NFPA 58

Liquefied Petroleum Gas Code

2004 Edition

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NFPA 58

Liquefied Petroleum Gas Code

2004 Edition

This edition of NFPA 58, *Liquefied Petroleum Gas Code*, was prepared by the Technical Committee on Liquefied Petroleum Gases and acted on by NFPA at its November Association Technical Meeting held November 15–19, 2003, in Reno, NV. It was issued by the Standards Council on January 16, 2004, with an effective date of February 5, 2004, and supersedes all previous editions.

This edition of NFPA 58 was approved as an American National Standard on January 16, 2004.

Origin and Development of NFPA 58

This first NFPA standard on LP-Gas was adopted in 1932. In the next eight years, separate standards covering various LP-Gas applications were adopted. In 1940, several standards were combined and adopted as NFPA 58.

Revisions of NFPA 58 were adopted in 1943, 1946, 1948, 1950, 1951, 1952, 1953, 1954, 1955, 1956, 1957, 1958, 1959, 1960, 1961, 1965, 1967, 1969, 1972, 1974, 1976, 1979, 1982, 1985, 1988, 1992, 1995, 1998, and 2001.

The 2001 edition was a complete revision of the code and included extensive editorial modifications that made the code clearer and easier to use. Major changes included a new Chapter 11, Operations and Maintenance, new retroactive requirements for valves with remote closing capability on all containers of 4000 gal to be completed within 10 years, and a requirement for a fire safety analysis for all installations of 4000 gal or more within three years of the effective date.

The 2004 edition brings NFPA 58 into compliance with the NFPA *Manual of Style*. Chapters 1 through 4 are taken from former Chapters 1 and 12. The remaining chapters are renumbered. The committee's work to make NFPA 58 clearer and easier to use continues with new tables and clearer requirements. New requirements include recertification criteria for cylinders and safety requirements for engine fuel cylinders.

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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 the design, construction, installation, and operation of fixed and portable liquefied petroleum gas systems in bulk plants and commercial, industrial (with specified exceptions), institutional, and similar properties; truck transportation of liquefied petroleum gas; engine fuel systems on motor vehicles and other mobile equipment; storage of containers awaiting use or resale; installation on commercial vehicles; and liquefied petroleum gas service stations.

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

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

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

Chapter 1 Administration

1.1* Scope. This code applies to the storage, handling, transportation, and use of LP-Gas.

1.2 Purpose. (Reserved)

1.3 Application.

1.3.1 Application of the Code. This code shall apply to the operation of all LP-Gas systems including the following:

(1) Containers, piping, and associated equipment, when delivering LP-Gas to a building for use as a fuel gas.
(2) Highway transportation of LP-Gas.
(3) The design, construction, installation, and operation of marine terminals whose primary purpose is the receipt of LP-Gas for delivery to transporters, distributors, or users except for marine terminals associated with refineries, petrochemicals, gas plants, and marine terminals whose purpose is the delivery of LP-Gas to marine vessels.
(4)*The design, construction, installation, and operation of pipeline terminals that receive LP-Gas from pipelines under the jurisdiction of the U.S. Department of Transportation, whose primary purpose is the receipt of LP-Gas for delivery to transporters, distributors, or users. Coverage shall begin downstream of the last pipeline valve or tank manifold inlet.

1.3.2 Nonapplication of Code. This code shall not apply to the following:

(1) Frozen ground containers and underground storage in caverns including associated piping and appurtenances used for the storage of LP-Gas.
(2) Natural gas processing plants, refineries, and petrochemical plants.
(3) LP-Gas (including refrigerated storage) at utility gas plants *(see NFPA 59, Utility LP-Gas Plant Code).*
(4) Chemical plants where specific approval of construction and installation plans, based on substantially similar requirements, is obtained from the authority having jurisdiction.
(5)*LP-Gas used with oxygen.
(6)*The portions of LP-Gas systems covered by NFPA 54 (ANSI Z223.1), *National Fuel Gas Code*, where NFPA 54 (ANSI Z223.1) is adopted, used, or enforced.
(7) Transportation by air (including use in hot air balloons), rail, or water under the jurisdiction of the U.S. Department of Transportation (DOT).
(8)*Marine fire protection.
(9) Refrigeration cycle equipment and LP-Gas used as a refrigerant in a closed cycle.
(10) The manufacturing requirements for recreational vehicle LP-Gas systems that are addressed by NFPA 1192, *Standard on Recreational Vehicles.*
(11) Propane dispensers located at multiple fuel refueling stations shall comply with NFPA 30A, *Code for Motor Fuel Dispensing Facilities and Repair Garages.*

1.4 Retroactivity.

1.4.1 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.

1.4.2 Unless otherwise specified, the provisions of this code shall not apply to facilities, equipment, appliances, structures, or installations that existed or were approved for construction or installation prior to the effective date of the code. Equipment and appliances include stocks in manufacturers' storage, distribution warehouses, and dealers' storage and showrooms in compliance with the provisions of this code in effect at the time of manufacture. Where specified, the provisions of this code shall be retroactive.

1.4.3 In those cases where the authority having jurisdiction determines that the existing situation presents a distinct hazard to life and property, the authority having jurisdiction shall be permitted to apply retroactively any portions of this code that are deemed appropriate.

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

1.5 Equivalency.

1.5.1 Nothing in this code is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this code.

1.5.2 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.5.3 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.6 Units and Formulas. (Reserved)

1.7 Enforcement. This code shall be administered and enforced by the authority having jurisdiction designated by the governing authority. *(See Annex J 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,* 2002 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2001 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2002 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* 2003 edition.

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

NFPA 50B, *Standard for Liquefied Hydrogen Systems at Consumer Sites,* 1999 edition.

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

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

NFPA 59, *Utility LP-Gas Plant Code,* 2004 edition.

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

NFPA *101®, Life Safety Code®,* 2003 edition.

NFPA 160, *Standard for Flame Effects Before an Audience,* 2001 edition.

NFPA 220, *Standard on Types of Building Construction,* 1999 edition.

NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials,* 1999 edition.

NFPA 1192, *Standard on Recreational Vehicles,* 2002 edition.

2.3 Other Publications.

2.3.1 API Publications. American Petroleum Institute, 1220 L Street, N.W., Washington, DC 20005-4070.

API-ASME *Code for Unfired Pressure Vessels for Petroleum Liquids and Gases*, Pre-July 1, 1961.

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

2.3.2 ASCE Publication. American Society of Civil Engineers, United Engineering Center, 345 East 47th Street, New York, NY 10017.

ASCE 7, *Minimum Design Loads for Buildings and Other Structures,* 1998.

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

"Rules for the Construction of Unfired Pressure Vessels," Section VIII, *ASME Boiler and Pressure Vessel Code*, 2001.

ASME B 31.3, *Process Piping*, 2002.

ASME B 36.10M, *Welded and Seamless Wrought Steel Pipe*, 1996.

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

ASTM A 47, *Standard Specification for Ferritic Malleable Iron Castings*, 1999.

ASTM A 48, *Standard Specification for Gray Iron Castings*, 1994.

ASTM A 53, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless*, 1999.

ASTM A 106, *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*, 1999.

ASTM A 395, *Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*, 1998.

ASTM A 513, *Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing*, 2000.

ASTM A 536, *Standard Specification for Ductile Iron Castings*, 1999.

ASTM A 539, *Standard Specification for Electric-Resistance-Welded Coiled Steel Tubing for Gas Fuel Oil Lines*, 1999.

ASTM B 42, *Standard Specification for Seamless Copper Pipe, Standard Sizes*, 1998.

ASTM B 43, *Standard Specification for Seamless Red Brass Pipe, Standard Sizes*, 1998.

ASTM B 86, *Standard Specification for Zinc-Alloy Die Casting*, 1998.

ASTM B 88, *Standard Specification for Seamless Copper Water Tube*, 1999.

ASTM B 135, *Standard Specification for Seamless Brass Tube*, 1996.

ASTM B 280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service*, 1999.

ASTM D 2513, *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings*, 2000.

ASTM D 2683, *Standard Specification for Socket-Type Polyethylene (PE) Fittings for Outside Diameter Controlled Polyethylene Pipe*, 1998.

ASTM D 3261, *Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing*, 1997.

ASTM F 1055, *Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing*, 1998.

ASTM F 1733, *Specification for Thermoplastic Gas Pressure Pipe, Tube and Fittings,* 2002.

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

CGA C-6, *Standard for Visual Inspection of Steel Compressed Gas Cylinders*, 1993.

ANSI/CGA C-7, *Guide to the Preparation of Precautionary Labeling and Markings of Compressed Gas Containers*, 2000.

CGA V-1, *Standard Compressed Gas Cylinder Valve Outlet and Inlet Connections*, 2002.

2.3.6 IAS Publications. International Approval Services, U.S., Inc., 8501 East Pleasant Valley Road, Cleveland, OH 44131.

ANSI/AGA LC-1, *Interior Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing*, 1991.

ANSI Z-21.80/CSA 6.22, *Standard for Line Pressure Regulators*, 1997.

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

National Board Inspection Code, 2001.

2.3.8 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 132, *Standard on Safety Relief Valves for Anhydrous Ammonia and LP-Gas*, 1997.

UL 144, *Standard for LP-Gas Regulators*, 1999.

UL 147A, *Standard for Nonrefillable (Disposable) Type Fuel Gas Cylinder Assemblies*, 1996.

UL 147B, *Standard for Nonrefillable (Disposal) Type Metal Container Assemblies for Butane*, 1996.

UL 567, *Standard Pipe Connectors for Flammable and Combustible Liquids and LP-Gas*, 1996.

UL 651, *Schedule 40 or 80 Rigid PVC Conduit*, 1995.

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

Title 49, Code of Federal Regulations, "Transportation." (Also available from the Association of American Railroads, American Railroads Bldg., 1920 L Street, N.W., Washington, DC 20036 and American Trucking Assns., Inc., 2201 Mill Road, Alexandria, VA 22314.)

Federal Motor Carrier Safety Regulations.

Interstate Commerce Commission (ICC) *Rules for Construction of Unfired Pressure Vessels,* U.S. Department of Transportation, Washington, DC.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this code. Where terms are not included, common usage of the terms shall apply.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). 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.

3.3 General Definitions.

3.3.1 Actuated Liquid Withdrawal Excess-Flow Valve. An excess-flow valve for liquid withdrawal applications that remains in a closed position until actuated by a pipe nipple or adapter, as recommended by the manufacturer, and that is used with a shutoff valve attached to the actuator.

3.3.2 Anodeless Riser. A transition assembly where polyethylene or polyamide pipe or tubing is permitted to be installed underground and is terminated above ground outside of a building.

3.3.3 ANSI. American National Standards Institute.

3.3.4 API. American Petroleum Institute.

3.3.5 API-ASME Container (or Tank). A container constructed in accordance with the pressure vessel code jointly developed by the American Petroleum Institute and the American Society of Mechanical Engineers.

3.3.6 ASME. American Society of Mechanical Engineers.

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

3.3.8 ASME Container. A container constructed in accordance with the ASME Code.

3.3.9 ASTM. American Society for Testing and Materials.

3.3.10* Bulk Plant. A facility where the primary function is to store LP-Gas prior to further distribution. LP-Gas is received by cargo tank vehicle, railroad tank car, or pipeline, and then distributed by portable container (package) delivery, by cargo tank vehicle, or through gas piping.

3.3.11 Cargo Tank. A container that is used to transport LP-Gas as liquid cargo and is either mounted on a conventional truck chassis or is an integral part of a cargo transporting vehicle.

3.3.12 CGA. The Compressed Gas Association.

3.3.13 Compressed Gas. Any material or mixture having, when in its container, an absolute pressure exceeding 40 psia (an absolute pressure of 276 kPa) at 70°F (21.1°C) or, regardless of the pressure at 70°F (21.1°C), having an absolute pressure exceeding 104 psia (an absolute pressure of 717 kPa) at 130°F (54.4°C).

3.3.14 Container. Any vessel, including cylinders, tanks, portable tanks, and cargo tanks, used for the transporting or storing of LP-Gases.

3.3.15 Container Appurtenances. Devices installed in container openings for safety, control, or operating purposes.

3.3.16 Container Assembly. An assembly consisting of the container and fittings for all container openings such as shutoff valves, excess-flow valves, liquid level gauging devices, pressure relief devices, and protective housings.

3.3.17 Cylinder. A container constructed in accordance with U.S. Department of Transportation specifications, Title 49, Code of Federal Regulations.

3.3.18 Design Certification. The process by which a product is evaluated and tested by an independent laboratory to affirm that the product design complies with specific requirements.

3.3.19 Diameter. The length of a straight line passing through the center of a cycle, terminating at the periphery.

3.3.20 Direct Gas-Fired Tank Heater. A gas-fired device that applies hot gas from the heater combustion chamber directly to a portion of the container surface in contact with LP-Gas liquid.

3.3.21 Dispensing.

3.3.21.1 ***Dispensing Station.*** Fixed equipment in which LP-Gas is stored and dispensed into portable containers.

3.3.21.2 ***Vehicle Fuel Dispenser.*** A device or system designed to transfer and measure LP-Gas into engine fuel and mobile containers on vehicles.

3.3.22 DOT. U.S. Department of Transportation.

3.3.23 Filling.

3.3.23.1 ***Volumetric Method Filling.*** Filling a container to not more than the maximum permitted liquid volume.

3.3.23.2 ***Weight Method Filling.*** Filling containers to not more than the maximum permitted filling limit by weighing the LP-Gas in the container.

3.3.24* Fire Protection. Fire protection for the purposes of this standard shall be defined in the broad sense to include fire prevention, fire detection, and fire suppression.

3.3.25 Fixed Piping System. Piping, valves, and fittings permanently installed in a location to connect the source of the LP-Gas to the utilization equipment.

3.3.26* Flexible Connector. A short [not exceeding 36 in. (0.91 m) overall length] component of a piping system fabricated of flexible material (such as hose) and equipped with suitable connections on both ends.

3.3.27 Gallon. U.S. Standard. 1 U.S. gal = 0.833 Imperial gal = 231 $in.^3$ = 3.785 L.

3.3.28 Gas. Liquefied petroleum gas in either the liquid or vapor state. The more specific terms *liquid LP-Gas* or *vapor LP-Gas* are used for clarity.

3.3.29* Gas–Air Mixer. A device or a system of piping and controls that mixes LP-Gas vapor with air to produce a mixed gas of a lower heating value than the LP-Gas.

3.3.30 Gauge.

3.3.30.1 ***Fixed Liquid Level Gauge.*** A liquid level indicator that uses a positive shutoff vent valve to indicate that the liquid level in a container being filled has reached the minimum point at which the indicator communicates with the liquid level in the container.

3.3.30.2 ***Fixed Maximum Liquid Level Gauge.*** A fixed liquid level gauge that indicates the liquid level at which the container is filled to its maximum permitted filling limit.

3.3.30.3 ***Float Gauge.*** A gauge constructed with an element installed inside the container that floats on the liquid surface and transmits its position to a device outside the container to indicate the liquid level.

3.3.30.4 ***Magnetic Gauge.*** See 3.3.30.3, Float Gauge.

3.3.30.5 ***Rotary Gauge.*** A variable liquid level gauge consisting of a small positive shutoff vent valve located at the outside end of a tube that has a bent end inside the container and can be manually rotated to determine the liquid level in the container. It is equipped with a pointer and an outside dial to indicate the liquid level.

3.3.30.6 ***Slip Tube Gauge.*** A variable liquid level gauge in which a relatively small positive shutoff valve is located at the outside end of a straight tube, normally installed vertically, that communicates with the container interior.

3.3.30.7 ***Variable Liquid Level Gauge.*** A device that indicates the liquid level in a container throughout a range of levels.

3.3.31 GPA. Gas Processors Association.

3.3.32 ICC. U.S. Interstate Commerce Commission.

3.3.33 Ignition Source. See 3.3.67, Sources of Ignition.

3.3.34 Industrial Occupancy. Includes factories that manufacture products of all kinds and properties devoted to operations such as processing, assembling, mixing, packaging, finishing or decorating, and repairing.

3.3.35 kPa. Absolute pressure in kilo-Pascals.

3.3.36 kPag. Gauge pressure in kilo-Pascals.

3.3.37 Liquefied Petroleum Gas (LP-Gas). Any material having a vapor pressure not exceeding that allowed for commercial propane that is composed predominantly of the following hydrocarbons, either by themselves or as mixtures: propane, propylene, butane (normal butane or isobutane), and butylenes.

3.3.38* Low Emission Transfer. Establishes a maximum fugitive emissions standard for certain product transfer operations. Low emission transfer specifications might be employed to comply with environmental regulations or to determine certain minimum distance requirements.

3.3.39 LP-Gas System. An assembly consisting of one or more containers with a means for conveying LP-Gas from a container to dispensing or consuming devices that incorporates components that control the quantity, flow, pressure, and physical state (liquid or vapor) of the LP-Gas.

3.3.40 Maximum Allowable Working Pressure (MAWP). The maximum pressure at which a pressure vessel is to operate is described by the ASME *Boiler and Pressure Vessel Code*.

3.3.41 Minimum Design Metal Temperature (MDMT). As described by the ASME *Boiler and Pressure Vessel Code*.

3.3.42 Mobile Container. A container that is permanently mounted on a vehicle and connected for uses other than supplying engine fuel.

3.3.43 Mounded Container. An ASME container designed for underground service installed above the minimum depth required for underground service and covered with earth, sand, or other material, or an ASME container designed for aboveground service installed above grade and covered with earth, sand, or other material.

3.3.44* Movable Fuel Storage Tender. A container equipped with wheels (including a farm cart) not in excess of 1200-gal (4.5-m^3) water capacity that is moved from one location to another.

3.3.45 MPa. Absolute pressure in mega-Pascals.

3.3.46 MPag. Gauge pressure in mega-Pascals.

3.3.47 Multipurpose Passenger Vehicle. A motor vehicle with motive power, with the exception of a trailer, designed to carry 10 or fewer persons that is constructed on a truck chassis or with special features for occasional off-road operations.

3.3.48 NFPA. National Fire Protection Association.

3.3.49 NPGA. National Propane Gas Association.

3.3.50 Overfilling Prevention Device (OPD). A safety device that is designed to provide an automatic means to prevent the filling of a container in excess of the maximum permitted filling limit.

3.3.51 Overpressure Shutoff Device. A device that shuts off the flow of LP-Gas vapor when the outlet pressure of the regulator reaches a predetermined maximum allowable pressure.

3.3.52 Permanent Installation. See 3.3.69, Stationary Installation.

3.3.53 Piping Systems. Pipe, tubing, hose, and flexible rubber or metallic hose connectors with valves and fittings made into complete systems for conveying LP-Gas from one point to another in either the liquid or the vapor state at various pressures.

3.3.54 Point of Transfer. The location where connections and disconnections are made or where LP-Gas is vented to the atmosphere in the course of transfer operations.

3.3.55* Portable Container. A container designed to be moved readily, as opposed to a container designed for stationary installations.

3.3.56* Portable Storage Container. A container that is designed and constructed to be moved over a highway from one usage location to another.

3.3.57 Portable Tank (or Skid Tank). A container of more than 1000-lb (454-kg) water capacity that is mounted on skids or runners, is equipped with protected container appurtenances, and is used to transport LP-Gas.

3.3.58 Pressure Relief Device. A device designed to open to prevent a rise of internal pressure in excess of a specified value due to emergency or abnormal conditions.

3.3.59 psi. Pounds per square inch.

3.3.60 psia. Pounds per square inch, absolute.

3.3.61 psig. Pounds per square inch gauge.

3.3.62 Quick Connectors. Fittings used to connect hose assemblies to piping and valves without the use of tools.

3.3.63 Refrigerated LP-Gas. LP-Gas that is maintained as a liquid at temperatures below ambient temperature to reduce the storage pressure including fully refrigerated LP-Gas at pressures near atmospheric pressure but not exceeding 15 psig (103 kPag) and semi-refrigerated LP-Gas at pressures above 15 psig (103 kPag).

3.3.64 Regulator.

3.3.64.1* *Automatic Changeover Regulator.* An integral two-stage regulator that combines two high pressure regulators and a second-stage regulator into a single unit designed for use with multiple cylinder installations.

3.3.64.2 *First-Stage Regulator.* A pressure regulator for LP-Gas vapor service designed to reduce pressure from the container to 10.0 psig (69 kPag) or less.

3.3.64.3 *High-Pressure Regulator.* A pressure regulator for LP-Gas liquid or vapor service designed to reduce pressure from the container to a lower pressure in excess of 1.0 psig (6.9 kPag).

3.3.64.4 *Integral 2-psi Service Regulator.* A pressure regulator for LP-Gas vapor service that combines a high pressure regulator and a 2-psi service regulator into a single unit.

3.3.64.5 *Integral Two-Stage Regulator.* A pressure regulator for LP-Gas vapor service that combines a high pressure regulator and a second-stage regulator into a single unit.

3.3.64.6 *Line Pressure Regulator.* A pressure regulator in accordance with the *Standard for Line Pressure Regulators*, ANSI Z-21.80/CSA 6.22, with no integral overpressure protection device for LP-Gas vapor service designed for installation inside a building to reduce a nominal 2-psi inlet pressure to 14 in. w.c. (4.0 kPa) or less.

3.3.64.7 *Second-Stage Regulator.* A pressure regulator for LP-Gas vapor service designed to reduce first-stage regulator outlet pressure to 14 in. w.c. (4.0 kPag) or less.

3.3.64.8 *Single-Stage Regulator.* A pressure regulator for LP-Gas vapor service designed to reduce pressure from the container to 1.0 psig (6.9 kPag) or less.

3.3.64.9 *2-psi Regulator System.* An LP-Gas vapor delivery system that combines a first-stage regulator, a 2-psi service regulator and a line pressure regulator(s).

3.3.64.10 *2-psi Service Regulator.* A pressure regulator for LP-Gas vapor service designed to reduce first-stage regulator outlet pressure to a nominal 2 psig (13.8 kPag).

3.3.64.11 *Two-Stage Regulator System.* An LP-Gas vapor delivery system that combines a first-stage regulator and a second-stage regulator(s), or utilizes a separate integral two-stage regulator.

3.3.65 Service Head Adapter. A transition fitting for use with polyethylene or polyamide pipe or tubing that is recommended by the manufacturer for field assembly and installation at the aboveground termination end of an anodeless riser.

3.3.66 Skid Tank. See 3.3.57, Portable Tank.

3.3.67 Sources of Ignition. Devices or equipment that, because of their modes of use or operation, are capable of providing sufficient thermal energy to ignite flammable LP-Gas vapor–air mixtures when introduced into such a mixture or when such a mixture comes into contact with them, and that will permit propagation of flame away from them.

3.3.68* Special Protection. A means of limiting the temperature of an LP-Gas container for purposes of minimizing the possibility of failure of the container as the result of fire exposure.

3.3.69 Stationary Installation (Permanent Installation). An installation of LP-Gas containers, piping, and equipment for indefinite use at a particular location; an installation not normally expected to change in status, condition, or location.

3.3.70 UL. Underwriters Laboratories Inc.

3.3.71 Universal Cylinder. A cylinder that can be connected for service in either the vertical or the horizontal position, so that the fixed maximum liquid level gauge, pressure relief device, and withdrawal appurtenances function properly in either position.

