	5	1.5
18,000–30,000	15.8–114	25	7.6	5	1.5
30,001–100,000	>114	40	12.2	5	1.5

△ **17.5.6** A clear space of at least 3 ft (0.9 m) shall be provided for access to all isolation valves serving multiple containers.

△ **17.5.7** LNG containers of greater than 125 gal (0.5 m³) capacity shall not be located in buildings.

17.5.8 LNG vehicles shall be permitted to be located in buildings.

17.6 Automatic Product Retention Valves.

△ **17.6.1** All liquid and vapor connections, except relief valve and instrument connections, shall be equipped with automatic fail-safe product retention valves.

△ **17.6.2** Automatic fail-safe product retention valves shall be designed to close on the occurrence of any of the following conditions:

- (1) Fire detection or exposure
- (2) Uncontrolled flow of LNG from the container
- (3) Manual operation from a local and remote location

△ **17.6.3** Connections used only for flow into the container shall be equipped with either two backflow valves, in series, or an automatic fail-safe product retention valve.

△ **17.6.4** Appurtenances shall be installed as close to the container as practical so that a break resulting from external strain shall occur on the piping side of the appurtenance while maintaining intact the valve and piping on the container side of the appurtenance.

17.7 Inspection.

△ **17.7.1** Prior to initial operation, containers shall be inspected to ensure compliance with the engineering design and material, fabrication, assembly, and test provisions of this chapter.

△ **17.7.2** Inspectors shall be qualified in accordance with the code or standard applicable to the container.

17.7.3 Performance of any part of the inspection shall be permitted to be delegated to inspectors who are employees of the operator's own organization, an engineering or scientific organization, or a recognized insurance or inspection company.

17.8 Testing and Purging of LNG Containers.

17.8.1 Shop Testing of LNG Containers.

△ **17.8.1.1** The outer tank shall be leak tested.

△ **17.8.1.2** Piping between the inner container and the first connection outside the outer container shall be tested in accordance with ANSI/ASME B31.3, *Process Piping*.

△ **17.8.1.3 Shipment of LNG Containers.** Containers shall be shipped under a minimum internal pressure of 10 psi (69 kPa) inert gas.

17.8.2 Field Testing of LNG Containers.

△ **17.8.2.1** Containers and associated piping shall be leak tested prior to filling with LNG.