3.3.72 Valve.

3.3.72.1 *Emergency Shutoff Valve.* A shutoff valve incorporating thermal and manual means of closing that also provides for remote means of closing.

3.3.72.2 *Excess-Flow Valve (or Excess-Flow Check Valve).* A valve designed to close when the liquid or vapor passing through it exceeds a prescribed flow rate.

3.3.72.3 ***Internal Excess-Flow Valve.*** An excess-flow valve constructed and installed so that damage to valve parts exterior to the container does not prevent closing of the valve.

3.3.72.4* ***Internal Valve.*** A container primary shutoff valve having the following features: (1) The seat and seat disc remain inside the container so that damage to parts exterior to the container or mating flange does not prevent effective sealing of the valve; (2) The valve is designed for the addition of a means for remote closure and is also designed for automatic shutoff when the flow through the valve exceeds its maximum rated flow capacity or when pump actuation differential pressure drops to a predetermined point.

3.3.72.5 ***Pressure Relief Valve.*** A type of pressure relief device designed to both open and close to maintain internal fluid pressure.

3.3.72.5.1* ***External Pressure Relief Valve.*** A pressure relief valve that is used on older domestic containers, on pressure relief valve manifolds, and for piping protection where all the working parts are located entirely outside the container or piping.

3.3.72.5.2* ***Flush-Type Full Internal Pressure Relief Valve.*** An internal pressure relief valve in which the wrenching section is also within the container connection, not including a small portion due to pipe thread tolerances on makeup.

3.3.72.5.3* ***Full Internal Pressure Relief Valve.*** A pressure relief valve, for engine fuel and mobile container use, in which all working parts are recessed within the container connection, and the spring and guiding mechanism are not exposed to the atmosphere.

3.3.72.5.4* ***Internal Spring-Type Pressure Relief Valve.*** A pressure relief valve, for use on ASME stationary containers that has a low profile and is similar to a full internal relief valve except the wrenching pads and seating section are above the container connection. The adjusting spring and the stem are below the seat and are not exposed to the atmosphere.

3.3.73 Vaporizer. A device, other than a container, that receives LP-Gas in liquid form and adds sufficient heat to convert the liquid to a gaseous state.

3.3.73.1 ***Direct-Fired Vaporizer.*** A vaporizer in which heat furnished by a flame is directly applied to some form of heat exchange surface in contact with the liquid LP-Gas to be vaporized. This classification includes submerged-combustion vaporizers.

3.3.73.2 ***Electric Vaporizer.*** A vaporizer that uses electricity as a source of heat.

3.3.73.2.1 ***Direct Immersion Electric Vaporizer.*** A vaporizer wherein an electric element is immersed directly in the LP-Gas liquid and vapor.

3.3.73.2.2 ***Indirect Electric Vaporizer.*** An immersion-type vaporizer wherein the electric element heats an interface solution in which the LP-Gas heat exchanger is immersed or heats an intermediate heat sink.

3.3.73.3 ***Indirect (or Indirect-Fired) Vaporizer.*** A vaporizer in which heat furnished by steam, hot water, the ground, surrounding air, or other heating medium is applied to a vaporizing chamber or to tubing, pipe coils, or other heat exchange surface containing the liquid LP-Gas to be vaporized; the heating of the medium used is at a point remote from the vaporizer.

3.3.73.4 ***Waterbath (or Immersion-Type) Vaporizer.*** A vaporizer in which a vaporizing chamber, tubing, pipe coils, or other heat exchange surface containing liquid LP-Gas to be vaporized is immersed in a temperature-controlled bath of water, water-glycol combination, or other noncombustible heat transfer medium that is heated by an immersion heater not in contact with the LP-Gas heat exchange surface.

3.3.74 Vaporizing Burner (Self-Vaporizing Liquid Burner). A burner that also vaporizes liquid LP-Gas prior to burning it.

3.3.75 Vehicle Fuel Dispenser. See 3.3.21, Dispensing.

3.3.76 Volumetric Loading. See 3.3.23.1, Volumetric Method Filling.

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

Chapter 4 General Requirements

4.1 Acceptance of Equipment and Systems.

4.1.1 Systems or components assembled to make up systems shall be approved as specified in Table 4.1.1.

Table 4.1.1 Containers

Containers Used	Capacity, Water		Approval Applies to …
	gal	m^3	
Cylinders	<120	0.445	Container valves and connectors Manifold valve assemblies Regulators and pressure relief devices
ASME containers	≤2000	≤7.6	Container system* including regulator, or container assembly* and regulator separately
ASME containers	>2000	>7.6	Container valves Container excess-flow valves, backflow check valves, or alternate means of providing this protection such as remotely controlled internal valves Container gauging devices Regulators and container pressure relief devices

*Where necessary to alter or repair such systems or assemblies in the field in order to provide for different operating pressures, change from vapor to liquid withdrawal, or the like, such changes shall be permitted to be made by the use of approved components.

4.1.2 Where necessary to alter or repair containers or container assemblies in the field, such changes shall be made using approved components.

4.1.3 Acceptance applies to the complete system or to the individual components of which it is comprised as specified in Table 4.1.1.

4.2 LP-Gas Odorization.

4.2.1* All LP-Gases shall be odorized prior to delivery to a bulk plant by the addition of a warning agent of such character that the gases are detectable, by a distinct odor, to a concentration in air of not over one-fifth the lower limit of flammability.

4.2.2 Odorization, however, shall not be required if it is harmful in the use or further processing of the LP-Gas or if such odorization will serve no useful purpose as a warning agent in such further use or processing.

4.2.3* If odorization is required, the presence of the odorant shall be determined by sniff-testing or other means and the results shall be documented as follows:

(1) When LP-Gas is delivered to a bulk plant
(2) When shipments of LP-Gas bypass the bulk plant

4.3 Notification of Installations.

4.3.1 Stationary Installations. Plans for stationary installations utilizing storage containers of over 2000 gal (7.6 m^3) individual water capacity, or with aggregate water capacity exceeding 4000 gal (15.1 m^3), and all rooftop installations of ASME containers shall be submitted to the authority having jurisdiction by the person or company that either installs or contracts to have the containers installed before the installation is started. *[See also 6.17.11.1(F).]*

4.3.2 Temporary Installations. The authority having jurisdiction shall be notified of temporary (not to exceed 6 months) installations of the container sizes covered in 4.3.1 before the installation is started.

4.4* Qualification of Personnel. Persons who transfer liquid LP-Gas, who are employed to transport LP-Gas, or whose primary duties fall within the scope of this code shall be trained in proper handling procedures. Refresher training shall be provided at least every 3 years. The training shall be documented.

4.5* Ammonia Contamination.

4.5.1 LP-Gas stored or used in systems within the scope of this code shall contain less ammonia than the quantity required to turn the color of red litmus paper to blue.

4.5.2 The initial fill of LP-Gas in a transportation or storage system that has been converted from ammonia to LP-Gas service shall be tested for ammonia contamination prior to being used or transferred from that system.

4.6* Minimum Requirements. For any purpose or application addressed within the scope of this code, where the minimum requirements of the code are met, additional features or components of equipment not prohibited by the code shall be permitted to be used.

Chapter 5 LP-Gas Equipment and Appliances

5.1 Scope. This chapter applies to the following:

(1) Individual components and components shop-fabricated into subassemblies, container assemblies, and complete container systems.
(2) The field assembly of components, subassemblies, container assemblies, or complete container systems into complete LP-Gas systems. *(See 3.3.39, LP-Gas System.)*

5.2 Containers.

5.2.1 General.

5.2.1.1* Containers shall be designed, fabricated, tested, and marked (or stamped) in accordance with the regulations of the U.S. Department of Transportation (DOT), the ASME *Boiler and Pressure Vessel Code*, Section VIII, "Rules for the Construction of Unfired Pressure Vessels," or the API-ASME *Code for Unfired Pressure Vessels for Petroleum Liquids and Gases*, except for UG-125 through UG-136.

(A) Adherence to applicable ASME Code case interpretations and addenda that have been adopted and published by ASME 180 calendar days prior to the effective date of this code shall be considered as compliant with the ASME Code.

(B) Containers fabricated to earlier editions of regulations, rules, or codes listed in 5.2.1.1 and of the Interstate Commerce Commission (ICC) *Rules for Construction of Unfired Pressure Vessels*, prior to April 1, 1967, shall be permitted to be continued to be used in accordance with Section 1.4.

5.2.1.2 Containers that have been involved in a fire and show no distortion shall be requalified for continued service before being used or reinstalled.

(A) Cylinders shall be requalified by a manufacturer of that type of cylinder or by a repair facility approved by DOT.

(B) ASME or API-ASME containers shall be retested using the hydrostatic test procedure applicable at the time of the original fabrication.

(C) All container appurtenances shall be replaced.

5.2.1.3 ASME paragraph U-68 or U-69 containers shall be permitted to be continued in use, installed, reinstalled, or placed back into service. Installation of containers shall be in accordance with all provisions listed in this code. *(See Section 5.2, Table 5.2.4.2 and Table 5.7.2.4(A), and Annex D.)*

5.2.1.4 Containers that show excessive denting, bulging, gouging, or corrosion shall be removed from service.

5.2.1.5 Repairs or alteration of a container shall comply with the regulations, rules, or code under which the container was fabricated. Repairs or alteration to ASME containers shall be in accordance with the *National Board Inspection Code*.

5.2.1.6 Field welding shall be permitted only on saddle plates, lugs, pads, or brackets that are attached to the container by the container manufacturer.

5.2.1.7 Containers for general use shall not have individual water capacities greater than 120,000 gal (454 m^3).

5.2.1.8 Containers in dispensing stations not located in LP-Gas bulk plants, industrial plants, or industrial applications shall have an aggregate water capacity not greater than 30,000 gal (114 m^3).

5.2.1.9 Heating or cooling coils shall not be installed inside storage containers.

5.2.2 Cylinders.

5.2.2.1* Cylinders shall be continued in service and transported in accordance with DOT regulations.

5.2.2.2 A cylinder with an expired requalification date shall not be refilled until it is requalified by the methods prescribed in DOT regulations.

5.2.3 Cylinders Filled on Site.

5.2.3.1 DOT cylinders in stationary service that are filled on site and therefore are not under the jurisdiction of DOT either shall be requalified in accordance with DOT requirements or shall be visually inspected within 12 years of the date of manufacture and within every five years thereafter, in accordance with 5.2.3.1(A) through 5.2.3.1(C).

(A) Any cylinder that fails one or more of the criteria in 5.2.3.1(C) shall not be refilled or continued in service until the condition is corrected.

(B) Personnel shall be trained and qualified to perform inspections. Training shall be documented in accordance with Section 4.4.

(C) Visual inspection shall be performed in accordance with the following:

(1) The cylinder is checked for exposure to fire, dents, cuts, digs, gouges, and corrosion according to CGA C-6, *Standard for Visual Inspection of Steel Compressed Gas Cylinders*, except that paragraph 4.2.1.1(1) of that standard (which requires tare weight verification), shall not be part of the required inspection criteria.
(2) The cylinder protective collar (where utilized) and the foot ring are intact and are firmly attached.
(3) The cylinder is painted or coated to retard corrosion.
(4) The cylinder pressure relief valve indicates no visible damage, corrosion of operating components, or obstructions.
(5) There is no leakage from the cylinder or its appurtenances that is detectable without the use of instruments.
(6) The cylinder is installed on a firm foundation and is not in contact with the soil.
(7) A cylinder that passes the visual examination shall be marked with the month and year of the examination followed by the letter "E" (example: 10-01E, indicating requalification in October 2001 by the external inspection method).
(8) The results of the visual inspection shall be documented, and a record of the inspection shall be retained for a 5-year period.

5.2.4 Container Service Pressure.

5.2.4.1 The minimum design or service pressure of cylinders shall be in accordance with the appropriate regulations published under 49 CFR, "Transportation."

5.2.4.2 The maximum allowable working pressure (MAWP) for ASME containers shall be in accordance with Table 5.2.4.2.

5.2.4.3 In addition to the applicable provisions for horizontal ASME containers, vertical ASME containers over 125 gal (0.5 m^3) water capacity shall comply with 5.2.4.3(A) through 5.2.4.3(E).

(A) Containers shall be designed to be self-supporting without the use of guy wires and shall be designed to withstand the wind, seismic (earthquake) forces, and hydrostatic test loads anticipated at the site.

(B) Design pressure *(see Table 5.2.4.2)* shall be the pressure at the top head with allowance made for increased pressure on lower shell sections and bottom head due to the static pressure of the product.

Table 5.2.4.2 Maximum Vapor Pressures and MAWP

Maximum Vapor Pressure in psig (MPag)		MAWP Pressure in psig (MPag)		
			Earlier Codes	
At 100°F	At 37.8°C	Current ASME Code[a]	API-ASME	ASME[b]
80	0.6	100 (0.7)	100 (0.7)	80 (0.6)
100	0.7	125 (0.9)	125 (0.9)	100 (0.7)
125	0.9	156 (1.1)	156 (1.1)	125 (0.9)
150	1.0	187 (1.3)	187 (1.3)	150 (1.0)
175	1.2	219 (1.5)	219 (1.5)	175 (1.2)
215	1.5	250 (1.7)[c]	250 (1.7)[c]	200 (1.4)
215	1.5	312 (2.2)[c]	312 (2.2)[c]	—

Note: See Annex D for information on earlier ASME or API-ASME codes.
[a]ASME Code, 1949 edition, paragraphs U-200 and U-201 and all later editions *(see D.2.1.5)*.
[b]All ASME codes up to the 1946 edition and paragraphs U-68 and U-69 of the 1949 edition *(see D.2.1.5)*.
[c]See 6.21.3.1(A), 6.21.3.1(C), and 6.21.3.1(D) for required minimum design pressure for ASME engine fuel and mobile containers.

(C) Wind loading on containers shall be based on wind pressures on the projected area at various height zones above ground in accordance with ASCE 7, *Minimum Design Loads for Buildings and Other Structures*. Wind speeds shall be based on a mean occurrence interval of 100 years.

(D) Seismic loading on containers shall be in accordance with ASCE 7, *Minimum Design Loads for Buildings and Other Structures*. A seismic analysis of the proposed installation shall be made that meets the approval of the authority having jurisdiction.

(E) Shop-fabricated containers shall be fabricated with lifting lugs or other means to lift the container.

5.2.4.4* ASME engine fuel and mobile containers shall have a MAWP of 312 psig (2.2 MPag) or higher.

5.2.4.5 Cylinders shall be designed and constructed for at least a 240 psig (1.6 MPag) service pressure.

5.2.5 ASME Container Openings.

5.2.5.1 ASME containers shall be equipped with openings for the service for which the container is to be used.

5.2.5.2 The openings required by 5.2.5.1 shall be located either in the shell, in the heads, or in a manhole cover.

5.2.5.3* ASME containers of more than 30 gal (0.1 m^3) through 2000 gal (7.6 m^3) water capacity that are designed to be filled volumetrically shall be equipped for filling into the vapor space.

5.2.5.4* ASME containers of 125 gal (0.5 m^3) through 2000 gal (7.6 m^3) water capacity shall be provided with an opening for an actuated liquid withdrawal excess-flow valve with a connection not smaller than ¾-in. national pipe thread.

5.2.5.5 ASME containers of more than 2000 gal (7.6 m^3) water capacity shall have an opening for a pressure gauge.

5.2.5.6 ASME containers in storage or use shall have pressure relief valve connections that have direct communication with the vapor space of the container.

(A) If the pressure relief valve is located in a well inside the ASME container with piping to the vapor space, then the design of the well and piping shall have a flow capacity equal to or greater than that of the pressure relief valve.

(B) If the pressure relief valve is located in a protecting enclosure, the enclosure shall be designed to minimize corrosion and to allow inspection.

(C) If the pressure relief valve is located in any position other than the uppermost point of the ASME container, the connection shall be internally piped to the uppermost point practical in the vapor space of the container.

5.2.5.7* ASME containers to be filled on a volumetric basis shall be fabricated so that they can be equipped with a fixed maximum liquid level gauge(s) that is capable of indicating the maximum permitted filling level(s) in accordance with 7.4.2.3.

5.2.6 Portable Container Appurtenance Physical Damage Protection.

5.2.6.1 Cylinders of 1000 lb (454 kg) water capacity [nominal 420 lb (191 kg) LP-Gas capacity] or less shall incorporate protection against physical damage to cylinder appurtenances and immediate connections to such appurtenances when not in use by either of the following means:

(1) A ventilated cap
(2) A ventilated collar

5.2.6.2 Protection of appurtenances of portable containers, skid tanks, and tanks for use as cargo tanks of more than 1000 lb (454 kg) water capacity [nominal 420 lb (191 kg) LP-Gas capacity] shall comply with 5.2.6.2(A) through 5.2.6.2(C):

(A) Appurtenance protection from physical damage shall be provided by recessing, by protective housings, or by location on the vehicle.

(B) Appurtenance protection shall comply with the provisions under which the containers are fabricated.

(C) Appurtenance protection shall be designed to withstand static loadings in any direction equal to twice the weight of the container and attachments when filled with LP-Gas, using a minimum safety factor of 4, based on the ultimate strength of the material used.

5.2.7 Containers with Attached Supports.

5.2.7.1 Vertical ASME containers of over 125 gal (0.5 m^3) water capacity for use in permanent installations in stationary service shall be designed with steel supports that allow the container to be mounted on and fastened to concrete foundations or supports.

(A) Steel supports shall be designed to make the container self-supporting without guy wires and to withstand the wind and seismic (earthquake) forces anticipated at the site.

(B) Steel supports shall be protected against fire exposure with a material having a fire resistance rating of at least 2 hours.

(C) Continuous steel skirts having only one opening of 18 in. (460 m) or less in diameter shall have 2-hour fire protection applied to the outside of the skirt.

5.2.7.2 ASME containers to be used as portable storage containers including movable fuel storage tenders and farm carts for temporary stationary service (normally not more than 12 months duration at any location) shall comply with 5.2.7.2(A) through 5.2.7.2(D).

(A) Steel legs or supports shall be either welded to the container by the manufacturer at the time of fabrication or attached to lugs that have been welded to the container.

(B) The legs or supports or the lugs for the attachment of legs or supports shall be secured to the container in accordance with the code or rule under which the container was designed and built, using a minimum safety factor of 4, to withstand loading in any direction equal to twice the weight of the empty container and attachments.

(C) The attachment of a container to either a trailer or semitrailer running gear, or the attachments to the container to make it a vehicle, so that the unit can be moved by a conventional over-the-road tractor, shall comply with the DOT requirements for cargo tank service. The stress calculations for the design of the attachment shall be based on twice the weight of the empty container.

(D) The unit shall be approved by the authority having jurisdiction.

5.2.7.3 Portable tank design and construction, securing of skids or lugs for the attachment of skids, and protection of fittings shall be in accordance with DOT portable tank specifications. The bottom of the skids shall be not less than 2 in. (50 mm) or more than 12 in. (300 mm) below the outside bottom of the tank shell.

5.2.7.4 Movable fuel storage tenders, including farm carts, shall be secured to the trailer support structure for the service involved.

5.2.8 Container Marking.

5.2.8.1 Cylinders shall be marked as provided in the regulations, rules, or code under which they are fabricated.

(A) Where LP-Gas and one or more other compressed gases are to be stored or used in the same area, the cylinders shall be marked "Flammable" and either "LP-GAS," "Propane," or "Butane," or shall be marked in accordance with the requirements of 49 CFR, "Transportation."

(B) When being transported, cylinders shall be marked and labeled in accordance with 49 CFR, "Transportation."

5.2.8.2* Cylinders shall be marked with the following information:

(1) The water capacity of the cylinder in pounds
(2) The tare weight of the cylinder in pounds, fitted for service

5.2.8.3* The markings specified for ASME containers shall be on a stainless steel metal nameplate attached to the container, located to remain visible after the container is installed.

(A) The nameplate shall be attached in such a way as to minimize corrosion of the nameplate or its fastening means and not contribute to corrosion of the container.

(B) Where the container is buried, mounded, insulated, or otherwise covered so the nameplate is obscured, the information contained on the nameplate shall be duplicated and installed on adjacent piping or on a structure in a clearly visible location.

(C) ASME containers shall be marked with the following information:

(1) Service for which the container is designed (for example, underground, aboveground, or both)
(2) Name and address of container supplier or trade name of container
(3) Water capacity of container in pounds or U.S. gallons
(4) MAWP in pounds per square inch
(5) The wording "This container shall not contain a product that has a vapor pressure in excess of ___ psig at 100°F" *(See Table 5.2.4.2.)*
(6) Outside surface area in square feet
(7) Year of manufacture
(8) Shell thickness and head thickness
(9) OL (overall length), OD (outside diameter), HD (head design)
(10) Manufacturer's serial number
(11) ASME Code symbol
(12) Minimum design metal temperature ___°F at MAWP ____ psi
(13) Type of construction "W"
(14) Degree of radiography "RT-___"

5.2.8.4 Warning labels shall meet the following requirements:

(1) Warning labels shall be applied to all cylinders of 100 lb (45.4 kg) LP-Gas capacity or less that are not filled on site.
(2) Warning labels shall include information on the potential hazards of LP-Gas.

5.2.8.5 All ASME containers that contain unodorized LP-Gas products shall be marked NOT ODORIZED in letters 4 in. (10 cm) in height with a contrasting background surrounded by a ½-in. (1.3-cm) rectangular border.

5.3 Reserved.

5.4 Reserved.

5.5 Reserved.

5.6 Reserved.

5.7 Container Appurtenances.

5.7.1 Materials.

5.7.1.1 Container appurtenances shall be fabricated of materials that are compatible with LP-Gas and shall be resistant to the action of LP-Gas under service conditions. The following materials shall not be used:

(1) Gray cast iron.
(2) Nonmetallic materials shall not be used for bonnets or bodies of valves or regulators.

5.7.1.2* Pressure-containing metal parts of appurtenances shall have a minimum melting point of 1500°F (816°C), except for the following:

(1) Fusible elements
(2) Approved or listed variable liquid level gauges used in containers of 3500 gal (13.2 m^3) water capacity or less

5.7.1.3 Container appurtenances shall have a service pressure rating of at least 250 psig (1.7 MPag).

5.7.1.4 Gaskets used to retain LP-Gas in containers shall be resistant to the action of LP-Gas.

(A) Gaskets shall be made of metal or other material confined in metal having a melting point over 1500°F (816°C) or shall be protected against fire exposure.

(B) When a flange is opened, the gasket shall be replaced.

(C) Aluminum O-rings and spiral wound metal gaskets shall be permitted.

(D) Gaskets for use with approved or listed liquid level gauges for installation on a container of 3500 gal (13.2 m^3) water capacity or less shall be exempt from the minimum melting point requirement.

5.7.2 Pressure Relief Devices. *(See Section 5.11 for hydrostatic relief valves.)*

5.7.2.1 ASME containers shall be equipped with one or more pressure relief valves that are designed to relieve vapor.

5.7.2.2 Cylinders shall be equipped with pressure relief valves as required by DOT regulations.

5.7.2.3 DOT nonrefillable metal containers shall be equipped with a pressure relief device(s) or system(s) that will prevent propulsion of the container when the container is exposed to fire.

5.7.2.4 ASME containers for LP-Gas shall be equipped with direct spring-loaded pressure relief valves conforming with applicable requirements of UL 132, *Standard on Safety Relief Valves for Anhydrous Ammonia and LP-Gas,* or other equivalent pressure relief valve standards.

(A) The start-to-leak setting of such pressure relief valves, in relation to the pressure rating of the container, shall be in accordance with Table 5.7.2.4(A).

Table 5.7.2.4(A) Start-to-Leak Pressure Settings of Pressure Relief Valves in Relation to Container Pressure Rating

Containers	Minimum	Maximum
All ASME codes prior to the 1949 edition, and the 1949 edition, paragraphs U-68 and U-69	110%	125%*
ASME code, 1949 edition, paragraphs U-200 and U-201, and all ASME codes later than 1949	100%	100%*

* Manufacturers of pressure relief valves are allowed a plus tolerance not exceeding 10 percent of the set pressure marked on the valve.

(B) Containers of 40,000 gal (151 m^3) or more water capacity shall be equipped with either a spring-loaded pressure relief valve or a pilot-operated pressure relief valve, as follows:

(1) The pilot-operated relief valve shall be combined with and controlled by a self-actuated, direct, spring-loaded pilot valve that complies with Table 5.7.2.4(A).
(2) The use of a pilot-operated pressure relief valve shall be approved.
(3) Pilot-operated pressure relief valves shall be inspected and maintained by persons with training and experience, and shall be tested for operation at intervals not exceeding 5 years.

5.7.2.5 The minimum rate of discharge of pressure relief valves shall be in accordance with Table 5.7.2.5 or shall be calculated using the following formula:

$$\text{Flow rate } \left(\text{ft}^3/\text{min air}\right) = 53.632 \times A^{0.82}$$

where:
A = total outside surface area of container in square feet

Table 5.7.2.5 Pressure Relief Valve Flow Capacity as a Function of Container Surface Area

Surface Area (ft^2)	Flow Rate (ft^3/min air)	Surface Area (ft^2)	Flow Rate (ft^3/min air)	Surface Area (ft^2)	Flow Rate (ft^3/min air)
≤20	626	170	3620	600	10,170
25	751	175	3700	650	10,860
30	872	180	3790	700	11,550
35	990	185	3880	750	12,220
40	1100	190	3960	800	12,880
45	1220	195	4050	850	13,540
50	1330	200	4130	900	14,190
55	1430	210	4300	950	14,830
60	1540	220	4470	1000	15,470
65	1640	230	4630	1050	16,100
70	1750	240	4800	1100	16,720
75	1850	250	4960	1150	17,350
80	1950	260	5130	1200	17,960
85	2050	270	5290	1250	18,570
90	2150	280	5450	1300	19,180
95	2240	290	5610	1350	19,780
100	2340	300	5760	1400	20,380
105	2440	310	5920	1450	20,980
110	2530	320	6080	1500	21,570
115	2630	330	6230	1550	22,160
120	2720	340	6390	1600	22,740
125	2810	350	6540	1650	23,320
130	2900	360	6690	1700	23,900
135	2990	370	6840	1750	24,470
140	3080	380	7000	1800	25,050
145	3170	390	7150	1850	25,620
150	3260	400	7300	1900	26,180
155	3350	450	8040	1950	26,750
160	3440	500	8760	2000	27,310
165	3530	550	9470	—	—

5.7.2.6 Relief valves for aboveground ASME containers shall relieve at not less than the flow rate specified in 5.7.2.5 before the pressure exceeds 120 percent of the minimum permitted start-to-leak pressure setting of the device. This does not include the 10 percent tolerance in Table 5.7.2.4(A).

5.7.2.7 The flow capacity of pressure relief valves installed on underground or mounded containers shall be permitted to be reduced to 30 percent of the flow specified in Table 5.7.2.5.

5.7.2.8 Each pressure relief valve shall be plainly and permanently marked with the following:

(1) The pressure in psig at which the valve is set to start-to-leak
(2) Rated relieving capacity in cubic feet per minute of air at 60°F (16°C) and 14.7 psia (101 kPa)
(3) The manufacturer's name and catalog number

5.7.2.9 Shutoff valves shall not be installed between pressure relief devices and the container unless a listed pressure relief valve manifold meeting the requirements of 6.7.2.9 is used.

5.7.2.10 Pressure relief valves shall be designed to minimize the possibility of tampering.

5.7.2.11 Externally set or adjusted valves shall be provided with an approved means of sealing the adjustment.

5.7.2.12 Where used on aboveground containers of 1200 gal (4.5 m^3) or less in addition to spring-loaded pressure relief valves, fusible plugs shall be in accordance with the following:

(1) Have a yield point between 208°F and 220°F (98°C and 104°C)
(2) Have a total discharge area not exceeding 0.25 $in.^2$ (1.6 cm^2)
(3) Communicate directly with the vapor space of the container

5.7.2.13 All cylinders used in industrial truck service (including forklift truck cylinders) shall have the cylinder's pressure relief valve replaced by a new or unused valve within 12 years of the date of manufacture of the cylinders and every 10 years thereafter.

5.7.3 Regulators.

5.7.3.1 Single-stage regulators shall have a maximum outlet pressure setting of 1.0 psig (7 kPag) and shall be equipped with one of the following *[see 6.7.4.4 for required protection from the elements]*:

(1) An integral pressure relief valve on the outlet pressure side having a start-to-discharge pressure setting within the limits specified in UL 144, *Standard for LP-Gas Regulators.*
(2) An integral overpressure shutoff device that shuts off the flow of LP-Gas vapor when the outlet pressure of the regulator reaches the overpressure limits specified in UL 144, *Standard for LP-Gas Regulators.* Such a device shall not open to permit flow of gas until it has been manually reset.

5.7.3.2 Second-stage regulators and integral two-stage regulators shall have a maximum outlet pressure setting of 14 in. w.c. (4.0 kPag) and shall be equipped with one of the following *(see 6.7.4.4 for required protection from the elements)*:

(1) An integral pressure relief valve on the outlet pressure side having a start-to-discharge pressure setting within the limits specified in UL 144, *Standard for LP-Gas Regulators.* This relief device shall limit the outlet pressure of the second-stage regulator to 2.0 psig (14 kPag) when the regulator seat disc is removed and the inlet pressure to the regulator is 10.0 psig (69 kPag) or less as specified in UL 144.
(2) An integral overpressure shutoff device that shuts off the flow of LP-Gas vapor when the outlet pressure of the regulator reaches the overpressure limits specified in UL 144, *Standard for LP-Gas Regulators.* Such a device shall not open to permit flow of gas until it has been manually reset.
(3) Regulators with a rated capacity of more than 500,000 Btu/hr (147 kW/hr) shall be permitted to have a separate overpressure protection device complying with 5.9.2 of NFPA 54, *National Fuel Gas Code* (ANSI Z223.1). The overpressure protection device shall limit the outlet pressure of the regulator to 2.0 psig (14 kPag) when the regulator seat disc is removed and the inlet pressure to the regulator is 10 psig (69 kPag) or less.

5.7.3.3 Integral two-stage regulators shall be provided with a means to determine the outlet pressure of the high-pressure regulator portion of the integral two-stage regulator.

5.7.3.4 Automatic changeover regulators shall be exempt from this requirement.

5.7.3.5 Integral two-stage regulators shall not incorporate an integral pressure relief valve in the high-pressure regulator portion of the unit.

5.7.3.6 First-stage regulators shall incorporate an integral pressure relief valve having a start-to-discharge setting within the limits specified in UL 144, *Standard for LP-Gas Regulators*.

5.7.3.7 First-stage regulators with a rated capacity of more than 500,000 Btu/hr (147 kW/hr) shall be permitted to have a separate pressure relief valve.

5.7.3.8 High-pressure regulators with a rated capacity of more than 500,000 Btu/hr (147 kW/hr) where permitted to be used in two-stage systems shall incorporate an integral pressure relief valve or shall have a separate relief valve.

5.7.3.9 First-stage regulators shall have an outlet pressure setting up to 10.0 psig (69 kPag) in accordance with UL 144, *Standard for LP-Gas Regulators*.

5.7.3.10 Regulators shall be designed so as to drain all condensate from the regulator spring case when the vent is directed down vertically.

5.7.3.11 Two-psi service regulators shall be equipped with one of the following:

(1) An integral pressure relief valve on the outlet pressure side having a start-to-discharge pressure setting within the limits specified in UL 144, *Standard for LP-Gas Regulators*. This relief device shall limit the outlet pressure of the 2 psi (14 kPa) service regulator to 5.0 psi (34.5 kPa) when the regulator seat disc is removed and inlet pressure to the regulator is 10.0 psi (69 kPa) or as specified in UL 144.
(2) An integral overpressure shutoff device that shuts off the flow of LP-Gas vapor when the outlet pressure of the regulator reaches the overpressure limits specified in UL 144, *Standard for LP-Gas Regulators*. Such a device shall not open to permit flow of gas until it has been manually reset.

5.7.4 Pressure Regulators. (Reserved)

5.7.5* Pipe for Regulator Venting.

5.7.5.1 Pipe or tubing used to vent regulators shall be one of the following:

(1) Metal pipe and tubing in accordance with 5.8.3
(2) PVC meeting the requirements of UL 651, *Schedule 40 or 80 Rigid PVC Conduit*

5.7.5.2 Other PVC piping materials and polyethylene and polyamide pipe and tubing shall not be permitted to be used to vent regulators.

5.7.6 Overfilling Prevention Devices.

5.7.6.1 Cylinders with 4 lb (1.8 kg) through 40 lb (18 kg) propane capacity for vapor service shall be equipped or fitted with a listed overfilling prevention device and a fixed maximum liquid level gauge. These devices shall be permitted to be a part of the container valve assembly.

5.7.6.2* Cylinders requalified after September 30, 1998, shall be equipped with a listed overfilling prevention device and a fixed maximum liquid level gauge, sized in accordance with 7.4.3.2(A) or Table 5.7.6.2, prior to being filled.

Table 5.7.6.2 Recommended Dip Tube Lengths for Various Cylinders

Cylinder Size	Material	Cylinder I.D. (in.)	Cylinder Water Capacity (lb)	Dip Tube Lengths for Various Cylinders (in.)
4.25#	Steel	8.9	10.2	2.2
5#	Steel	7.8	11.9	3.0
6#	Steel	7.5	15.5	3.2
10#	Steel	8.9	26.1	3.6
11#	Steel	8.9	26.2	3.6
11#	Steel	12.0	26.2	3.0
11.5#	Steel	12.0	27.3	3.2
20#	Steel	12.0	47.6	4.0
25#	Steel	12.0	59.7	4.8
30#	Steel	12.0	71.5	4.8
40#	Steel	12.0	95.3	6.5
6#	Aluminum	6.0	15.0	4.8
10#	Aluminum	10.0	23.6	4.0
20#	Aluminum	12.0	47.6	4.8
30#	Aluminum	12.0	71.5	6.0
40#	Aluminum	12.0	95.2	7.0

Note: This table indicates the approximate fixed maximum liquid level gauge dip tube lengths to be used for retrofitting cylinders with valves incorporating an overfilling prevention device. This table does not cover every cylinder design or configuration. If the dip tube length that is marked on the cylinder does not appear in this table, use the next longer dip tube shown in the table.

5.7.6.3 No cylinder shall be filled unless it is equipped with an overfilling prevention device and a fixed maximum liquid level gauge. The length of the fixed maximum liquid level gauge dip tube shall be in accordance with 7.4.3.2(A) or Table 5.7.6.2.

5.7.6.4 Cylinders required to have an overfilling prevention device installed shall be equipped with either a CGA connection number 791 or a CGA connection number 810 as described in CGA V-1, *Standard Compressed Gas Cylinder Valve Outlet and Inlet Connections*.

5.7.6.5 The following types of cylinders shall be exempt from the requirements of 5.7.6.1 through 5.7.6.4 for installing a listed overfilling prevention device:

(1) Cylinders used in industrial truck service and cylinders identified and used for industrial welding and cutting gases
(2) Cylinders manufactured prior to October 1, 1998, and designed for use in the horizontal position and where an overfilling prevention device is not available

5.7.6.6 Exempted horizontal cylinders shall be marked with a label to indicate that they are not equipped with an overfilling prevention device.

5.7.7 Container Connections and Appurtenances.

5.7.7.1 Containers of 2000 gal (7.6 m^3) water capacity or less shall comply with Table 5.7.7.1. Containers of 2001 gal through 4000 gal in bulk plant and industrial plant service shall be in accordance with Table 5.7.7.3. Containers of 2001 gal through 4000 gal in other than bulk plant and industrial plant service shall be in accordance with Table 5.7.7.1.

Table 5.7.7.1 Container Connection and Appurtenance Requirements for Containers Used in Other than Bulk Plants and Industrial Plants

Part	Appurtenances	1 Cylinders 2-lb to 100-lb (0.9-kg to 45.4-kg) Propane Capacity for Vapor Service	2 Cylinders 2-lb to 100-lb (0.9-kg to 45.4-kg) Propane Capacity for Liquid Service	3 Cylinders 2-lb to 100-lb (0.9-kg to 45.4-kg) Propane Capacity for Liquid and Vapor Service	4 Cylinders 100-lb to 420-lb (45.4-kg to 190-kg) Propane Capacity Filled on Site	5 Stationary ASME Containers Through 4000-gal (15.2-m^3) Water Capacity	6 DOT and ASME Engine Fuel or Mobile Containers
A	Manual shutoff valve with an integral external pressure relief valve	R *(see 5.7.6.4) [see 5.7.7.1(G)]*					
B	Manual shutoff valve (CGA 555 outlet) with integral external pressure relief valve and excess-flow valve attached to the internal liquid line inside the cylinder		R√ *(see 5.7.2.2)*				
C	Manual shutoff valve (CGA 555 outlet) with excess-flow valve for liquid service attached to the internal liquid line inside the cylinder; manual shutoff valve (CGA 510 outlet) with integral external pressure relief valve for vapor service			R√ *(5.7.2.2)*			
D	Double backflow check filler valve		O√		R√	R√	O-DOT R-ASME
E	Manual shutoff valve for vapor service *[see 5.7.7.1(F) and 6.17.2.1(5)]*				R√	R√	
F	Fixed maximum liquid level gauge	R√	R√	R√	R√	R√	R
G	External pressure relief valve *(see 5.7.2)*				R√		
H	Internal spring-type pressure relief valve *(see 5.7.2)*					R *[see 5.7.7.1(A)]*	
I	Float gauge	O√	O√	O√	O	R√	O
J	Backflow check and excess-flow vapor return valve					O√	
K	Actuated liquid withdrawal excess-flow valve *[see 5.7.7.1(B) through 5.7.7.1(D)]*					R	
L	Manual shutoff liquid or vapor valve with internal excess-flow check valve						R
M	Full internal or flush-type full internal pressure relief valve						R
N	Overfilling prevention device	R√ (4 to 40 lb only) *[see 5.7.7.1(G)]*					R *[see 5.7.7.1(E)]*

R: Required as a separate appurtenance.
O: Optional.
R√: Required as a separate appurtenance or as part of a multipurpose valve.
O√: Optional as a separate appurtenance or as part of a multipurpose valve.

(A) The requirement for internal spring-type pressure relief valves that are shown in Table 5.7.7.1 for stationary ASME containers up to and including 4000 gal (15.2 m^3) water capacity shall not apply to underground containers where external pressure relief valves are permitted or to containers that were originally equipped with external pressure relief valves.

(B) Containers of 125 gal through 4000 gal (0.5 m^3 through 15.2 m^3) water capacity shall be provided with an actuated liquid withdrawal excess-flow valve with a connection not smaller than ¾-in. national pipe thread.

(C) An actuated liquid withdrawal excess-flow valve shall not be required on container connections equipped for liquid withdrawal with a positive shutoff valve that is located as close to the container as practical in combination with an excess-flow valve installed in the container connection.

(D) The actuated liquid withdrawal excess flow valve shall not be connected for continuous use unless the valve is recommended by the manufacturer for such service.

(E) An overfilling prevention device shall not be required for engine fuel cylinders used on industrial (and forklift) trucks powered by LP-Gas or for engine fuel cylinders used on vehicles (including floor maintenance machines) having LP-Gas-powered engines mounted on them.

(F) Excess-flow protection shall not be required for manual shutoff valves for vapor service where an approved regulator is directly attached or attached with a flexible connector to the outlet of the manual shutoff valve for vapor service and the controlling orifice between the container contents and the shutoff valve outlet does not exceed 5/16 in. (8 mm) in diameter.

(G) Overfilling prevention devices shall be required on cylinders having 4 lb through 40 lb (1.8 kg through 18 kg) propane capacity for vapor service. *(See 5.7.6.)*

5.7.7.2 ASME containers over 4000 gal (15.2 m^3) water capacity shall be equipped in accordance with 5.7.7.2(A) through 5.7.7.2(G) and Table 5.7.7.3.

(A) Vapor withdrawal openings shall be equipped with either of the following:

(1) A positive shutoff valve located as close to the container as practical in combination with an excess-flow valve installed in the container
(2) An internal valve

(B) Liquid withdrawal openings in new installations shall be equipped with an internal valve that is fitted for remote closure and automatic shutoff using thermal (fire) actuation where the thermal element is located within 5 ft (1.5 m) of the internal valve.

(C) Liquid withdrawal openings in existing installations where the container is equipped with an internal valve that is not fitted for remote closure and automatic shutoff using thermal (fire) actuation shall be equipped for remote and thermal closure by July 1, 2003.

(D) Liquid withdrawal openings in existing installations shall be equipped with either of the following by July 1, 2011:

(1) An internal valve that is fitted for remote closure and automatic shutoff using thermal (fire) actuation where the thermal element is located within 5 ft (1.5 m) of the internal valve
(2) An emergency shutoff valve that is installed in the line downstream as close as practical to a positive shutoff valve in combination with an excess flow valve installed in the container

(E) Vapor inlet openings shall be equipped with either of the following:

(1) A positive shutoff valve that is located as close to the container as practical in combination with either a backflow check valve or excess-flow valve installed in the container
(2) An internal valve

(F) Liquid inlet openings in new installations shall be equipped with either of the following:

(1) An internal valve that is fitted for remote closure and automatic shutoff using thermal (fire) actuation where the thermal element is located within 5 ft (1.5 m) of the internal valve
(2) A positive shutoff valve that is located as close to the container as practical in combination with a backflow check valve that is designed for the intended application and is installed in the container

(G) Liquid inlet openings in existing installations where the container is equipped with an internal valve that is not fitted for remote closure and automatic shutoff using thermal (fire) actuation shall be equipped for remote and thermal closure by July 1, 2003.

(H) Liquid inlet openings in existing installations shall be equipped with any of the following by July 1, 2011:

(1) An internal valve that is fitted for remote closure and automatic shutoff using thermal (fire) actuation where the thermal element is located within 5 ft (1.5 m) of the internal valve
(2) An emergency shutoff valve that is installed in the line upstream as close as practical to a positive shutoff valve in combination with an excess flow valve installed in the container
(3) A positive shutoff valve that is located as close to the container as practical in combination with a backflow check valve that is designed for the intended application and is installed in the container
(4) A backflow check valve that is designed for the intended application and is installed in the line upstream as close as practical to a positive shutoff valve in combination with an excess-flow valve installed in the container

(I) Container openings that are not compatible with internal valves shall be permitted to utilize both an excess flow valve installed in the container and a valve complying with API 607, *Fire Test for Soft-Seated Quarter Turn Ball Valves*, with the following features:

(1) The valve shall be activated either hydraulically or pneumatically and shall fail in the closed position.
(2) The valve shall be equipped for remote closure and thermal actuation with a thermal element located within 5 ft of the valve.

5.7.7.3 Appurtenances used on inlet and outlet connections of containers larger than 2000 gallons water capacity through 4000 gallons water capacity shall be in accordance with Table 5.7.7.1. Appurtenance requirements for inlet and outlet connections of containers in bulk plant and industrial plant service shall be in accordance with Table 5.7.7.3.

Table 5.7.7.3 Connection and Appurtenance Requirements for New and Existing Container Installations in Bulk Plants and Industrial Plants

Service	2001 gal Through 4000 gal W.C.[a]	Greater Than 4000 gal W.C.[a]	Requirements for Containers of Greater Than 4000 gal W.C. With and Without Internal Valves[b]	
			Without Existing Internal Valves (by 7/1/11)	With Existing Internal Valves
Vapor inlet	Option A or Option B or Option C	Option A or Option B or Option C	See Note	See Note
Vapor outlet	Option B or Option C	Option B or Option C	See Note	See Note
Liquid inlet	Option A or Option B or Option C	Option D or Option E	Option D or Option E or Option F or Option G	RT
Liquid outlet	Option B or Option C	Option E	Option E or Option H	RT

Option A: Positive shutoff valve installed as close as practical to a backflow check valve installed in the container.
Option B: Positive shutoff valve installed as close as practical to an excess flow valve installed in the container and sized in accordance with 5.7.11.1(H).
Option C: Internal valve installed in the container or an excess flow valve in accordance with 5.7.7.2(I).
Option D: Positive shutoff valve installed as close as practical to a backflow check valve designed for the intended application and installed in the container.
Option E: Internal valve installed in the container equipped for remote closure and automatic shutoff using thermal (fire) activation within 5 ft of valve or an excess flow valve in accordance with 5.7.7.2(I).
Option F: Emergency shutoff valve equipped for remote closure and automatic shutoff using thermal (fire) activation installed in the line upstream as close as practical to an existing positive shutoff valve/excess flow valve combination.
Option G: Backflow check valve designed for the intended application and installed in the line upstream as close as practical to the existing positive shutoff valve/excess flow valve combination.
Option H: Emergency shutoff valve equipped for remote closure and automatic shutoff using thermal (fire) activation, installed in the line downstream as close as practical to an existing positive shutoff valve/excess-flow valve combination.
RT: Equipping an existing internal valve for remote closure and automatic shutoff using thermal (fire) actuation within 5 ft of the internal valve.
Note: Vapor connections on containers installed prior to the effective date of the 2001 edition of NFPA 58 are not required to be modified.
[a]Applicable to installations constructed on or after the effective date of this code.
[b]Applicable to installations constructed prior to the effective date of this code.

5.7.7.4 ASME containers over 4000 gal (15.2 m^3) water capacity shall also be equipped with the following appurtenances:

(1) An internal spring-type, flush-type full internal, or external pressure relief valve *(see Annex E)*
(2) A fixed maximum liquid level gauge
(3) A float gauge, rotary gauge, slip tube gauge, or a combination of these gauges
(4) A pressure gauge
(5) A temperature gauge

5.7.7.5 The appurtenances specified in Table 5.7.7.1 and 5.7.7.3 shall comply with the following:

(1) Manual shutoff valves shall be designed to provide positive closure under service conditions.
(2) Excess-flow check valves shall be designed to close automatically at the rated flows of vapor or liquid specified by the manufacturer.
(3) Excess-flow valves shall be designed with a bypass that shall not exceed a No. 60 drill size opening to allow equalization of pressure.
(4) Excess-flow valves of less than ½ in. (1.3 cm) NPT shall have a bypass that limits propane vapor flow to 10 scf/hr at 100 psig (690 kPag).
(5) Backflow check valves shall be of the spring-loaded or weight-loaded type with in-line or swing operation and shall close when the flow is either stopped or reversed.
(6) Internal valves *(see 3.3.72.4, Internal Valve)*, either manually or remotely operated and designed to remain closed except during operating periods, shall be considered positive shutoff valves.

5.7.8 Liquid Level Gauging Devices.

5.7.8.1 Liquid level gauging devices shall be installed on all containers filled by volume.

5.7.8.2 The gauging devices shall be either fixed maximum liquid level gauges or variable gauges of the slip tube, rotary, or float types (or combinations of such gauges).

5.7.8.3* Every container designed to be filled on a volumetric basis shall be equipped with a fixed maximum liquid level gauge(s) to indicate the maximum filling level(s) for the service(s) in which the container is to be filled or used *(see 7.4.3.3)*.

5.7.8.4 ASME containers shall have permanently attached to the container adjacent to the fixed maximum liquid level gauge, or on the container nameplate, markings showing the percentage of capacity that is indicated by that gauge.

5.7.8.5 Cylinders shall have the letters DT stamped on them followed by the vertical distance (to the nearest tenth of an inch) measured from the top of the boss or coupling into which the gauge, or the cylinder valve of which it is a part, is installed to the end of the dip tube.

5.7.8.6 Cylinders equipped with a fixed maximum liquid level gauge where the dip tube is not welded to the inside of the cylinder shall be permanently marked adjacent to the gauge.

(A) Cylinders designed to be filled in one position shall be marked as follows:

(1) The marking shall be the letters DT followed by the dip tube length to the nearest tenth of an inch.
(2) The dip tube length is measured from the top center of the cylinder boss or coupling where the gauge is installed to the maximum permitted filling level.

(B) Universal-type cylinders, where the dip tube is not welded to the inside of the cylinder and that are permitted to be filled in either the vertical or horizontal position, shall be marked as follows:

(1) Vertical filling — With the letters VDT followed by the vertical distance (to the nearest tenth of an inch) measured from the top center of the coupling where the gauge is installed to the maximum permitted filling level
(2) Horizontal filling — With the letters HDT followed by the vertical distance (to the nearest tenth of an inch) measured from the centerline of the coupling opening into which the gauge is installed, that is located at the maximum filling level in the horizontal position, to the inside top of the cylinder

5.7.8.7 Cargo tanks and ASME containers utilizing multiple fixed liquid level gauges shall have the loading percentage (to the nearest 2/10 percent) stamped adjacent to each gauge.

5.7.8.8 Variable liquid level gauges shall comply with the following:

(1) Variable liquid level gauges installed on containers over 2000 gal (7.6 m^3) water capacity shall be marked with the maximum liquid level, in inches, metric units, or percent of capacity of the container where they are to be installed.
(2) Markings shall indicate the maximum liquid level at liquid temperatures from 20°F to 130°F (–6.7°C to 54.4°C) and in increments not greater than 20°F (11°C) for propane, for 50/50 butane–propane mixtures, and for butane.
(3) Markings indicating the various liquid levels from empty to full shall be shown on the system nameplate, on the gauging device, or on both.
(4) Dials of magnetic float gauges or rotary gauges shall indicate whether they are for cylindrical or spherical containers and whether they are for aboveground or underground service.
(5) The dials of gauges for use only on aboveground containers of over 1200 gal (4.5 m^3) water capacity shall be so marked.

5.7.8.9 Variable liquid level gauges shall comply with the provisions of 7.4.3.2(B) if they are used for filling containers.

5.7.8.10 Gauging devices requiring bleeding of product to the atmosphere, such as fixed liquid level, rotary tube, and slip tube gauges, shall be designed so that the bleed valve maximum opening to the atmosphere is not larger than a No. 54 drill size.

5.7.9 Pressure Gauges.

5.7.9.1 Pressure gauges shall be attached directly to the container opening or to a valve or fitting that is directly attached to the container opening.

5.7.9.2 If the cross sectional area of the opening into the container described in 5.7.9.1 is greater than that of a No. 54 drill size, an excess-flow check valve shall be provided for the container connection.

5.7.10 Other Container Connections.

5.7.10.1 Container openings shall be equipped with one of the following:

(1) A positive shutoff valve in combination with either an excess-flow check valve or a backflow check valve, plugged
(2) An internal valve, plugged
(3) A backflow check valve, plugged
(4) An actuated liquid withdrawal excess-flow valve, normally closed and plugged, with provision to allow for external actuation
(5) A plug, blind flange, or plugged companion flange

5.7.10.2 Pressure relief valves in accordance with 5.7.2, connections for flow controls in accordance with 5.7.7, liquid level gauging devices in accordance with 5.7.8, and pressure gauges in accordance with 5.7.9 shall be exempt from the requirements of 5.7.11.1.

5.7.11 Container Appurtenance Protection.

5.7.11.1 All container openings except those used for pressure relief devices, liquid level gauging devices, pressure gauges, double check filler valves, combination backflow check and excess-flow vapor return valves, actuated liquid withdrawal excess flow valves, and plugged openings shall be equipped with internal valves or with positive shutoff valves and either excess-flow or backflow check valves

(A) ASME containers where excess-flow or backflow check valves are installed between the LP-Gas in the container and the shutoff valves shall be installed either inside the container or at a point immediately outside where the line enters or leaves the container.

(B) If excess-flow and backflow check valves are installed outside the container, installation shall be made so that any strain beyond the excess-flow or backflow check valves will not cause breakage between the container and the valve.

(C) All connections that are listed in the ASME Manufacturers' Data Report for the container shall be considered part of the container.

(D) If an excess-flow valve is required for cylinders other than for mobile or engine fuel service, it shall be permitted to be located at the outlet of the cylinder shutoff valve.

(E) Shutoff valves shall be located as close to the container as practical.

(F) Shutoff valves shall be readily accessible for operation and maintenance under normal and emergency conditions.

(G) Shutoff valves either shall be located in a readily accessible position less than 6 ft (1.8 m) above ground level or shall have extension handles, stairs, ladders, or platforms for access, or shall be equipped for remote operation.

(H) The connection or line that leads to or from any individual opening shall have greater flow capacity than the rated flow of the excess-flow valve protecting the opening.

5.7.11.2 Valves, regulators, gauges, and other container appurtenances shall be protected against physical damage.

5.7.11.3 Valves and other appurtenances that are part of the assembly of portable multicylinder systems shall be arranged so that replacement of cylinders can be made without shutting off the flow of gas in the system.

5.7.11.4 Connections to ASME containers installed underground shall be located within a substantial dome, housing, or manhole and shall have a cover.

(A) Underground containers shall be installed so that all connections for hose and any opening through which there can be a flow from pressure relief devices or pressure regulator vents are located above the normal maximum water table.

(B) Such manholes or housings shall be ventilated.

(C) The area of ventilation openings shall equal or exceed the combined discharge areas of the pressure relief devices and other vent lines that discharge into the manhole or housing.

5.7.11.5 Container inlet and outlet connections on ASME containers of more than 2000 gal (7.6 m^3) water capacity shall be labeled to designate whether they communicate with the vapor or liquid space.

(A) Labels shall be permitted to be on valves.

(B) Connections for pressure relief devices, liquid level gauging devices, and pressure gauges shall not be required to be labeled.

5.7.11.6 Every ASME storage container of more than 2000 gal (7.6 m^3) water capacity shall be provided with a pressure gauge.

5.8 Piping (Including Hose), Fittings, and Valves.

5.8.1 General.

5.8.1.1 Material specifications for pipe, tubing, pipe and tubing fittings, valves (including hydrostatic relief valves), hose, hose connections, and flexible connectors shall be in accordance with Section 5.8.

5.8.1.2 Piping, pipe and tubing fittings, and valves used to supply utilization equipment within the scope of NFPA 54, *National Fuel Gas Code*, shall comply with that code.

5.8.1.3 Pipe and tubing shall comply with one of the following requirements:

(1) Pipe and tubing shall comply with 5.8.3.
(2) Pipe and tubing shall be recommended for that service by the manufacturer and shall be approved.

5.8.1.4 Piping that can contain liquid LP-Gas and that can be isolated by valving and that requires hydrostatic relief valves, as specified under Section 6.11, shall have an operating pressure of 350 psig (2.4 MPag) or a pressure that is equivalent to the maximum discharge pressure of any pump or other source feeding the piping system if it is greater than 350 psig (2.4 MPag).

5.8.2 Reserved.

5.8.3 Pipe and Tubing.

5.8.3.1 Pipe. Pipe shall be wrought iron or steel (black or galvanized), brass, copper, polyamide, or polyethylene and shall comply with the following:

(1) Wrought iron — ASME B 36.10M, *Welded and Seamless Wrought Steel Pipe*
(2) Steel pipe — ASTM A 53, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless*
(3) Steel pipe — ASTM A 106, *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*
(4) Brass pipe — ASTM B 43, *Standard Specification for Seamless Red Brass Pipe, Standard Sizes*
(5) Copper pipe — ASTM B 42, *Standard Specification for Seamless Copper Pipe, Standard Sizes*
(6) Polyamide and polyethylene pipe — ASTM D 2513, *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings*, and shall be recommended by the manufacturer for use with LP-Gas

5.8.3.2 Tubing. Tubing shall be steel, stainless steel, brass, copper, polyamide, or polyethylene *(see 6.8.4)* and shall comply with the following:

(1) Steel tubing — ASTM A 539, *Standard Specification for Electric-Resistance-Welded Coiled Steel Tubing for Gas Fuel Oil Lines*
(2) Brass tubing — ASTM B 135, *Standard Specification for Seamless Brass Tube*
(3) Copper tubing
  (a) Type K or L — ASTM B 88, *Specification for Seamless Copper Water Tube*
  (b) ASTM B 280, *Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service*
(4) Polyamide and polyethylene tubing — ASTM D 2513, *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings*, and shall be recommended by the manufacturer for use with LP-Gas
(5) Corrugated stainless steel tubing — ANSI/AGA LC1, *Interior Fuel Gas Piping Systems Using Corrugated Stainless Steel Tubing*

5.8.4 Fittings for Metallic Pipe and Tubing. Fittings shall be steel, brass, copper, malleable iron, or ductile (nodular) iron.

5.8.4.1 Pipe fittings shall have a minimum pressure rating as specified in Table 5.8.4.1 and shall comply with the following:

(1) Cast-iron pipe fittings shall not be used.
(2) Brazing filler material shall have a melting point that exceeds 1000°F (538°C).

Table 5.8.4.1 Service Pressure Rating of Pipe, Tubing Fittings, and Valves

Service	Minimum Pressure
Higher than container pressure	350 psig (2.4 MPag), or the MAWP, whichever is higher, or 400 psig (2.8 MPag) WOG rating
LP-Gas liquid, or vapor at operating pressure over 125 psig and at or below container pressure	250 psig (1.7 MPag)
LP-Gas vapor at operating pressure of 125 psig (0.9 MPag) or less	125 psig (0.9 MPag)

5.8.4.2 Metal tube fittings shall have a minimum pressure rating as specified in Table 5.8.4.1.

5.8.5* Fittings for Polyethylene and Polyamide Pipe and Tubing. Joints in polyamide and polyethylene pipe and polyethylene tubing shall be made by heat fusion, by compression-type mechanical fittings, or by factory-assembled transition fittings.

(A) Polyethylene pipe shall not be joined by a threaded or miter joint.

(B) Polyamide and polyethylene fusion fittings shall be recommended by the manufacturer for use with LP-Gas and shall conform to one of the following:

(1) ASTM D 2683, *Standard Specification for Socket-Type Polyethylene (PE) Fittings for Outside Diameter Controlled Polyethylene Pipe*
(2) ASTM D 3261, *Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing*
(3) ASTM F 1055, *Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing*
(4) ASTM F 1733, *Standard Specification for Butt Heat Fusion Polyamide (PA) Plastic Fitting for Polyamide (PA) Plastic Pipe and Tubing*

(C) Installation instructions specific to the type and grade of polyethylene being joined shall be provided with heat fusion fittings.

(D)* Mechanical fittings shall comply with Category 1 of ASTM D 2513, *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings,* and the following:

(1) Mechanical joints shall be tested and recommended by the manufacturer for use with polyethylene pipe and tubing.
(2) Compression-type mechanical fittings shall include a rigid internal tubular stiffener, other than a split tubular stiffener, to support the pipe.
(3) Gasket material in the fitting shall be resistant to the action of LP-Gas and shall be compatible with the polyamide or polyethylene pipe material.

(E) Anodeless risers shall comply with the following:

(1) The metal gas carrying portion of the anodeless riser after the transition shall have a wall thickness equal to Schedule 40 pipe.
(2) Factory-assembled anodeless risers shall be recommended for LP-Gas use and shall be leak tested by the manufacturer in accordance with written procedures.
(3) Field-assembled anodeless risers with service head adapters shall be equipped with moisture seals and shall be recommended for LP-Gas use by the manufacturer and shall be design certified to meet the requirements of Category 1 of ASTM D 2513, *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings*; U.S. Department of Transportation, 49 CFR 192.281(e), "Transportation"; and 6.8.4.1 through 6.8.4.5.
(4) The manufacturer shall provide the user qualified installation instructions as prescribed by U.S. Department of Transportation, 49 CFR 192.283(b).

5.8.6 Hose, Quick Connectors, Hose Connections, and Flexible Connectors.

5.8.6.1 Hose, hose connections, and flexible connectors *(see 3.3.26, Flexible Connector)* shall be fabricated of materials that are resistant to the action of LP-Gas both as liquid and vapor.

5.8.6.2 If wire braid is used for reinforcement, it shall be of corrosion-resistant material such as stainless steel.

5.8.6.3 Hose and quick connectors shall be approved.

5.8.6.4 Hose, hose connections, and flexible connectors used for conveying LP-Gas liquid or vapor at pressures in excess of 5 psig (34 kPag), and as provided in Section 6.17 regardless of the pressure, shall comply with 5.8.6.4(A) through 5.8.6.4(D).

(A) Hose shall be designed for a working pressure of 350 psig (2.4 MPag) with a safety factor of 5 to 1 and shall be continuously marked with LP-GAS, PROPANE, 350 PSI WORKING PRESSURE, and with the manufacturer's name or trademark.

(B) Hose assemblies, after the application of couplings, shall have a design capability of not less than 700 psig (4.8 MPag).

(C) If a pressure test is performed, such assemblies shall be pressure tested at 120 percent of the maximum working pressure [350 psig (24 MPag) minimum] of the hose.

(D) Hose assemblies shall be leak tested at time of installation at not less than the operating pressure of the system in which they are installed.

5.8.6.5 Hoses at a pressure of 5 psig (34 kPag) or less in agricultural buildings not normally occupied by the public shall be designed for the working pressure of the system and shall be constructed of material resistant to the action of LP-Gas.

5.8.6.6 Hoses or flexible connectors used to supply LP-Gas to utilization equipment or appliances shall be installed in accordance with the provisions of 6.8.7 and 6.18.2.

5.9 Internal Valves. (Reserved)

5.10 Valves Other Than Container Valves.

5.10.1 Pressure-containing metal parts of valves shall be of steel, ductile (nodular) iron, malleable iron, or brass.

(A) Ductile iron shall meet the requirements of ASTM A 395, *Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures,* or equivalent.

(B) Malleable iron shall meet the requirements of ASTM A 47, *Standard Specification for Ferritic Malleable Iron Castings,* or equivalent.

(C) All materials used, including valve seat discs, packing, seals, and diaphragms, shall be resistant to the action of LP-Gas under service conditions.

5.10.2 Valves shall have a service pressure rating as specified in Table 5.8.4.1.

5.10.3 Manual shutoff valves, emergency shutoff valves, excess-flow check valves, and backflow check valves used in piping systems shall comply with the provisions for container valves.

5.10.4 Emergency shutoff valves shall be approved and shall incorporate all of the following means of closing:

(1) Automatic shutoff through thermal (fire) actuation
(2) Manual shutoff from a remote location
(3) Manual shutoff at the installed location

5.10.5 Where fusible elements are used, they shall have a melting point not exceeding 250°F (121°C).

5.10.6 Valves in polyethylene piping systems shall be manufactured from thermoplastic materials listed in ASTM D 2513, *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings,* that have been shown to be resistant to the action

of LP-Gas and comply with ASTM D 2513. Valves in polyamide piping systems shall be manufactured from polyamide material as defined in ASTM D 2513. Metallic valves in polyethylene and polyamide piping systems shall be protected to minimize corrosion in accordance with 6.14.

5.10.7 Valves shall be recommended for LP-Gas service by the manufacturer.

5.11 Hydrostatic Relief Valves.

5.11.1 Hydrostatic relief valves designed to relieve the hydrostatic pressure that can develop in sections of liquid piping between closed shutoff valves shall have pressure settings not less than 400 psig (2.8 MPag) or more than 500 psig (3.5 MPag) unless installed in systems designed to operate above 350 psig (2.4 MPag).

5.11.2 Hydrostatic relief valves for use in systems designed to operate above 350 psig (2.4 MPag) shall have settings not less than 110 percent or more than 125 percent of the system design pressure.

5.12 Reserved.

5.13 Reserved.

5.14 Reserved.

5.15 Equipment.

5.15.1 General.

5.15.1.1 This section shall apply to pressure-containing metal parts of LP-Gas equipment.

5.15.1.2 The service pressure rating of equipment shall be in accordance with Table 5.15.1.2.

5.15.1.3 Equipment shall be fabricated of materials that are compatible with LP-Gas under service conditions.

(A) Pressure-containing metal parts shall be made from the following materials:

(1) Steel
(2) Ductile (nodular) iron (ASTM A 395, *Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures,* or ASTM A 536, *Standard Specification for Ductile Iron Castings,* Grade 60-40-18 or 65-45-12)
(3) Malleable iron (ASTM A 47, *Standard Specification for Ferritic Malleable Iron Castings*)
(4) Higher strength gray iron (ASTM A 48, *Standard Specification for Gray Iron Castings,* Class 40B)
(5) Brass
(6) Materials equivalent to 5.15.1.3(A)(1) through 5.15.1.3(A)(5) in melting point, corrosion resistance, toughness, and strength

(B) Cast iron shall not be used as a material of construction for strainers or flow indicators.

(C) Aluminum shall be permitted to be used for approved meters.

(D) Aluminum or zinc shall be permitted to be used for approved regulators.

(E) Zinc used for regulators shall comply with ASTM B 86, *Standard Specification for Zinc-Alloy Die Casting.*

(F) Nonmetallic materials shall not be used for upper or lower casings of regulators.

5.15.2 Pumps. Pumps shall be designed for LP-Gas service.

Table 5.15.1.2 Service Pressure Rating

Fluid	Pressure	Equipment Design Pressure
LP-Gas vapor	≤20 psig (≤138 kPag)	Maximum anticipated pressure
	20–125 psig (138 kPag–0.9 MPag)	125 psig (0.9 MPag)
	> 125 psig (>0.9 MPag)	250 psig (1.7 MPag) or the anticipated pressure, whichever is higher
LP-Gas liquid	≤250 psig (≤1.7 MPag)	250 psig (1.7 MPag)
	> 250 psig (>1.7 MPag)	350 psig (2.4 MPag) or the anticipated pressure, whichever is higher

5.15.3 Compressors.

5.15.3.1 Compressors shall be designed for LP-Gas service.

5.15.3.2 Compressors shall be constructed or shall be equipped with auxiliary devices to limit the suction pressure to the maximum for which the compressor is designed.

5.15.3.3 Compressors shall be constructed or shall be equipped with auxiliary devices to prevent the entrance of LP-Gas liquid into the compressor suction.

5.15.3.4 Portable compressors used with temporary connections shall not require means to prevent liquid entrance into the compressor suction.

5.15.4 Reserved.

5.15.5 Meters.

5.15.5.1 Vapor meters of the tin or brass case type of soldered construction shall not be used at pressures in excess of 1 psig (7 kPag).

5.15.5.2 Vapor meters of the die cast or iron case type shall be permitted to be used at any pressure equal to or less than the working pressure for which they are designed and marked.

5.15.6 Engines. Engines used to drive portable pumps and compressors shall be equipped with exhaust system spark arresters and shielded ignition systems.

5.15.7 Sight Flow Indicators. Where installed, sight flow indicators shall either be the simple observation type or be combined with a backflow check valve.

5.16 Reserved.

5.17 Reserved.

5.18 Appliances.

5.18.1 New residential, commercial, and industrial LP-Gas consuming appliances shall be approved.

5.18.2 Any appliance originally manufactured for operation with a gaseous fuel other than LP-Gas shall not be used with LP-Gas unless it is converted to use LP-Gas and is tested for performance with LP-Gas before being placed into use.

5.18.3 Unattended heaters used inside buildings for animal or poultry production or care shall be equipped with approved automatic devices to shut off the flow of gas to the main burners and to pilots, if used, in the event of flame extinguishment or combustion failure.

5.18.4 Approved automatic devices to shut off the flow of gas to the main burners and pilots shall not be required in structures without enclosing walls with the approval of the authority having jurisdiction.

5.18.5 Appliances using vaporizing burners shall comply with 5.19.5.

5.18.6* Appliances used in mobile homes and recreational vehicles shall be approved for such service.

5.18.7* LP-Gas appliances used on commercial vehicles shall be approved for the service.

(A) Gas-fired heating appliances and water heaters shall be equipped with automatic devices designed to shut off the flow of gas to the main burner and the pilot in the event the pilot flame is extinguished.

(B) Catalytic heating appliances shall be equipped with an approved automatic device to shut off the flow of gas in the event of combustion failure.

(C) Gas-fired heating appliances and water heaters to be used in vehicles intended for human occupancy shall be designed for complete separation of the combustion system and the living space.

(D) If the separation between the combustion system and the living space is not integral with the appliance, it shall be provided in accordance with installation requirements in 6.21.7.

5.19 Vaporizers, Tank Heaters, Vaporizing Burners, and Gas–Air Mixers.

5.19.1 Reserved.

5.19.2 Indirect Vaporizers.

5.19.2.1 Indirect vaporizers shall be constructed in accordance with the applicable provision of the ASME Code for a MAWP of 250 psig (1.7 MPag) and shall be permanently and legibly marked with the following:

(1) The marking required by the ASME Code
(2) The maximum allowable working pressure and temperature for which designed
(3) The name of the manufacturer

5.19.2.2 Indirect vaporizers that have an inside diameter of 6 in. (152 mm) or less are exempt from the ASME Code and shall not be required to be marked. They shall be constructed for a MAWP of 250 psig (1.7 MPag).

5.19.2.3 Indirect vaporizers shall be provided with an automatic means to prevent the passage of liquid through the vaporizer to the vapor discharge piping.

5.19.2.4 Indirect vaporizers, including atmospheric-type vaporizers using heat from the surrounding air or the ground and of more than 1 qt (0.9 L) capacity shall be equipped with a spring-loaded pressure relief valve providing a relieving capacity in accordance with 5.19.9. Fusible plug devices shall not be used.

5.19.2.5 Indirect atmospheric-type vaporizers of less than 1 qt (0.9 L) capacity shall not be required to be equipped with pressure relief valves but shall be installed in accordance with 6.19.2.11.

5.19.3 Direct-Fired Vaporizers.

5.19.3.1 Design and construction of direct fired vaporizers shall be in accordance with the applicable requirements of the ASME Code for the working conditions to which the vaporizer will be subjected, and the vaporizer shall be permanently and legibly marked with the following:

(1) The markings required by the ASME Code
(2) The maximum vaporizing capacity in gallons per hour
(3) The rated heat input in British thermal units per hour (Btu/hr)
(4) The name or symbol of the manufacturer

5.19.3.2 Direct-fired vaporizers shall be equipped with a spring-loaded pressure relief valve that provides a relieving capacity in accordance with 5.19.9.

5.19.3.3 The relief valve shall be located so as not to be subject to temperatures in excess of 140°F (60°C). Fusible plug devices shall not be used.

5.19.3.4 Direct-fired vaporizers shall be provided with automatic means to prevent the passage of liquid from the vaporizer to its vapor discharge piping.

5.19.3.5 A means for manually turning off the gas to the main burner and pilot shall be provided.

5.19.3.6 Direct-fired vaporizers shall be equipped with an automatic safety device to shut off the flow of gas to the main burner if the pilot light is extinguished.

5.19.3.7 If the pilot flow exceeds 2000 Btu/hr (2 MJ/hr), the safety device shall also shut off the flow of gas to the pilot.

5.19.3.8 Direct-fired vaporizers shall be equipped with a limit control to prevent the heater from raising the product pressure above the design pressure of the vaporizer equipment, and to prevent raising the pressure within the storage container above the pressure specified in the first column of Table 5.2.4.2 that corresponds with the design pressure of the container (or its ASME Code equivalent). *(See notes to Table 5.2.4.2.)*

5.19.4 Direct Gas-Fired Tank Heaters.

5.19.4.1 Direct gas-fired tank heaters shall be designed exclusively for outdoor aboveground use and so that there is no direct flame impingement upon the container.

5.19.4.2 Tank heaters shall be approved and shall be permanently and legibly marked with the following:

(1) The rated input to the burner in British thermal units per hour
(2) The maximum vaporizing capacity in gallons per hour
(3) The name or symbol of the manufacturer

5.19.4.3 The tank heater shall be designed so that it can be removed for inspection of the entire container.

5.19.4.4 The fuel gas supply connection to the tank heater shall originate in the vapor space of the container being heated and shall be provided with a manually operated shutoff valve at the heater.

5.19.4.5 The heater control system shall be equipped with an automatic safety shutoff valve of the manual-reset type arranged to shut off the flow of gas to both the main and pilot burners if the pilot flame is extinguished.

5.19.4.6 Where installed on a container exceeding 1000-gal (3.8-m^3) water capacity, the heater control system shall include a valve to automatically shut off the flow of gas to both the main and pilot burners if the container becomes empty of liquid.

5.19.4.7 Direct gas-fired tank heaters shall be equipped with a limit control to prevent the heater from raising the pressure in the storage container to more than 75 percent of the pressure shown in the first column of Table 5.2.4.2 that corresponds with the MAWP of the container (or its ASME *Boiler and Pressure Vessel Code* equivalent).

5.19.5 Vaporizing Burners.

5.19.5.1 Vaporizing burners shall be constructed with a pressure rating of 250 psig (1.7 MPag) with a safety factor of 5 to 1.

5.19.5.2 The vaporizing burner or the appliance in which it is installed shall be permanently and legibly marked with the following:

(1) The maximum burner input in British thermal units per hour
(2) The name or symbol of the manufacturer

5.19.5.3 Vaporizing coils or jackets shall be made of ferrous metals or high-temperature alloys.

5.19.5.4 The vaporizing section shall be protected by a relief valve, located where it will not be subject to temperatures in excess of 140°F (60°C), and with a pressure setting sufficient to protect the components involved but not lower than 250 psig (1.7 MPag).

5.19.5.5 The relief valve discharge shall be directed upward and away from the component parts of the vaporizing burner. Fusible plug devices shall not be used.

5.19.5.6 A valve shall be provided to turn off the gas supply to the main burner and the pilot.

5.19.5.7 Vaporizing burners shall be provided with an automatic safety device to shut off the flow of gas to the main burner and pilot in the event the pilot is extinguished.

5.19.5.8* Dehydrators and dryers utilizing vaporizing burners shall be equipped with automatic devices both upstream and downstream of the vaporizing section. These devices shall be installed and connected to shut off in the event of excessive temperature, flame failure, and, if applicable, insufficient air flow.

5.19.5.9 Pressure-regulating and control equipment shall be so located or so protected to prevent its exposure to temperatures above 140°F (60°C), unless designed and recommended for use at a higher temperature by the manufacturer.

5.19.5.10 Pressure-regulating and control equipment located downstream of the vaporizing section shall be designed to withstand the maximum discharge temperature of hot vapor.

5.19.6 Waterbath Vaporizers.

5.19.6.1 The vaporizing chamber, tubing, pipe coils, or other heat exchange surface containing the LP-Gas to be vaporized, hereinafter referred to as heat exchanger, shall be constructed in accordance with the applicable provisions of the ASME Code for a MAWP of 250 psig (1.7 MPag) and shall be permanently and legibly marked with the following:

(1) The marking required by the ASME Code
(2) The MAWP and temperature for which the heat exchanger is designed
(3) The name or symbol of the manufacturer

5.19.6.2 Heat exchangers for waterbath vaporizers that have an inside diameter of 6 in. (150 mm) or less are exempt from the ASME Code and shall not be required to be marked.

5.19.6.3 Heat exchangers for waterbath vaporizers shall be provided with automatic control to prevent the passage of liquid through the heat exchanger to the vapor discharge piping. This control shall be integral with the vaporizer.

5.19.6.4 Heat exchangers for waterbath vaporizers shall be equipped with a spring-loaded pressure relief valve that provides a relieving capacity in accordance with 5.19.9. Fusible plug devices shall not be used.

5.19.6.5 Waterbath sections of waterbath vaporizers shall be designed to prevent a pressure from exceeding the design pressure.

5.19.6.6 The immersion heater that provides heat to the waterbath shall be installed so as not to contact the heat exchanger and shall be permitted to be electric or gas-fired.

5.19.6.7 A control to limit the temperature of the waterbath shall be provided.

5.19.6.8 Gas-fired immersion heaters shall be equipped with an automatic safety device to shut off the flow of gas to the main burner and pilot in the event of flame failure.

5.19.6.9 Gas-fired immersion heaters with an input of 400,000 Btu/hr (422 MJ/hr) or more shall be equipped with an electronic flame safeguard and with programming to provide for prepurge prior to ignition, proof of pilot before the main burner valve opens, and full shutdown of the main gas valve and pilot upon flame failure.

5.19.6.10 The heat source shall be shut off if the level of the heat transfer medium falls below the top of the heat exchanger.

5.19.7 Reserved.

5.19.8 Gas–Air Mixers.

5.19.8.1 Gas–air mixers shall be designed for the air, vapor, and mixture pressures to which they are subjected.

5.19.8.2 Gas–air mixers that are capable of producing combustible mixtures shall be equipped with safety interlocks on both the LP-Gas and air supply lines to shut down the system if combustible limits are approached.

5.19.8.3 In addition to the interlocks required in 5.19.8.2, a method shall be provided to prevent air from accidentally entering gas distribution lines without LP-Gas being present. Gas mixing control valves installed in the air and LP-Gas supply lines that fail closed when actuated by safety trip devices shall meet this requirement.

5.19.8.4 Check valves shall be installed in the air and LP-Gas supply lines close to the mixer to minimize the possibility of backflow of gas into the air supply lines or of air into the LP-Gas system. Gas-mixing control valves installed in the air and LP-Gas supply lines that fail closed when actuated by safety trip devices shall meet this requirement.

5.19.8.5 Gas–air mixers that utilize the kinetic energy of the LP-Gas vapor to entrain air from the atmosphere and are so designed that maximum air entrained is less than 85 percent of the mixture shall comply with the following:

(1) Be exempt from the interlock provisions in 5.19.8.2 through 5.19.8.4
(2) Be equipped with a check valve at the air intake to prevent the escape of gas to atmosphere when shut down

5.19.8.6 Gas–air mixers of this type receiving air from a blower, compressor, or any source of air other than directly from the atmosphere shall prevent air without LP-Gas, or mixtures of air and LP-Gas within the flammable range, from entering the gas distribution system accidentally.

5.19.9 Vaporizer Pressure Relief Valve. The minimum rate of discharge in cubic feet of air per minute for pressure relief valves for LP-Gas vaporizers, either of the indirect type or direct-fired, shall comply with 5.19.9(A) through 5.19.9(C).

(A) Based on conservative heat transfer calculations (assuming that the vaporizing chamber is liquid full), the maximum vapor generating capacity (rate) shall be determined when maximum heat is available. That vapor rate shall be converted to an equivalent air rate.

(B) If the vaporizer is direct fired or if a substantial exterior surface is in contact with the LP-Gas, the sum of the vaporizer surface and the LP-Gas wetted exterior surface shall be used in conjunction with Table 5.7.2.5 to determine the required relief valve capacity.

(C) The minimum rate of discharge in cubic feet of air per minute for pressure relief valves for LP-Gas vaporizers, of either the indirect type or direct fire type, shall be at least 150 percent of the rated vaporizing capacity.

Chapter 6 Installation of LP-Gas Systems

6.1 Scope.

6.1.1* Application. This chapter shall apply to the following:

(1) The location and field installation of LP-Gas systems that use components, subassemblies, container assemblies, and container systems that are fabricated in accordance with Chapter 5
(2) The location of containers and liquid transfer systems
(3) The installation of container appurtenances and regulators
(4) The installation of piping (including flexible connectors and hose), hydrostatic relief valves, and piping service limitations
(5) The installation of equipment
(6) The testing of piping systems

6.1.2 Nonapplication. This chapter shall not apply to the following:

(1) Refrigerated containers
(2) Installation of systems used in the highway transportation of LP-Gas

6.1.3* Additional Features. For any purpose or application addressed within the scope of this chapter, if the requirements of the chapter are met, any or all additional features or components of equipment not prohibited by the chapter shall be permitted to be used.

6.2 Location of Containers.

6.2.1 LP-Gas containers shall be located outside of buildings unless they are specifically allowed to be located inside of buildings.

6.2.2 LP-Gas containers shall be allowed in buildings only for the following applications:

(1) Cylinders as specifically provided for in Section 6.17
(2) Containers of less than 125 gal (0.5 m^3) water capacity for the purposes of being filled in buildings or structures complying with Chapter 10
(3) Containers on LP-Gas vehicles complying with and parked or garaged in accordance with Chapter 9
(4) Containers used with LP-Gas stationary or portable engine fuel systems complying with Chapter 11
(5) Containers used with LP-Gas fueled industrial trucks complying with 11.12.4
(6) Containers on LP-Gas fueled vehicles garaged in accordance with Section 11.15
(7) Cylinders awaiting use, resale, or exchange when stored in accordance with Chapter 8

6.3 Container Separation Distances.

6.3.1 Containers installed outside of buildings, whether of the portable type replaced on a cylinder exchange basis or permanently installed and refilled at the installation, shall be located with respect to the adjacent containers, important building, group of buildings, or line of adjoining property that can be built upon, in accordance with Table 6.3.1, Table 6.4.2, Table 6.4.5.8, and 6.3.2 through 6.3.12.

6.3.2 When the provisions of 6.24.3 through 6.24.5 are met, the minimum distance from an ASME container to a building shall be reduced by one-half for ASME containers of 2001 gal through 30,000 gal (7.6 m^3 through 114 m^3) water capacity.

6.3.3 The 25 ft (7.6 m) distance from aboveground ASME containers of 501 gal to 2000 gal (1.9 m^3 to 7.6 m^3) water capacity to buildings, a group of buildings, or the line of adjoining property that can be built upon shall be reduced to 10 ft (3 m) for a single ASME container of 1200 gal (4.5 m^3) or less water capacity where such container is at least 25 ft (7.6 m) from any other LP-Gas container of more than 125 gal (0.5 m^3) water capacity.

6.3.4 Minimum distances for underground or mounded ASME containers of 2001 gal through 30,000 gal (7.6 m^3 through 114 m^3) water capacity incorporating all the provisions of Section 6.24 shall be reduced to 10 ft (3 m).

6.3.4.1 Distances for all underground and mounded ASME containers shall be measured from the pressure relief valve and the filling connection.

6.3.4.2 No part of an underground ASME container shall be less than 10 ft (3 m) from a building or line of adjoining property that can be built upon.

6.3.4.3 No part of a mounded ASME container that is installed above grade shall be less than 5 ft (1.5 m) from a building or line of adjoining property that can be built upon.

6.3.5 The separation distances specified in Table 6.3.1 between containers and of buildings of other than wood-frame construction devoted exclusively to gas manufacturing and distribution operations shall be reduced to 10 ft (3 m).

Table 6.3.1 Separation Distances Between Containers, Important Buildings, and Other Properties

Water Capacity per Container		Minimum Distances					
		Mounded or Underground Containers[a]		Aboveground Containers[b]		Between Containers[c]	
gal	m^3	ft	m	ft	m	ft	m
<125[d]	<0.5[d]	10	3	0[e]	0[e]	0	0
125–250	0.5–1.0	10	3	10	3	0	0
251–500	1.0+–1.9	10	3	10	3	3	1
501–2000	1.9+–7.6	10	3	25[f]	7.6	3	1
2001–30,000	7.6+–114	50	15	50	15	5	1.5
30,001–70,000	114+–265	50	15	75	23		
70,001–90,000	265+–341	50	15	100	30	¼ of sum of	
90,001–120,000	341+–454	50	15	125	38	diameters of	
120,001–200,000	454+–757	50	15	200	61	adjacent	
200,001–1,000,000	757+–3785	50	15	300	91	containers	
>1,000,000	>3785	50	15	400	122		

[a] See 6.3.4.
[b] See 6.3.12.
[c] See 6.3.11.
[d] See 6.3.9.
[e] See 6.3.7, 6.3.8, and 6.3.9.
[f] See 6.3.3.

6.3.6 If the aggregate water capacity of a multicontainer installation is 501 gal (1.9 m^3) or more comprised of individual containers each with a water capacity of less than 125 gal (0.5 m^3), the minimum distance shall comply with Table 6.3.1 and the following:

(1) The aggregate capacity shall be used rather than the capacity per container.
(2) If more than one such installation is made, each installation shall be separated from any other installation by at least 25 ft (7.6 m).
(3) The minimum distances between containers shall not be applied to installations covered by 6.3.6.

6.3.7 Cylinders installed alongside of buildings shall be positioned so that the discharge from the cylinder pressure relief device is located as follows:

(1) At least 3 ft (1 m) horizontally away from any building opening that is below the level of such discharge
(2) At least 5 ft (1.5 m) in any direction away from any exterior source of ignition, openings into direct-vent (sealed combustion system) appliances, or mechanical ventilation air intakes

6.3.8 Cylinders shall not be located and installed underneath any building unless the space is open to the atmosphere for 50 percent of its perimeter or more.

6.3.9 The distance measured horizontally from the point of discharge of a container pressure relief valve to any building opening below the level of such discharge shall be in accordance with Table 6.3.9.

6.3.10 The distance measured in any direction from the point of discharge of a container pressure relief valve, vent of a fixed maximum liquid level gauge on a container, and the container filling connection to exterior sources of ignition, openings into direct-vent (sealed combustion system) appliances, and mechanical ventilation air intakes shall be in accordance with Table 6.3.9.

6.3.11 Access at the ends or sides of individual underground containers having a water capacity of 125 gal (0.5 m^3) or more shall be provided in multicontainer installations to facilitate working with cranes or hoists.

6.3.12 The horizontal distance between the portion of a building that overhangs out of the building wall and an ASME container of 125 gal. (0.5 m^3) or more water capacity shall comply with the following:

(1) The horizontal distance shall be measured from a point determined by projecting the outside edge of the overhanging structure vertically downward to grade or other level upon which the container is installed.
(2) This horizontal distance shall be at least 50 percent of the separation distance required in Table 6.3.1.
(3) This requirement shall apply only when the overhang extends more than 5 ft (1.5 m) from the building.
(4) This requirement shall not apply when the overhanging structure is 50 ft (15 m) or more above the relief valve discharge outlet.
(5) This requirement shall not apply to ASME containers, 2001 to 30,000 gal water capacity, where the container distance from a building is in accordance with 6.24.2.

6.4 Other Container Location Requirements.

6.4.1 Where storage containers having an aggregate water capacity of more than 4000 gal (15.1 m^3) are located in heavily populated or congested areas, the siting provisions of 6.3.1 and Table 6.3.1 shall be permitted to be modified as indicated by the incident prevention review described in 6.23.3.

Table 6.3.9 Separation Distance Between Container Pressure Relief Valve and Building Openings

Container Type	Exchange or Filled on Site	Distance Horizontally from Relief Valve Discharge to Opening Below Discharge		Discharge from Relief Valve, Vent Discharge, and Filling Connection to Exterior Source of Ignition, Openings into Direct-Vent Appliances, Mechanical Ventilation Air Intakes	
		ft	m	ft	m
Cylinder	Exchange	3	0.9	5	1.5
Cylinder	Filled on site	3	0.9	10	3.0
ASME	Filled on site	5	1.5	10	3.0

6.4.2 Aboveground multicontainer installations comprised of ASME containers having an individual water capacity of 12,000 gal (45 m^3) or more and installed for use in a single location shall be limited to the number of containers in one group, with each group separated from the next group in accordance with the degree of fire protection provided in Table 6.4.2.

Table 6.4.2 Maximum Number of Containers in a Group and Their Separation Distances

Fire Protection Provided by	Maximum Number of Containers in One Group	Minimum Separation Between Groups	
		ft	m
Hose streams only *(see 6.4.2 and 6.23.3.1)*	6	50	15
Fixed monitor nozzles per 6.23.6.3	6	25	7.6
Fixed water spray per 6.23.3.1	9	25	7.6
Insulation per 6.23.5.1	9	25	7.6

6.4.3 Where the provisions of 6.24.3 and 6.24.4 are met, the minimum separation distance between groups of ASME containers protected by hose stream only shall be one-half the distances in Table 6.4.2.

6.4.4 Underground or mounded ASME containers shall be located in accordance with 6.4.4.1 through 6.4.4.5.

6.4.4.1 They shall be located outside of any buildings.

6.4.4.2 Buildings shall not be constructed over any underground or mounded containers.

6.4.4.3 The sides of adjacent containers shall be separated in accordance with Table 6.3.1 but shall not be separated less than 3 ft (1 m).

6.4.4.4 Where containers are installed parallel with ends in line, the number of containers in one group shall not be limited.

6.4.4.5 Where more than one row of containers is installed, the adjacent ends of the containers in each row shall be separated by not less than 10 ft (3 m).

6.4.5 Additional container installation requirements shall comply with 6.4.5.1 through 6.4.5.12, 6.4.6, and 6.4.7.

6.4.5.1 Containers shall not be stacked one above the other.

6.4.5.2 Loose or piled combustible material and weeds and long dry grass shall be separated from containers by a minimum of 10 ft (3 m).

6.4.5.3* The area under containers shall be graded or shall have dikes or curbs installed so that the flow or accumulation of flammable liquids with flash points below 200°F (93.4°C) is prevented.

6.4.5.4 LP-Gas containers shall be located at least 10 ft (3 m) from the centerline of the wall of diked areas containing flammable or combustible liquids.

6.4.5.5 The minimum horizontal separation between aboveground LP-Gas containers and aboveground tanks containing liquids having flash points below 200°F (93.4°C) shall be 20 ft (6 m).

6.4.5.6 No horizontal separation shall be required between aboveground LP-Gas containers and underground tanks containing flammable or combustible liquids installed in accordance with NFPA 30, *Flammable and Combustible Liquids Code*.

6.4.5.7 The requirements of 6.4.5.6 shall not apply where LP-Gas containers of 125 gal (0.5 m^3) or less water capacity are installed adjacent to fuel oil supply tanks of 660 gal (2.5 m^3) or less capacity.

6.4.5.8* The minimum separation between LP-Gas containers and oxygen or gaseous hydrogen containers shall be in accordance with Table 6.4.5.8.

6.4.5.9 Where protective structures having a minimum fire resistance rating of 2 hours interrupt the line of sight between uninsulated portions of the oxygen or hydrogen containers and the LP-Gas containers, no minimum distance shall apply.

6.4.5.10 The minimum separation between LP-Gas containers and liquefied hydrogen containers shall be in accordance with NFPA 50B, *Standard for Liquefied Hydrogen Systems at Consumer Sites*.

6.4.5.11 Where LP-Gas cylinders are to be stored or used in the same area with other compressed gases, the cylinders shall be marked to identify their content in accordance with ANSI/CGA C-7, *Guide to the Preparation of Precautionary Labeling and Marking of Compressed Gas Containers*.

6.4.5.12 An aboveground LP-Gas container and any of its parts shall not be located within 6 ft (1.8 m) of a vertical plane beneath overhead electric power lines that are over 600 volts, nominal.

6.4.6* Refrigerated LP-Gas containers shall be located within an impoundment in accordance with Section 12.3.

Table 6.4.5.8 Separation Distances of LP-Gas Containers and Oxygen and Hydrogen Containers

LP-Gas Containers Aggregate Water Capacity		Separation from Oxygen Containers Aggregate Capacity					Separation from Gaseous Hydrogen Containers Aggregate Capacity				
		400 ft³ (11 m³)* or Less	More than 400 ft³ (11 m³)* to 20,000 ft³ (566 m³)* Including Unconnected Reserves		More than 20,000 ft³ (566 m³)* Including Unconnected Reserves		Less than 400 ft³ (11 m³)*	400 ft³ (11 m³)* to 3000 ft³ (85 m³)*		More Than 3000 ft³ (85 m³)*	
gal	m³		ft	m	ft	m		ft	m	ft	m
≤1200	≤4.5	None	20	6	25	7.6	—	—	—	—	—
>1200	>4.5	None	20	6	50	15	—	—	—	—	—
≤500	≤1.9	—	—	—	—	—	None	10	3	25	7.6
>500	>1.9	—	—	—	—	—	None	25	7.6	50	15

* Cubic feet (m³) measured at 70°F (21°C) and atmospheric pressure.

6.4.7* Structures such as fire walls, fences, earth or concrete barriers, and other similar structures shall not be permitted around or over installed nonrefrigerated containers unless specifically allowed as follows:

(1) Structures partially enclosing containers shall be permitted if designed in accordance with a sound fire protection analysis.
(2) Structures used to prevent flammable or combustible liquid accumulation or flow shall be permitted in accordance with 6.4.5.3.
(3) Structures between LP-Gas containers and gaseous hydrogen containers shall be permitted in accordance with 6.4.5.9.
(4) Structures such as fences shall be permitted in accordance with 6.16.5.

6.5 Location of Transfer Operations.

6.5.1* Liquid shall be transferred into containers, including containers mounted on vehicles, only outdoors, or in structures specially designed for that purpose.

6.5.1.1 The transfer of liquid into containers mounted on vehicles shall not take place within a building but shall be permitted to take place under a weather shelter or canopy *(see 6.22.3.3)*.

6.5.1.2 Structures housing transfer operations or converted for such use after December 31, 1972, shall comply with Chapter 10.

6.5.1.3 The transfer of liquid into containers on the roofs of structures shall be permitted, provided that the installation conforms to the requirements contained in 6.6.7 and 6.17.11.

6.5.1.4 The transfer hose shall not be routed in or through any building except those specified in 6.5.1.2.

6.5.2 Filling of containers located outdoors in stationary installations in accordance with Section 6.3 shall be permitted to be filled at that location.

6.5.3 If the point of transfer of containers located outdoors in stationary installations is not located at the container, it shall be located in accordance with Table 6.5.3.

6.5.4 Containers not located in stationary installations shall be filled at a location determined by the point of transfer in accordance with Table 6.5.3.

6.5.4.1 If the point of transfer is a component of a system covered by Section 6.21 or Chapter 11, the requirements of parts A, B, and C of Table 6.5.3 shall not apply to the structure containing the point of transfer.

6.5.4.2 If LP-Gas is vented to the atmosphere under the conditions stipulated in 7.3.1(4), the distances in Table 6.5.3 shall be doubled.

6.5.4.3 If the point of transfer is housed in a structure complying with Chapter 10, the distances in Table 6.5.3 shall be permitted to be reduced provided the common walls comply with 10.3.1.3.

6.5.4.4 The distances in Table 6.5.3, parts B, C, D, E, F(2), and J shall be reduced by one-half where the system incorporates the provisions of low emission transfer as provided in 6.24.5.

6.6 Installation of Containers.

6.6.1 General Requirements.

6.6.1.1 Containers shall be positioned so that the pressure relief valve is in direct communication with the vapor space of the container.

6.6.1.2 LP-Gas containers or systems of which they are a part shall be protected from damage from vehicles.

6.6.1.3 Field welding on containers shall be limited to nonpressure parts such as saddle plates, wear plates, or brackets installed by the container manufacturer.

6.6.1.4* Aboveground containers shall be painted.

6.6.1.5 Containers shall be installed so that all container operating appurtenances are accessible.

6.6.1.6 Where necessary to prevent flotation due to possible high flood waters around aboveground or mounded containers, or high water table for those underground and partially underground, containers shall be securely anchored.

Table 6.5.3 Distance Between Point of Transfer and Exposures

Part	Exposure	Minimum Horizontal Distance ft	Minimum Horizontal Distance m
A	Buildings,[a] mobile homes, recreational vehicles, and modular homes with fire-resistive walls[b]	10[c]	3.1
B	Buildings[a] with other than fire-resistive walls[b]	25[c]	7.6[c]
C	Building wall openings or pits at or below the level of the point of transfer	25[c]	7.6[c]
D	Line of adjoining property that can be built upon	25[c]	7.6[c]
E	Outdoor places of public assembly including schoolyards, athletic fields, and playgrounds	50[c]	15[c]
F	Public ways including public streets, highways, thoroughfares, and sidewalks		
	(1) From points of transfer in LP-Gas dispensing stations and at vehicle fuel dispensers	10	3.1
	(2) From other points of transfer	25[c]	7.6[c]
G	Driveways[d]	5	1.5
H	Mainline railroad track centerlines	25	7.6
I	Containers[e] other than those being filled	10	3.1
J	Flammable and Class II combustible liquid[f] dispensers and the fill connections of containers	10[c]	3.1[c]
K	Flammable and Class II combustible liquid containers, aboveground containers, and containers underground	20	6.1

[a]Buildings, for the purpose of the table, also include structures such as tents and box trailers at construction sites.

[b]Walls constructed of noncombustible materials having, as erected, a fire resistance rating of at least 1 hour as determined by NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*.

[c]See 6.5.4.4.

[d]Not applicable to driveways and points of transfer at vehicle fuel dispensers.

[e]Not applicable to filling connections at the storage container or to dispensing vehicle fuel dispenser units of 2000 gal (7.6 m^3) water capacity or less when used for filling containers not mounted on vehicles.

[f]NFPA 30, *Flammable and Combustible Liquids Code*, defines these as follows: Flammable liquids include those having a flash point below 100°F (37.8°C) and having a vapor pressure not exceeding 40 psia (an absolute pressure of 2068 mm Hg) at 100°F (37.8°C). Class II combustible liquids include those having a flash point at or above 100°F (37.8°C) and below 140°F (60°C).

6.6.2 Installation of Cylinders.

6.6.2.1 Cylinders shall be installed only aboveground and shall be set upon a firm foundation or otherwise be firmly secured. The cylinder shall not be in contact with the soil.

6.6.2.2 Flexibility shall be provided in the connecting piping. Where flexible connectors are used, they shall comply with 6.8.7.

6.6.3 Installation of Horizontal Aboveground ASME Containers.

6.6.3.1 Horizontal ASME containers designed for permanent installation in stationary service above ground shall be placed on masonry or other noncombustible structural supports located on concrete or masonry foundations with the container supports.

(A) Where saddles are used to support the container, they shall allow for expansion and contraction and prevent an excessive concentration of stresses.

(B) Where structural steel supports are used, they shall comply with 6.6.3.3.

(C) Containers of more than 2000 gal (7.6 m^3) water capacity shall be provided with concrete or masonry foundations formed to fit the container contour or, if furnished with saddles in compliance with Table 6.6.3.3, shall be placed on flat-topped foundations.

(D) Containers of 2000 gal (7.6 m^3) water capacity or less shall either be installed on concrete or masonry foundations formed to fit the container contour, or in accordance with 6.6.3.1(E).

(E) Containers of 2000 gal (7.6 m^3) water capacity or less equipped with attached supports complying with Table 6.6.3.3 shall be installed on a fire-resistive foundation if the bottoms of the horizontal members of the container saddles, runners, or skids are more than 12 in. (300 mm) above grade.

(F) Containers of 2000 gal (7.6 m^3) water capacity or less shall not be mounted with the outside bottom of the container shell more than 5 ft (1.5 m) above the surface of the ground.

(G) Containers of 2000 gal (7.6 m^3) water capacity or less and container-pump assemblies mounted on a common base complying with Table 6.6.3.3 shall be placed either on paved surfaces or on concrete pads at ground level within 4 in. (102 mm) of ground level.

6.6.3.2 ASME containers that have liquid interconnections shall be installed so that the maximum permitted filling level of each container is at the same elevation.

6.6.3.3 Horizontal ASME containers with attached supports and designed for permanent installation in stationary service shall be installed in accordance with Table 6.6.3.3.

6.6.3.4 Where a single ASME container complying with Table 6.6.3.3 is installed in isolated locations with nonfireproofed steel supports resting on concrete pads or footings and the outside bottom of the container shell is not more than 5 ft (1.5 m) above the ground level, the approval of the authority having jurisdiction shall be obtained.

6.6.3.5 The part of an ASME container in contact with saddles or foundations or masonry shall be coated or protected to minimize corrosion.

Table 6.6.3.3 Installation of Permanently Installed Horizontal ASME Containers with Attached Supports

Container Size			
gal	m^3	Attached Support	Height of Bottom of the Container
>2000	≥7.6	Nonfireproofed steel on flat topped concrete foundations	6 in. (150 mm) maximum above concrete foundations
≤2000	≤7.6	Nonfireproofed steel on firm foundations or concrete foundations more than 12 in. (300 mm) above the ground	2 in.–12 in. (51 mm–305 mm) above concrete foundation
≤2000	≤7.6	Nonfireproofed steel on paved surfaces or concrete pads within 4 in. (100 mm) of the ground	24 in. (610 mm) maximum above paved surface or top of concrete pads

6.6.3.6 In locations where the monthly maximum depth of snow accumulation, as determined from the National Weather Service or other published statistics, is more than the height of aboveground containers, excluding the dome cover, the following requirements shall apply:

(1) A stake or other marking shall be installed higher than the average snow cover depths, up to a height of 15 ft (4.6 m).
(2) The container shall be installed to prevent its movement resulting from snow accumulation.

6.6.3.7 If the container is mounted on or is part of a vehicle in accordance with 5.2.7.2(B), the unit shall be located in accordance with 6.3.1.

(A) The surface on which the vehicle is parked shall be level and if not paved shall be able to support heavy vehicular traffic and shall be clear of dry grass and weeds and other combustible material within 10 ft (3 m) of the container.

(B) Flexibility shall be provided in the connecting piping in accordance with 6.8.7.

6.6.3.8 Portable tanks of 2000 gal (7.6 m^3) water capacity or less that comply with 5.2.7.3 shall be installed in accordance with 6.6.3.1(E).

6.6.4 Installation of Vertical ASME Containers.

6.6.4.1 Vertical ASME containers over 125 gal (0.5 m^3) water capacity designed for permanent installation in stationary service aboveground shall be installed on reinforced concrete or steel structural supports on reinforced concrete foundations that are designed to meet the loading provisions established in 5.2.4.3.

6.6.4.2 The requirements in 6.6.4.3 through 6.6.4.5 shall also apply to the installation of vertical ASME containers.

6.6.4.3 Steel supports shall be protected against fire exposure with a material that has a fire resistance rating of at least 2 hours, except that continuous steel skirts that have only one opening that is 18 in. (460 mm) or less in diameter shall have fire protection applied to the outside of the skirts.

6.6.4.4 Vertical ASME containers used in liquid service shall not be manifolded to horizontal ASME containers.

6.6.4.5 Vertical ASME containers of different dimensions shall not be manifolded together.

6.6.5 Temporary Container Installations.

6.6.5.1 Single containers constructed as portable storage containers for temporary stationary service in accordance with 5.2.7.2(A) and 5.2.7.2(B) shall be placed on concrete pads, paved surfaces, or firm earth for such temporary service (not more than 12 months at a given location).

6.6.5.2 The surface on which the containers are placed shall be level and if not paved shall be clear of dry grass and weeds and other combustible material within 10 ft (3 m) of the container.

6.6.5.3 Flexibility shall be provided in the connecting piping in accordance with 6.8.7.

6.6.5.4 Where portable storage containers are installed at isolated locations with the bottoms of the skids or runners above the ground, either fire-resistive supports shall be provided or non–fire-resistive supports shall be permitted when all the following conditions are met:

(1) The height of the outside bottom of the container does not exceed 5 ft (1.5 m) above the ground.
(2) The approval of the authority having jurisdiction is obtained.

6.6.6 Installation of Underground and Mounded Containers.

6.6.6.1 ASME container assemblies listed for underground installation, including interchangeable aboveground-underground container assemblies, shall be installed underground in accordance with 6.6.6.1(A) through 6.6.6.1(L).

(A) Containers installed in areas with no vehicle traffic shall be installed at least 6 in. (15 cm) below grade.

(B) In areas where vehicle traffic is expected, a noninterchangeable underground container shall be installed at least 18 in. (460 mm) below grade, or the container shall be protected from damage from vehicles.

(C) Protection shall be provided for the fitting housing, housing cover, tank connections, and piping against vehicular damage.

(D) Where containers are installed underground within 10 ft (3 m) of where vehicular traffic can be expected, protection against vehicular damage shall be provided for the fitting housing, housing cover, tank connections, and piping.

(E) Approved interchangeable aboveground-underground container assemblies installed underground shall not be placed with the container shell more than 12 in. (0.30 m) below grade.

(F) Any party involved in construction or excavation in the vicinity of a buried container shall be responsible for determining the location of, and providing protection for, the container and piping against their physical damage from vehicular traffic.

(G) Where a container is to be abandoned underground, the following procedure shall be followed:

(1) As much liquid LP-Gas as practical shall be removed through the container liquid withdrawal connection.
(2)*As much of the remaining LP-Gas vapor as practical shall be removed through a vapor connection.
(3) The vapor shall either be recovered, burned, or vented to the atmosphere.
(4) Where only vapor LP-Gas at atmospheric pressure remains in the container, the container shall be filled with water, sand, or foamed plastic or shall be purged with an inert gas.
(5) If purged, the displaced vapor shall be either recovered, burned, or vented to the atmosphere.

(H) The discharge of the regulator vent shall be above the highest probable water level.

(I) Containers shall be coated or protected to minimize corrosion.

(J) Any damage to the coating shall be repaired before backfilling.

(K)* Containers shall be set level and shall be surrounded by earth or sand firmly tamped in place.

(L) Backfill shall be free of rocks and abrasives.

6.6.6.2 Partially underground, unmounded ASME containers shall be installed as follows:

(1) The portion of the container below the surface, and for a vertical distance of at least 3 in. (75 mm) above the surface, shall be coated or protected to minimize corrosion.
(2) Any damage to the coating shall be repaired before backfilling.
(3) Containers shall be set level and shall be surrounded by earth or sand firmly tamped in place.
(4) Backfill shall be free of rocks and abrasives.
(5) Spacing provisions shall be as specified for aboveground containers in 6.3.1 and Table 6.3.1.
(6) The container shall be located so as not to be subject to vehicular damage or shall be protected against such damage.

6.6.6.3 Mounded containers shall be installed as follows:

(1)*Mounding material shall be earth, sand, or other noncombustible, noncorrosive materials and shall provide a minimum thickness of cover for the container of at least 1 ft (0.3 m).
(2) A protective cover shall be provided on top of mounding materials subject to erosion.
(3) Container valves and appurtenances shall be accessible for operation or repair, without disturbing mounding material, as follows:
   (a) Where containers are mounded and the bottom of the container is 30 in. (0.76 m) or more above the surrounding grade, access to bottom connections shall be provided by an opening or tunnel with a 4 ft (1.2 m) minimum diameter and a 3 ft (0.9 m) minimum clear area.
   (b) Bottom connections that extend beyond the mound shall be part of the ASME container or shall be installed in compliance with the ASME Code and shall be designed for the forces that can act on the connections.
(4)*Mounded containers shall be coated or protected to minimize corrosion.

6.6.7 Installation of Containers on Roofs of Buildings.

6.6.7.1 Installation of containers on roofs of buildings shall be prohibited, unless approved by the authority having jurisdiction and the fire department.

6.6.7.2 Where the authority having jurisdiction and the fire department have approved an installation of a container, it shall comply with the following:

(1) The building shall be of Type I, 443 or 332, or Type II, 222, construction as specified in NFPA 220, *Standard on Types of Building Construction.*
(2) LP-Gas containers installed on roofs shall be 2000 gal (7.6 m^3) water capacity or less.
(3) The aggregate water capacity of LP-Gas containers installed on the roof or terrace of a building shall not exceed 4000 gal (15.1 m^3) in one location. Additional installations on the same roof or terrace shall be located at least 50 ft (15 m) apart.
(4) An ASME container installed on the roof of a building shall always be filled by two operators, one at the controls of the vehicle supplying LP-Gas and another at the controls of the container.
(5) Containers shall be installed in external locations only.
(6) Where a fill line to the container is required, it shall be located entirely outside the building.
(7) The fill connection shall be located entirely outside the building.
(8) The fill connection shall be located at least 8 ft (2.4 m) above ground level.
(9) Containers shall be installed on a level surface.
(10) The container shall be secured to the building structure.
(11) The support of the container shall be designed to the same seismic criteria as the building.
(12) The roof on which the container is located shall be able to support the weight of the container filled with water, with the safety margins required by local codes.
(13) Containers shall be located in areas where there is free air circulation, at least 10 ft (3 m) from building openings (such as windows and doors), and at least 20 ft (6.1 m) from air intakes of air-conditioning and ventilating systems.
(14) The location of containers shall permit access to all valves and controls and shall have enough surrounding area to permit the required maintenance.
(15) The location of the container shall have fixed stairs or another method to reach it.

(16) If the installation requires the use of more than one container, the distances between containers from Table 6.3.1 shall apply.
(17) If the container location is higher than 23 ft (7 m) from the ground, or the filling hose cannot be observed by the operators in its entire length, the container shall have a filling line constructed to withstand liquid transfer, and it shall have the following appurtenances: filler valve with back check valve, filler valve cap, two control valves, hydrostatic relief valve, and venting line.
(18) The liquid and vapor fill connections shall be conspicuously marked or labeled.
(19) An incident prevention review shall be prepared in accordance with 6.23.3.

6.7 Installation of Container Appurtenances.

6.7.1 Reserved.

6.7.2 Installation of Pressure Relief Devices.

6.7.2.1 Pressure relief devices shall be installed so that the relief device is in direct communication with the vapor space of the container.

6.7.2.2 Pressure relief devices on cylinders shall be installed to minimize the possibility of relief device discharge impingement on the cylinder.

6.7.2.3 Pressure relief devices on the following ASME containers shall be installed so that any gas released is vented away from the container upward and unobstructed to the open air:

(1) Containers of 125 gal (0.5 m^3) or more water capacity installed in stationary service
(2) Portable storage containers
(3) Portable tanks of nominal 120 gal (0.5 m^3) or more water capacity
(4) Cargo tanks

6.7.2.4 Rain caps or other means shall be provided to minimize the possibility of the entrance of water or other extraneous matter into the relief device or any discharge piping. Provision shall be made for drainage where the accumulation of water is anticipated.

6.7.2.5 The rain cap or other protector shall be designed to remain in place, except during pressure relief device operation, and shall not restrict pressure relief device flow.

6.7.2.6 The design of the pressure relief valve drain opening shall provide the following:

(1) Protection of the container against flame impingement resulting from ignited product escaping from the drain opening
(2) Direction of the pressure relief valve drain opening so that adjacent container(s), piping, or equipment are not subjected to flame impingement

6.7.2.7 The pressure relief valve discharge on each aboveground container of more than 2000 gal (7.6 m^3) water capacity shall be piped vertically upward to a point at least 7 ft (2.1 m) above the top of the container, and the discharge opening shall be unobstructed to the open air.

6.7.2.8 Shutoff valves shall not be installed between pressure relief devices and the container unless a listed pressure relief valve manifold meeting the requirements of 6.7.2.9 is used.

6.7.2.9 Listed pressure relief valve manifolds shall be exempt from the requirements of 6.7.2.8, when the following conditions are met:

(1) Two or more pressure relief devices are installed in the manifold.
(2) Only one pressure relief device in the manifold is designed to shut off at any one time.
(3) The remaining pressure relief device(s) remains open and provides the rated relieving capacity required for the container.

6.7.2.10 Shutoff valves shall not be installed between a pressure relief device and the pressure relief device discharge piping.

6.7.2.11 The pressure relief valve discharge piping from underground containers of 2000 gal (7.6 m^3) or less water capacity shall extend beyond the manhole or housing or shall discharge into the manhole or housing, where the manhole or housing is equipped with ventilated louvers or their equivalent, in accordance with 5.7.11.4(H).

6.7.2.12 Pressure relief valve discharge on underground containers of more than 2000 gal (7.6 m^3) water capacity shall be piped vertically and directly upward to a point at least 7 ft (2.1 m) above the ground.

6.7.2.13 Pressure relief devices installed in underground containers in dispensing stations shall be piped vertically upward to a point at least 10 ft (3 m) above the ground.

6.7.2.14 Discharge piping shall be supported and protected against physical damage.

6.7.2.15 The discharge piping shall comply with the following:

(1) Piping shall be sized to provide the rate of flow specified in 5.7.2.5.
(2) Piping shall be metallic and have a melting point over 1500°F (816°C).
(3) Discharge piping shall be designed so that excessive force applied to the discharge piping will result in breakage on the discharge side of the valve rather than on the inlet side without impairing the function of the valve.
(4) Return bends and restrictive pipe or tubing fittings shall not be used.

6.7.3 Selection of Pressure Regulators. A two-stage regulator system, an integral two-stage regulator, or a 2 psi regulator system shall be required on all fixed piping systems that serve ½ psig (3.4 kPag) appliance systems [normally operated at 11 in. water capacity (2.7 kPag) pressure].

(A) The requirement for two-stage regulation shall include fixed piping systems for appliances on RVs (recreational vehicles), mobile home installations, manufactured home installations, catering vehicles, and food service vehicle installations.

(B) Single-stage regulators shall not be installed in fixed piping systems after June 30, 1997, except for installations covered in 6.7.3(C).

(C) Single stage regulators shall be permitted on small portable appliances and outdoor cooking appliances with input ratings of 100,000 Btu/hr (29 kW) or less.

(D) Gas distribution systems utilizing multiple second-stage regulators shall be permitted to use a high-pressure regulator installed at the container provided a first-stage regulator is installed downstream of the high-pressure regulator and ahead of the second-stage regulators.

(E) High-pressure regulators with an overpressure protection device and a rated capacity of more than 500,000 Btu/hr (147 kW) shall be permitted to be used in two-stage systems where the second-stage regulator incorporates an integral or separate overpressure protection device.

(F) The overpressure protection device described in (E) shall limit the outlet pressure of the second-stage regulator to 2.0 psig (14 kPag) when the regulator seat disc is removed and with an inlet pressure equivalent to the maximum outlet pressure setting of the high-pressure regulator.

(G) Systems consisting of listed components that provide an equivalent level of overpressure protection shall be exempt from the requirement of 6.7.3.

(H)* A 2 psi regulator system shall consist of a first-stage regulator and a 2 psi service regulator in compliance with the requirements of 5.7.3.1 in conjunction with a line pressure regulator in compliance with ANSI Z21.80/CSA 6.22, *Standard for Line Pressure Regulators*.

6.7.4 Regulator Installation.

6.7.4.1 First-stage or high-pressure regulators shall be directly attached or attached by flexible connectors to the vapor service valve of a container, or to a vaporizer outlet, or to interconnecting piping of manifolded containers or vaporizers.

6.7.4.2 First-stage regulators installed downstream of high-pressure regulators shall be exempt from the requirement of 6.7.4.1.

6.7.4.3 First-stage and high-pressure regulators shall be installed outside of buildings, except as follows:

(1) Regulators on cylinders installed indoors in accordance with Section 6.17
(2) Regulators on containers of less than 125 gal (0.5 m^3) water capacity for the purpose of being filled or in structures complying with Chapter 10
(3) Regulators on containers on LP-Gas vehicles complying with and parked or garaged in accordance with Chapter 11
(4) Regulators on containers used with LP-Gas stationary or portable engine fuel systems complying with Chapter 11
(5) Regulators on containers used with LP-Gas–fueled industrial trucks complying with 11.12.4
(6) Regulators on containers on LP-Gas–fueled vehicles garaged in accordance with Section 11.15
(7) Regulators on cylinders awaiting use, resale, or exchange when stored in accordance with Chapter 8

6.7.4.4 All regulators for outdoor installations shall be designed, installed, or protected so their operation will not be affected by the elements (freezing rain, sleet, snow, ice, mud, or debris).

(A) This protection shall be permitted to be integral with the regulator.

(B) Regulators used for portable industrial applications shall be exempt from the requirements of 6.7.4.4.

6.7.4.5 The point of discharge from the required pressure relief device on regulating equipment installed outside of buildings in fixed piping systems shall be located not less than 3 ft (1 m) horizontally away from any building opening below the level of such discharge, and not beneath any building unless this space is well ventilated to the outside and is not enclosed for more than 50 percent of its perimeter.

6.7.4.6 The point of discharge shall also be located not less than 5 ft (1.5 m) in any direction away from any source of ignition, openings into direct-vent (sealed combustion system) appliances, or mechanical ventilation air intakes.

6.7.4.7 Where a vent line is used to comply with the point of discharge requirements, it shall comply with 6.7.4.8(1) and 6.7.4.8(3).

6.7.4.8 The discharge from the required pressure relief device of a second-stage regulator other than a line pressure regulator, installed inside of buildings in fixed piping systems shall comply with the following:

(1) The discharge shall be directly vented with supported piping to the outside air.
(2) The vent line shall be at least the same nominal pipe size as the regulator vent connection pipe size.
(3) Where there is more than one regulator at a location, either each regulator shall have a separate vent to the outside or the vent lines shall be manifolded in accordance with accepted engineering practices to minimize back pressure in the event of high vent discharge.
(4) The material of the vent line shall comply with 5.8.3 or 5.7.5.
(5) The discharge outlet shall be located not less than 3 ft (1 m) horizontally away from any building opening below the level of such discharge.
(6) The discharge outlet shall also be located not less than 5 ft (1.5 m) in any direction away from any source of ignition, openings into direct-vent appliances, or mechanical ventilation air intakes.
(7) The discharge outlet shall be designed, installed, or protected from blockage so it will not be affected by the elements (freezing rain, sleet, snow, ice, mud, or debris) or insects.
(8) The requirement in 6.7.4.8 shall not apply to appliance regulators otherwise protected, to line pressure regulators listed as complying with ANSI Z21.80/CSA 6.22, *Standard for Line Pressure Regulators*, or to regulators used in connection with containers in buildings as provided for in 6.2.2(1), 6.2.2(2), 6.2.2(4), 6.2.2(5), and 6.2.2(6).

6.7.4.9 The requirement in 6.7.4.8 shall not apply to vaporizers.

6.7.4.10 Single-stage regulators shall be permitted to be used only on portable appliances and outdoor cooking appliances with input ratings of 100,000 Btu/hr (29 kW) maximum.

6.7.4.11 Line pressure regulators shall be installed in accordance with the requirements of NFPA 54, *National Fuel Gas Code*.

6.8 Piping Systems.

6.8.1 Piping System Service Limitations.

6.8.1.1 The physical state (vapor or liquid) and pressure at which LP-Gas shall be transmitted through piping systems shall be as follows:

(1) Outdoor LP-Gas liquid or vapor metallic piping systems shall have no pressure limitations.
(2) Outdoor LP-Gas liquid or vapor polyamide piping systems shall have pressure limitations as defined by the design pressure of the piping being installed.
(3) Polyethylene piping systems shall be limited to the following:
   (a) Vapor service not exceeding 30 psig (208 kPag)
   (b) Installation outdoors and underground

(4)*LP-Gas vapor at pressures exceeding 20 psig (138 kPag) or LP-Gas liquid shall not be piped into any building except where allowed in Section 6.8.

6.8.1.2 LP-Gas vapor at pressures exceeding 10 psi (138 kPag) shall be permitted in buildings or separate areas of buildings constructed in accordance with Chapter 10 and used exclusively to house the following:

(1) Equipment for vaporization, pressure reduction, gas mixing, gas manufacturing, or distribution.
(2) Internal combustion engines, industrial processes, research and experimental laboratories, or equipment or processing having a similar hazard.
(3) Engine-mounted fuel vaporizers.
(4) Corrugated stainless steel piping systems shall be limited to vapor service not exceeding 5 psig (34 kPag).

6.8.1.3 Piping systems in buildings or structures under construction or undergoing major renovation, where the temporary piping is in accordance with 6.17.2 and 6.17.12 shall be exempt from 6.8.1.1(4).

6.8.1.4 Liquid piping systems in buildings or structures feeding a vaporizer other than those covered by 6.8.1.2(1) and 6.8.1.2(2) shall comply with the material requirements of Chapter 11.

6.8.2 Sizing of LP-Gas Vapor Piping Systems.

6.8.2.1 LP-Gas vapor piping systems downstream of the first-stage pressure regulator shall be sized so that all appliances operate within their manufacturer's specifications.

6.8.2.2 LP-Gas vapor piping systems shall be sized and installed to provide a supply of gas to meet the maximum demand of all gas utilization equipment using Table 15.1(a) through Table 15.1(q) or engineering methods.

6.8.3 Installation of Metallic Pipe, Tubing, and Fittings.

6.8.3.1 All metallic LP-Gas piping shall be installed in accordance with ASME B 31.3, *Process Piping*, or Section 6.8.

6.8.3.2 All welding and brazing of metallic piping shall be in accordance with ASME *Boiler and Pressure Vessel Code*, Section IX.

6.8.3.3 Metallic piping shall comply with the following:

(1) Piping used at pressures higher than container pressure, such as on the discharge side of liquid transfer pumps, shall be designed for a pressure rating of at least 350 psig (2.4 MPag).
(2) Vapor LP-Gas piping with operating pressures in excess of 125 psig (0.9 MPag) and liquid piping not covered by 6.8.3.3(1) shall be designed for a working pressure of at least 250 psig (1.7 MPag).
(3) Vapor LP-Gas piping subject to pressures of not more than 125 psig (0.9 MPag) shall be designed for a pressure rating of at least 125 psig (0.9 MPag).

6.8.3.4 Pressure relief valve discharge piping shall be exempt from the requirement of 6.8.3.3(3).

6.8.3.5 Metallic pipe joints shall be permitted to be threaded, flanged, welded, or brazed using pipe and fittings that comply with 5.8.3 and 5.8.4 as follows:

(1) Metallic threaded and welded pipe joints shall be in accordance with Table 6.8.3.5.
(2) Fittings and flanges shall be designed for a pressure rating equal to or greater than the required working pressure of the service for which they are used.
(3) Brazed joints shall be made with a brazing material having a melting point exceeding 1000°F (538°C).
(4) Gaskets used to retain LP-Gas in flanged connections in piping shall be resistant to the action of LP-Gas.
(5) Gaskets shall be made of metal or material confined in metal having a melting point over 1500°F (816°C) or shall be protected against fire exposure.
(6) When a flange is opened, the gasket shall be replaced.
(7) Aluminum O-rings and spiral wound metal gaskets shall be permitted.
(8) Nonmetallic gaskets used in insulating fittings shall be permitted.

Table 6.8.3.5 Types of Metallic Pipe Joints in LP-Gas Service

Service	Schedule 40	Schedule 80
Liquid	Welded	Threaded or welded
Vapor, ≤125 psig (≤0.9 MPag)	Threaded or welded	Threaded or welded
Vapor, >125 psig (>0.9 MPag)	Welded	Threaded or welded

6.8.3.6 Metallic tubing joints shall be flared or brazed using tubing and fittings in accordance with 5.8.3 and 5.8.4.

6.8.3.7 Piping in systems shall be run as directly as is practical from one point to another, with as few fittings as practical.

6.8.3.8 Where condensation of vapor can occur, piping shall be sloped back to the container, or means shall be provided for revaporizing the condensate.

6.8.3.9 Piping systems including interconnecting of permanently installed containers shall compensate for expansion, contraction, jarring, vibration, and settling.

(A) The use of metallic flexible connectors shall be permitted.

(B) The use of nonmetallic pipe, tubing, or hose for permanently interconnecting containers shall be prohibited.

6.8.3.10 Aboveground piping shall be supported and protected against physical damage by vehicles.

6.8.3.11 The portion of aboveground piping in contact with a support or a corrosion-causing substance shall be protected against corrosion.

6.8.3.12 Buried metallic pipe and tubing shall be installed underground with a minimum 12 in. (300 mm) of cover. The minimum cover shall be increased to 18 in. (460 mm) if external damage to the pipe or tubing from external forces is likely to result. If a minimum 12 in. (300 mm) of cover cannot be maintained, the piping shall be installed in conduit or shall be bridged (shielded).

6.8.3.13 Where underground piping is beneath driveways, roads, or streets, possible damage by vehicles shall be taken into account.

6.8.3.14 Underground metallic piping shall be protected against corrosion as warranted by soil conditions *(see Section 6.14)*.

6.8.3.15 LP-Gas piping shall not be used as a grounding electrode.

6.8.4 Installation of Polyamide and Polyethylene Pipe, Tubing, and Fittings.

6.8.4.1 Polyethylene and polyamide pipe, tubing, and fittings shall be installed outdoors underground only.

6.8.4.2 Polyethylene and polyamide pipe and tubing shall be buried as follows:

(1) With a minimum 12 in. (300 mm) of cover
(2) With a minimum of 18 in. (460 mm) of cover if external damage to the pipe or tubing is likely to result
(3) With piping installed in conduit or bridged (shielded) if a minimum 12 in. (300 mm) of cover cannot be provided

6.8.4.3 Assembled anodeless risers shall be used to terminate underground polyamide and polyethylene piping systems above ground.

(A) The horizontal portion of risers shall be buried at least 12 in. (300 mm) below grade, and the casing material used for the risers shall be protected against corrosion in accordance with Section 6.14.

(B) Either the aboveground portion of the riser casing shall be provided with a plastic sleeve inside the riser casing or the pipe or tubing shall be centered in the riser casing.

(C) Factory-assembled risers shall be sealed and leak tested by the manufacturer.

6.8.4.4 Field-assembled risers shall be supplied only in kit form with all necessary hardware for installation.

(A) Field-assembled risers shall comply with the following:

(1) They shall be design certified.
(2) They shall be sealed and pressure tested by the installer.
(3) They shall be assembled and installed in accordance with the riser manufacturer's instructions.

(B) The casing of the riser shall be constructed of one of the following materials:

(1) ASTM A 53, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless,* Schedule 40 steel pipe
(2) ASTM A 513, *Standard Specification for Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing,* mechanical steel tubing with a minimum wall thickness of 0.073 in. (1.9 mm)
(3) Flexible metal tubing with a minimum crush strength of 1000 lb (453.6 kg) and a tensile strength of 300 lb (136 kg) including the transition connection as tested by the manufacturer

6.8.4.5* Polyamide and polyethylene piping shall be installed in accordance with the following:

(1) Thrust forces caused by contraction or expansion of the piping or by anticipated external or internal loading shall be minimized.
(2) Each joint shall be designed to sustain the thrust forces.

6.8.4.6 An electrically continuous corrosion-resistant tracer wire (minimum AWG 14) or tape shall be buried with the polyamide or polyethylene pipe to facilitate locating the pipe.

(A) One end of the tracer wire shall be brought aboveground at a building wall or riser.

(B) The tracer wire or tape shall not be in direct contact with the polyamide or polyethylene pipe.

6.8.4.7 Polyamide and polyethylene piping that is installed in a vault or any other belowground enclosure shall be completely encased in gastight metal pipe and fittings that are protected from corrosion.

6.8.4.8 Polyamide and polyethylene piping shall be installed in accordance with the manufacturer's installation instructions.

6.8.4.9 Where polyamide or polyethylene pipe or tubing is inserted into an existing steel pipe, the following shall apply:

(1) The polyamide or polyethylene pipe or tubing shall be protected from being damaged during the insertion process.
(2) The leading end of the polyamide or polyethylene pipe or tubing being inserted shall also be closed prior to insertion.

6.8.4.10 Polyamide and polyethylene pipe that is not encased shall have a minimum wall thickness of 0.090 in. (2.3 mm).

6.8.4.11 Polyamide or polyethylene pipe with an outside diameter of 0.875 in. (22.2 mm) or less shall be permitted to have a minimum wall thickness of 0.062 in. (1.6 mm).

6.8.4.12 Each imperfection or damaged piece of polyamide or polyethylene pipe shall be replaced by fusion or mechanical fittings.

6.8.4.13 Repair clamps shall not be used to cover damaged or leaking sections.

6.8.5 Valves in Polyamide and Polyethylene Piping Systems.

6.8.5.1 Valves in polyamide and polyethylene piping shall comply with following:

(1) Valves shall protect the pipe from excessive torsional or shearing loads when the valve is operated.
(2) Valve boxes shall be installed so as to minimize transmitting external loads to the valve or pipe.

6.8.5.2 Valves shall be recommended for LP-Gas service by the manufacturer.

6.8.5.3 Valves shall be manufactured from thermoplastic materials fabricated from materials listed in ASTM D 2513, *Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing and Fittings,* that have been shown to be resistant to the action of LP-Gas, or from metals protected to minimize corrosion in accordance with Section 6.14.

6.8.6 Reserved.

6.8.7 Flexible Connectors.

6.8.7.1 Flexible connectors shall be installed in accordance with the manufacturer's instructions.

6.8.7.2* Flexible connectors and hose used as flexible connectors shall not exceed 36 in. (1 m) in length where used with liquid or vapor piping on portable or stationary tanks.

6.8.7.3 Hose shall be permitted to be installed if flexibility is required for liquid or vapor transfer.

6.9 Internal Valves.

6.9.1 The requirements of 6.9.2 through 6.9.5 shall be required for internal valves in liquid service that are installed in containers over 4000 gal (15.2 m^3) water capacity by July 1, 2003.

6.9.2 Internal valves shall be installed in accordance with 5.7.7.2 and Table 5.7.7.3 on containers over 4000 gal (15.2 m^3) water capacity.

6.9.3 Automatic shutdown of internal valves in liquid service shall be provided using thermal (fire) actuation. The thermal sensing element of the internal valve shall be within 5 ft (1.5 m) of the internal valve.

6.9.4 At least one remote shutdown station for internal valves in liquid service shall be installed not less than 25 ft (7.6 m) or more than 100 ft (30 m) from the liquid transfer point. This shall be retroactive to all internal valves required by the code.

6.9.5 Emergency remote shutdown stations shall be identified by a sign, visible from the point of transfer, incorporating the words "Propane — Container Liquid Valve Emergency Shutoff" in block letters of not less than 2 in. (51 mm) in height on a background of contrasting colors to the letters.

6.10 Emergency Shutoff Valves.

6.10.1 On new installations and on existing installations, stationary container storage systems with an aggregate water capacity of more than 4000 gal (15.1 m^3) utilizing a liquid transfer line that is 1½ in. (39 mm) or larger and a pressure equalizing vapor line that is 1¼ in. (32 mm) or larger shall be equipped with emergency shutoff valves.

6.10.2 An emergency shutoff valve shall be installed in the transfer lines of the fixed piping transfer system within 20 ft (6 m) of lineal pipe from the nearest end of the hose or swivel-type piping connections.

6.10.3 When the flow is only into the container, a backflow check valve shall be permitted to be used in lieu of an emergency shutoff valve if installed in the fixed piping transfer system downstream of the hose or swivel-type piping connections.

6.10.4 The backflow check valve shall have a metal-to-metal seat or a primary resilient seat with metal back-up, not hinged with combustible material, and shall be designed for this specific application.

6.10.5 Where there are two or more liquid or vapor lines with hoses or swivel-type piping connected of the sizes designated, an emergency shutoff valve or a backflow check valve where allowed shall be installed in each leg of the piping.

6.10.6 Emergency shutoff valves shall be installed so that the temperature-sensitive element in the valve, or a supplemental temperature-sensitive element [250°F (121°C) maximum] connected to actuate the valve, is not more than 5 ft (1.5 m) from the nearest end of the hose or swivel-type piping connected to the line in which the valve is installed.

6.10.7 Temperature-sensitive elements of emergency shutoff valves shall not be painted, nor shall they have any ornamental finishes applied after manufacture.

6.10.8* The emergency shutoff valves or backflow check valves shall be installed in the fixed piping so that any break resulting from a pull will occur on the hose or swivel-type piping side of the connection while retaining intact the valves and piping on the plant side of the connection.

6.10.9 Emergency shutoff valves and backflow check valves required by the code shall be tested annually for the functions required by 5.10.4. The results of the test shall be documented.

6.10.10 All emergency shutoff valves shall comply with the following:

(1) Each emergency shutoff valve shall have at least one clearly identified and easily accessible manually operated remote emergency shutoff device.
(2) The shutoff device shall be located not less than 25 ft (7.6 mm) or more than 100 ft (30.5 m) in the path of egress from the emergency shutoff valve.
(3) Where an emergency shutoff valve is used in lieu of an internal valve in compliance with 5.7.7.2(D)(2), the remote shutoff device shall be installed in accordance with 6.9.4.

6.10.11 Emergency shutoff valves for railroad tank car transfer systems shall be in accordance with 6.16.2.3, 6.16.2.6, 6.24.4, 7.2.3.6, 7.2.3.7, and 7.2.3.8.

6.11 Hydrostatic Relief Valve Installation. A hydrostatic relief valve or a device providing pressure-relieving protection shall be installed in each section of piping and hose in which liquid LP-Gas can be isolated between shutoff valves so as to relieve the pressure that could develop from the trapped liquid to a safe atmosphere or product-retaining section.

6.12 Testing Piping Systems.

6.12.1 After assembly, piping systems (including hose) shall be tested and proven free of leaks at not less than the normal operating pressure.

6.12.2 Piping within the scope of NFPA 54, *National Fuel Gas Code*, shall be pressure tested in accordance with that code.

6.12.3 Tests shall not be made with a flame.

6.13 Installation in Areas of Heavy Snowfall. In areas where heavy snowfall is anticipated, piping, regulators, meters, and other equipment installed in the piping system shall be protected from the forces anticipated as a result of accumulated snow.

6.14* Corrosion Protection.

6.14.1 All metallic equipment and components that are buried or mounded shall be coated or protected and maintained to minimize corrosion.

6.14.2 Corrosion protection of all other materials shall be in accordance with accepted engineering practice.

6.15 Equipment Installation.

6.15.1 Reserved.

6.15.2 Pump Installation.

6.15.2.1 Pumps shall be installed in accordance with the pump manufacturers' installation instructions.

6.15.2.2 Installation shall be made so that the pump casing is not subjected to excessive strains transmitted to it by the suction and discharge piping. This protection shall be accomplished by piping design, the use of flexible connectors or expansion loops, or by other means.

6.15.2.3 Positive displacement pumps shall incorporate a bypass valve or recirculating device to limit the normal operating discharge pressure.

(A) The bypass valve or recirculating device to limit the normal operating discharge pressure shall discharge either into a storage container or into the pump inlet.

(B) If the bypass valve or recirculating device is equipped with a shutoff valve, a secondary device shall be required and designed to do one of the following:

(1) Operate at not more than 400 psig (2.8 MPag)
(2) Operate at a pressure of 50 psi (345 kPa) above the operating pressure where the design pressure exceeds 350 psig (2.4 MPag)

(C) The secondary device shall be incorporated, if not integral with the pump, in the pump piping and shall be designed or installed so that it cannot be rendered inoperative and shall discharge either into a storage container or into the pump inlet.

(D) A pump operating control or disconnect switch shall be located near the pump. Remote control points shall be provided for other plant operations such as container filling, loading or unloading of cargo tank vehicles and railroad tank cars, or operation of the engine fuel dispenser.

6.15.3 Compressor Installation.

6.15.3.1 Compressors shall be installed in accordance with the compressor manufacturers' installation instructions.

6.15.3.2 Installation shall be made so that the compressor housing is not subjected to excessive strains transmitted to it by the suction and discharge piping. The use of flexible connectors to isolate the piping shall be permitted to be installed.

6.15.3.3 Engines used to drive portable compressors shall be equipped with exhaust system spark arresters and shielded ignition systems.

6.15.3.4 Where the compressor is not equipped with an integral means to prevent the LP-Gas liquid from entering the suction, a liquid trap shall be installed in the suction piping as close to the compressor as practical.

6.15.3.5 Portable compressors used with temporary connections shall be excluded from the requirement in 6.15.5.3 unless used to unload railroad tank cars.

6.15.4 Installation of Strainers. Strainers shall be installed so that the strainer element can be removed without removing equipment or piping.

6.15.5 Installation of Meters.

6.15.5.1 Liquid or vapor meters shall be installed in accordance with the manufacturers' installation instructions.

6.15.5.2 Liquid meters shall be installed so that the meter housing is not subject to excessive strains from the connecting piping. If not provided in the piping design, the use of flexible connectors shall be permitted.

6.15.5.3 Vapor meters shall be installed so as to minimize the possibility of physical damage.

6.16 Bulk Plant and Industrial LP-Gas Systems.

6.16.1 Operations and Maintenance. The provisions of Chapter 14 shall apply to all new and existing LP-Gas installations at bulk plants, industrial occupancies, and industrial plants.

6.16.2 Installation of Liquid Transfer Facilities.

6.16.2.1 Points of transfer or the nearest part of a structure housing transfer operations shall be located in accordance with 6.5.3 and 6.5.4.

6.16.2.2 Buildings used exclusively for housing pumps or vapor compressors shall be located in accordance with 6.5.4, considering the building as one that houses a point of transfer.

6.16.2.3 Liquid transfer facilities at rail sidings shall comply with 6.16.2.3(A) through 6.16.2.3(C).

(A) The track of the railroad siding or the roadway surface at the transfer points shall be relatively level.

(B) Clearances from buildings, structures, or stationary containers shall be provided for the siding or roadway approaches to the unloading or loading points to prevent the railroad tank car or cargo tank vehicle from contacting buildings, structures, or stationary containers.

(C) Barriers shall be provided at the ends of railroad sidings.

6.16.2.4 Pumps and compressors shall comply with 6.16.2.4(A) through 6.16.2.4(C).

(A) Compressors used for liquid transfer normally shall withdraw vapor from the vapor space of the container being filled and discharge into the vapor space of the container from which the withdrawal is being made.

(B) An operating control or disconnect switch shall be located nearby.

(C) Remote shutoff controls shall be provided as necessary in other liquid transfer systems.

6.16.2.5* System piping shall be designed to prevent debris from impeding the action of valves and other components of the piping system.

6.16.2.6 Where a hose or swivel-type piping is used for liquid transfer, it shall be protected as follows:

(1) An emergency shutoff valve shall be installed at the railroad tank car end of the hose or swivel-type piping where flow into or out of the tank car is possible.
(2) An emergency shutoff valve or a backflow check valve shall be installed on the tank car end of the hose or swivel piping where flow is only into the railroad type tank car.

6.16.2.7 Transfer hose larger than ½ in. (12 mm) internal diameter shall not be used for making connections to individual containers being filled indoors.

6.16.2.8 If gas is to be discharged from containers inside a building, the provisions of 7.3.2.1 shall apply.

6.16.3 Installation of Gas Distribution Facilities.

6.16.3.1 Gas distribution facilities shall include the following:

(1) Gas manufacturing facilities
(2) Gas storage facilities, other than cylinder storage
(3) Gas–air mixing and vaporization facilities
(4) Compressors not associated with liquid transfer

6.16.3.2 Gas distribution facilities shall not include the following:

(1) Cylinder storage facilities
(2) Facilities for vaporizing LP-Gas and gas–air mixing

6.16.3.3 Separate buildings and attachments to such buildings or rooms within other buildings housing gas distribution facilities shall comply with Chapter 10.

6.16.3.4 Separate buildings used for housing vapor compressors shall be located in accordance with 6.5.3, considering the building as one that houses a point of transfer.

6.16.3.5 Gas distribution facilities located in pits shall have automatic flammable vapor detecting systems.

6.16.3.6 Drains or blow-off lines shall not be directed into or in proximity of sewer systems.

6.16.3.7 If gas is to be discharged from containers inside a building, the installation provisions of 7.3.2.1 shall apply.

6.16.4 Installation of Electrical Equipment. Installation of electrical equipment shall comply with 6.20.2.

6.16.5 Security and Protection Against Tampering for Section 6.16 and Section 6.22 Systems.

6.16.5.1 The facility operator shall provide security measures to minimize entry by unauthorized persons. At a minimum, such measures shall include security awareness training as outlined in Section 4.4 and limitation of unauthorized access to plant areas that include container appurtenances, pumping equipment, loading and unloading facilities, and container filling facilities.

6.16.5.2 The facility area shall be enclosed with at least a 6 ft (1.8 m) high industrial-type fence, chain link fence, or equivalent protection.

(A) There shall be at least two means of emergency egress from the enclosure except as follows:

(1) The fenced or otherwise enclosed area is not over 100 ft^2 (9 m^2)
(2) The point of transfer is within 3 ft (1 m) of the gate
(3) Containers are not filled within the enclosure

(B) Clearance of at least 3 ft (1 m) shall be provided to allow emergency access to the required means of egress.

(C) If guard service is provided, it shall be extended to the LP-Gas installation.

(D) The requirements of Section 4.4 shall apply to guard personnel.

(E) Fencing shall not be required where devices that can be locked in place are provided that prevent unauthorized operation of valves, equipment, and appurtenances.

6.16.5.3 As an alternate to fencing the operating area, devices that can be locked in place shall be provided. Such devices, when in place, shall effectively prevent unauthorized operation of any of the container appurtenances, system valves, or equipment.

6.16.6 Lighting. If operations are normally conducted during other than daylight hours, lighting shall be provided to illuminate storage containers, containers being loaded, control valves, and other equipment.

6.16.7 Ignition Source Control. Ignition source control shall comply with Section 6.20.

6.17 LP-Gas Systems in Buildings or on Building Roofs or Exterior Balconies.

6.17.1 Application.

6.17.1.1 Section 6.17 shall apply to the installation of the following LP-Gas systems in buildings or structures:

(1) Cylinders inside of buildings or on the roofs or exterior balconies of buildings
(2) Systems in which the liquid is piped from outside containers into buildings or onto the roof

6.17.1.2 Cylinders in use shall mean connected for use.

(A) The use of cylinders indoors shall be only for the purposes specified in 6.17.4 through 6.17.9.

(B) The use of cylinders indoors shall be limited to those conditions where operational requirements make the indoor use of cylinders necessary and location outside is impractical.

(C) The use of cylinders on roofs shall be limited to those conditions where operational requirements make use of cylinders necessary and location other than on roofs of buildings or structures is impractical.

(D) Liquid LP-Gas shall be piped into buildings or structures only for the purposes specified in 6.8.1.1(4).

6.17.1.3 Storage of cylinders awaiting use shall be in accordance with Chapter 8.

6.17.1.4 Transportation of cylinders within a building shall be in accordance with 6.17.3.6.

6.17.1.5 The following provisions shall be required in addition to those specified in Sections 6.2 and 6.3:

(1) Liquid transfer systems shall be in accordance with Chapter 7.
(2) Engine fuel systems used inside buildings shall be in accordance with Chapter 11.
(3) LP-Gas transport or cargo tank vehicles stored, serviced, or repaired in buildings shall be in accordance with Chapter 9.

6.17.2 Additional Equipment Requirements for Cylinders, Equipment, Piping, and Appliances Used in Buildings, Building Roofs, and Exterior Balconies.

6.17.2.1 Cylinders shall be in accordance with the following:

(1) Cylinders shall comply with DOT cylinder specifications.
(2) Cylinders shall not exceed 245 lb (111 kg) water capacity [nominal 100 lb (45 kg) LP-Gas capacity] each.
(3) Cylinders shall comply with other applicable provisions of Section 5.2, and they shall be equipped as provided in Section 5.7.
(4) Cylinders shall be marked in accordance with 5.2.8.1 and 5.2.8.2.
(5) Cylinders with propane capacities greater than 2 lb (0.9 kg) shall be equipped as provided in Table 5.7.7.1, and an excess-flow valve shall be provided for vapor service when used indoors.
(6) Cylinder valves shall be protected in accordance with 5.2.6.1.
(7) Cylinders having water capacities greater than 2.7 lb (1.2 kg) and connected for use shall stand on a firm and substantially level surface.
(8) Cylinders shall be secured in an upright position if necessary.
(9) Cylinders and the valve-protecting devices used with them shall be oriented to minimize the possibility of impingement of the pressure relief device discharge on the cylinder and adjacent cylinders.

6.17.2.2 Only regulators recommended by the manufacturer for use with LP-Gas shall be used.

6.17.2.3 Manifolds and fittings connecting cylinders to pressure regulator inlets shall be designed for at least 250-psig (1.7-MPag) service pressure.

6.17.2.4 Piping shall comply with Section 5.8 and shall have a pressure rating of 250 psig (1.7 MPag).

6.17.2.5 Liquid piping and vapor piping at pressures above 125 psig (0.9 MPag) shall be installed in accordance with 6.8.3.

6.17.2.6 Hose, hose connections, and flexible connectors shall comply with the following:

(1) Hose used at pressures above 5 psi (34 kPa) shall be designed for a pressure of at least 350 psig (2.4 MPag).
(2) Hose used at a pressure of 5 psi (34 kPa) or less and used in agricultural buildings not normally occupied by the public shall be designed for the operating pressure of the hose.
(3) Hose shall comply with 5.8.6.
(4) Hose shall be installed in accordance with Section 6.18.2.
(5) Hose length requirements of 6.18.2.2(1) shall be applicable.
(6) Hose shall be as short as practical, without kinking or straining hose or causing it to be close enough to a burner to be damaged by heat.

6.17.2.7* Portable heaters, including salamanders, shall comply with the following:

(1) Portable heaters shall be equipped with an approved automatic device to shut off the flow of gas to the main burner and to the pilot, if used, in the event of flame extinguishment or combustion failure.
(2) Portable heaters shall be self-supporting unless designed for cylinder mounting.
(3) Portable heaters shall not be installed utilizing cylinder valves, connectors, regulators, manifolds, piping, or tubing as structural supports.
(4) Portable heaters having an input of more than 50,000 Btu/hr (53 MJ/hr) shall be equipped with either a pilot that must be lighted and proved before the main burner can be turned on or an approved electric ignition system.

6.17.2.8 The provisions of 6.17.2.7 shall not be applicable to the following:

(1) Tar kettle burners, hand torches, or melting pots
(2) Portable heaters with less than 7500 Btu/hr (8 MJ/hr) input if used with cylinders having a maximum water capacity of 2.7 lb (1.2 kg) and filled with no more than 16.8 oz (0.522 kg) of LP-Gas

6.17.3 Installation Requirements for Cylinders, Equipment, Piping, and Appliances in Buildings, Building Roofs, and Exterior Balconies.

6.17.3.1 Cylinders having water capacities greater than 2.7 lb (1.2 kg) and connected for use shall stand on a firm and substantially level surface. If necessary, they shall be secured in an upright position.

6.17.3.2 Cylinders, regulating equipment, manifolds, pipe, tubing, and hose shall be located to minimize exposure to the following:

(1) Abnormally high temperatures (such as might result from exposure to convection and radiation from heating equipment or installation in confined spaces)
(2) Physical damage
(3) Tampering by unauthorized persons

6.17.3.3 Heat-producing equipment shall be installed with clearance to combustibles in accordance with the manufacturer's installation instructions.

6.17.3.4 Heat-producing equipment shall be located and used to minimize the possibility of the ignition of combustibles.

6.17.3.5 Where cylinders are located on a floor, roof, or balcony, cylinders shall be secured to prevent falling over the edge.

6.17.3.6 Transportation (movement) of cylinders having water capacities greater than 2.7 lb (1.2 kg) within a building shall be restricted to movement directly associated with the uses covered by Section 6.17.

(A) Valve outlets on cylinders having water capacities greater than 2.7 lb (1.2 kg) shall be tightly plugged, capped, or sealed with a listed quick-closing coupling or a listed quick-connect coupling.

(B) Only emergency stairways not normally used by the public shall be used, and precautions shall be taken to prevent the cylinder from falling down the stairs where freight or passenger elevators are used.

(C) Emergency stairways shall be occupied only by those engaged in moving the cylinder.

6.17.4 Buildings Under Construction or Undergoing Major Renovation.

6.17.4.1 Cylinders shall be permitted to be used and transported in buildings or structures under construction or undergoing major renovation where such buildings are not occupied by the public.

6.17.4.2 The use and transportation of cylinders in the unoccupied portions of buildings or structures under construction or undergoing major renovation that are partially occupied by the public shall be approved by the authority having jurisdiction.

6.17.4.3 Cylinders, equipment, piping, and appliances shall comply with 6.17.2.

6.17.4.4 Heaters used for temporary heating shall be located at least 6 ft (1.8 m) from any cylinder.

6.17.4.5 Integral heater-cylinder units specifically designed for the attachment of the heater to the cylinder, or to a supporting standard attached to the cylinder, and designed and installed to prevent direct or radiant heat application to the cylinder shall be exempt from the spacing requirement of 6.17.4.4.

6.17.4.6 Blower-type and radiant-type units shall not be directed toward any cylinder within 20 ft (6.1 m).

6.17.4.7 If two or more heater-cylinder units of either the integral or nonintegral type are located in an unpartitioned area on the same floor, the cylinder(s) of each such unit shall be separated from the cylinder(s) of any other such unit by at least 20 ft (6.1 m).

6.17.4.8 If heaters are connected to cylinders manifolded together for use in an unpartitioned area on the same floor, the total water capacity of cylinders manifolded together serving any one heater shall not be greater than 735 lb (333 kg) [nominal 300 lb (136 kg) LP-Gas capacity]. If there is more than one such manifold, it shall be separated from any other by at least 20 ft (6.1 m).

6.17.4.9 Where cylinders are manifolded together for connection to a heater or heaters on another floor, the following shall apply:

(1) Heaters shall not be installed on the same floors with manifolded cylinders.
(2) The total water capacity of the cylinders connected to any one manifold shall not be greater than 2450 lb (1111 kg) [nominal 1000 lb (454 kg) LP-Gas capacity].
(3) Manifolds of more than 735 lb (333 kg) water capacity [nominal 300 lb (136 kg) LP-Gas capacity], if located in the same unpartitioned area, shall be separated from each other by at least 50 ft (15 m).

6.17.4.10 Where compliance with the provisions of 6.17.4.6 through 6.17.4.9 is impractical, alternate installation provisions shall be allowed with the approval of the authority having jurisdiction.

6.17.5 Buildings Undergoing Minor Renovation When Frequented by the Public.

6.17.5.1 Cylinders used and transported for repair or minor renovation in buildings frequented by the public during the hours the public normally occupies the building shall comply with the following:

(1) The maximum water capacity of individual cylinders shall be 50 lb (23 kg) [nominal 20 lb (9.1 kg) LP-Gas capacity], and the number of cylinders in the building shall not exceed the number of workers assigned to the use of the LP-Gas.
(2) Cylinders having a water capacity greater than 2.7 lb (1.2 kg) shall not be left unattended.

6.17.5.2 During the hours the building is not open to the public, cylinders used and transported within the building for repair or minor renovation and with a water capacity greater than 2.7 lb (1.2 kg) shall not be left unattended.

6.17.6 Buildings Housing Industrial Occupancies.

6.17.6.1 Cylinders used in buildings housing industrial occupancies for processing, research, or experimental purposes shall comply with 6.17.6.1(A) and 6.17.6.1(B).

(A) If cylinders are manifolded together, the total water capacity of the connected cylinders shall be not more than 735 lb (333 kg) [nominal 300 lb (136 kg) LP-Gas capacity]. If there is more than one such manifold in a room, it shall be separated from any other by at least 20 ft (6.1 m).

(B) The amount of LP-Gas in cylinders for research and experimental use in the building shall be limited to the smallest practical quantity.

6.17.6.2 The use of cylinders to supply fuel for temporary heating in buildings housing industrial occupancies with essentially noncombustible contents shall comply with the requirements for cylinders in buildings under construction in 6.17.4.

6.17.6.3 The use of fuel cylinders for temporary heating shall be permitted only where portable equipment for space heating is essential and a permanent heating installation is not practical.

6.17.7 Buildings Housing Educational and Institutional Occupancies.

6.17.7.1 The use of cylinders in classrooms shall be prohibited unless they are used temporarily for classroom demonstrations in accordance with 6.17.9.1.

6.17.7.2 Where cylinders are used in buildings housing educational and institutional laboratory occupancies for research and experimental purposes, the following shall apply:

(1) The maximum water capacity of individual cylinders used shall be 50 lb (23 kg) [nominal 20 lb (9.1 kg) LP-Gas capacity] if used in educational occupancies and 12 lb (5.4 kg) [nominal 5 lb (2 kg) LP-Gas capacity] if used in institutional occupancies.
(2) If more than one such cylinder is located in the same room, the cylinders shall be separated by at least 20 ft (6.1 m).
(3) Cylinders not connected for use shall be stored in accordance with Chapter 8.
(4) Cylinders shall not be stored in a laboratory room.

6.17.8 Temporary Heating and Food Service Appliances in Buildings in Emergencies.

6.17.8.1 Cylinders shall not be used in buildings for temporary emergency heating purposes except when all of the following conditions are met:

(1) The permanent heating system is temporarily out of service.
(2) Heat is necessary to prevent damage to the buildings or contents.
(3) The cylinders and heaters comply with and are used and transported in accordance with 6.17.2 and 6.17.4.
(4) The temporary heating equipment is not left unattended.

6.17.8.2 When a public emergency has been declared and gas, fuel, or electrical service has been interrupted, portable listed LP-Gas commercial food service appliances meeting the requirements of 6.17.9.4 shall be permitted to be temporarily used inside affected buildings.

6.17.8.3 The portable appliances used shall be discontinued and removed from the building at the time the permanently installed appliances are placed back in operation.

6.17.9 Use in Buildings for Demonstrations or Training, and Use of Small Cylinders.

6.17.9.1 Cylinders used temporarily inside buildings for public exhibitions or demonstrations, including use in classroom demonstrations, shall be in accordance with the following:

(1) The maximum water capacity of a cylinder shall be 12 lb (5.4 kg) [nominal 5 lb (2 kg) LP-Gas].
(2) If more than one such cylinder is located in a room, the cylinders shall be separated by at least 20 ft (6.1 m).

6.17.9.2 Cylinders used temporarily in buildings for training purposes related to the installation and use of LP-Gas systems shall be in accordance with the following:

(1) The maximum water capacity of individual cylinders shall be 245 lb (111 kg) [nominal 100 lb (45 kg) LP-Gas capacity], but not more than 20 lb (9.1 kg) of LP-Gas shall be placed in a single cylinder.
(2) If more than one such cylinder is located in the same room, the cylinders shall be separated by at least 20 ft (6.1 m).
(3) The training location shall be acceptable to the authority having jurisdiction.
(4) Cylinders shall be promptly removed from the building when the training class has terminated.

6.17.9.3* Cylinders used in buildings as part of approved self-contained torch assemblies or similar appliances shall be in accordance with the following:

(1) Cylinders used in buildings shall comply with UL 147A, *Standard for Nonrefillable (Disposable) Type Fuel Gas Cylinder Assemblies*.
(2) Cylinders shall have a maximum water capacity of 2.7 lb (1.2 kg).

6.17.9.4 Cylinders used with commercial food service appliances shall be used inside restaurants and in attended commercial food catering operations in accordance with the following:

(1) Cylinders and appliances shall be listed.
(2) Commercial food service appliances shall not have more than two 10 oz (296 ml) nonrefillable butane gas cylinders, each having a maximum capacity of 1.08 lb (0.490 kg).
(3) Cylinders shall comply with UL 147B, *Standard for Nonrefillable (Disposal) Type Metal Container Assemblies for Butane*.
(4) Cylinders shall be connected directly to the appliance and shall not be manifolded.
(5) Cylinders shall be an integral part of the listed, approved, commercial food service device and shall be connected without the use of a rubber hose.
(6) Storage of cylinders shall be in accordance with 8.3.1.

6.17.10 Use in Building for Flame Effects Before a Proximate Audience.

(A) Where cylinders are used temporarily in buildings for flame effects before an audience, the flame effect shall be in accordance with NFPA 160, *Standard for Flame Effects Before an Audience*.

(B) The maximum water capacity of individual cylinders shall be 48 lb (22 kg) [nominal 20 lb (9.1 kg) LP-Gas capacity].

(C)* If more than one cylinder is located in the same room, the cylinders shall be separated by at least 20 ft (6.1 m).

(D) Where separation of 20 ft (6.1 m) is not practical, reduction of distances shall be permitted with the approval of the authority having jurisdiction.

(E) Cylinders shall not be connected or disconnected during the flame effect or performance.

6.17.11 Cylinders on Roofs or Exterior Balconies.

6.17.11.1 Where cylinders are installed permanently on roofs of buildings, the buildings shall be of fire-resistant construction or noncombustible construction having essentially noncombustible contents, or of other construction or contents that are protected with automatic sprinklers.

(A) The total water capacity of cylinders connected to any one manifold shall be not greater than 980 lb (445 kg) [nominal 400 lb (181 kg) LP-Gas capacity]. If more than one manifold is located on the roof, it shall be separated from any other by at least 50 ft (15 m).

(B) Cylinders shall be located in areas where there is free air circulation, at least 10 ft (3 m) from building openings (such as windows and doors), and at least 20 ft (6.1 m) from air intakes of air-conditioning and ventilating systems.

(C) Cylinders shall not be located on roofs that are entirely enclosed by parapets more than 18 in. (460 mm) high unless the parapets are breached with low-level ventilation openings no more than 20 ft (6.1 m) apart, or all openings communicating with the interior of the building are at or above the top of the parapets.

(D) Piping shall be in accordance with 6.17.2.4 through 6.17.2.6.

(E) Hose shall not be used for connection to cylinders.

(F) The fire department shall be advised of each installation.

6.17.11.2 Cylinders having water capacities greater than 2.7 lb (1 kg) [nominal 1 lb (0.5 kg)] LP-Gas capacity shall not be located on decks or balconies of dwellings of two or more living units above the first floor unless they are served by exterior stairways.

6.17.12 Liquid LP-Gas Piped into Buildings or Structures.

6.17.12.1 Buildings or separate areas of buildings into which LP-Gas liquid at pressures exceeding 20 psig (138 kPag) is piped shall be constructed in accordance with Chapter 10 and shall be used for the purposes listed in 6.8.1.2.

6.17.12.2 Liquid LP-Gas piped into buildings under construction or major renovations in accordance with 6.8.1.3 shall comply with 6.17.12.2(A) through 6.17.12.2(J).

(A) Liquid piping shall not exceed ¾ in. and shall comply with 6.8.1 and 6.8.3.

(B) Copper tubing with a maximum outside diameter of ¾ in. shall be used where approved by the authority having jurisdiction.

(C) Liquid piping in buildings shall be kept to a minimum length and shall be protected against construction hazards by fastening it to walls or other surfaces to provide protection against breakage and by locating it so as to avoid exposure to high ambient temperatures.

(D) A readily accessible shutoff valve shall be located at each intermediate branch line where it leaves the main line.

(E) A second shutoff valve shall be located at the appliance end of the branch and upstream of any flexible appliance connector.

(F) Excess-flow valves shall be installed downstream of each branch line shutoff valve.

(G) Excess-flow valves shall be located at any point in the piping system where branch lines are used and the pipe size of the branch line is reduced. The excess flow valve shall be sized for the reduced size of the branch line piping.

(H) Hose shall not be used to carry liquid between the container and building and shall not be used at any point in the liquid line.

(I) Hydrostatic relief valves shall be installed where required.

(J) The release of fuel when any section of piping or appliances is disconnected shall be minimized by either using an approved automatic quick-closing coupling that shuts off the gas on both sides when uncoupled or by closing the shutoff valve closest to the point to be disconnected and allowing the appliance or appliances on that line to operate until the fuel in the line is consumed.

6.18 Installation of Appliances.

6.18.1 Application.

6.18.1.1 Section 6.18 shall apply to the installation of LP-Gas appliances.

6.18.1.2 Installation of appliances on commercial vehicles shall be in accordance with 6.21.7.

6.18.2 Hose for Portable Appliances.

6.18.2.1 The requirements of Section 6.18 shall apply to hoses used on the low-pressure side of regulators to connect portable appliances.

6.18.2.2 Where used inside buildings, the following shall apply:

(1) The hose shall be the minimum practical length not exceeding 6 ft (1.8 m).
(2) The hose shall not extend from one room to another or pass through any partitions, walls, ceilings, or floors except as provided by 6.17.4.9.
(3) The hose shall not be concealed from view or used in concealed locations.

6.18.2.3 Where installed outside of buildings, the hose length shall be permitted to exceed 6 ft (1.8 m) but shall be as short as practical.

6.18.2.4 Hose shall be securely connected to the appliance.

6.18.2.5 The use of rubber slip ends shall not be permitted.

6.18.2.6 A shutoff valve shall be provided in the piping immediately upstream of the inlet connection of the hose.

6.18.2.7 Where more than one such appliance shutoff is located near another, the valves shall be marked to indicate which appliance is connected to each valve.

6.18.2.8 Hose shall be protected against physical damage.

6.19 Vaporizer Installation.

6.19.1 Application. Section 6.19 shall not apply to engine fuel vaporizers or to integral vaporizing burners such as those used for weed burners or tar kettles.

6.19.2 Installation of Indirect-Fired Vaporizers.

6.19.2.1 Indirect-fired vaporizers shall be installed outdoors, or in separate buildings or structures that comply with Section 10.2, or in attached structures or rooms that comply with Section 10.3.

6.19.2.2 The building or structure shall not have any unprotected drains to sewers or sump pits.

6.19.2.3 Pressure relief valves on vaporizers within buildings in industrial or gas manufacturing plants shall be piped to a point outside the building or structure and shall discharge vertically upward.

6.19.2.4 If the heat source of an indirect-fired vaporizer is gas fired and is located within 15 ft (4.6 m) of the vaporizer, the vaporizer and its heat source shall be installed as a direct-fired vaporizer and shall be subject to the requirements of 6.19.3.

6.19.2.5 The installation of a heat source serving an indirect-fired vaporizer that utilizes a flammable or combustible heat transfer fluid shall comply with one of the following:

(1) It shall be located outdoors.
(2) It shall be located within a structure that complies with Section 10.2.
(3) It shall be located within a structure attached to, or in rooms within, a building or structure that complies with Section 10.3.

6.19.2.6 Gas-fired heating systems supplying heat for vaporization purposes shall be equipped with automatic safety devices to shut off gas to the main burners if ignition fails to occur.

6.19.2.7 The installation of a heat source serving an indirect-fired vaporizer that utilizes a noncombustible heat transfer fluid, such as steam, water, or a water-glycol mixture, shall be installed outdoors or in industrial occupancies.

6.19.2.8 Industrial occupancies in which a source of heat for an indirect-fired vaporizer is installed shall comply with Chapter 40 of NFPA *101, Life Safety Code*, and Section 6.3 of NFPA 54, *National Fuel Gas Code* (ANSI Z223.1).

6.19.2.9 The following shall apply to indirect-fired vaporizers installed in buildings:

(1) The heat transfer fluid shall be steam or hot water.
(2) The heat transfer fluid shall not be recirculated.
(3) A backflow preventer shall be installed between the vaporizer and the heat source.

6.19.2.10 If the heat transfer fluid is recirculated after leaving the vaporizer, the heat source shall be installed in accordance with 6.20.2.5 and a phase separator shall be installed with the gas vented.

6.19.2.11 Indirect-fired vaporizers employing heat from the atmosphere shall be installed outdoors and shall be located in accordance with Table 6.19.3.6.

6.19.2.12 Where atmospheric vaporizers of less than 1-qt (0.9-L) capacity are installed inside an industrial building, they shall be installed as close as practical to the point of entry of the supply line in the building.

6.19.3 Installation of Direct-Fired Vaporizers.

6.19.3.1 Where a direct-fired vaporizer is installed in a separate structure, the separate structure shall be constructed in accordance with Chapter 10.

6.19.3.2 The housing for direct-fired vaporizers shall not have any drains to a sewer or a sump pit that is shared with any other structure.

6.19.3.3 Pressure relief valve discharges on direct-fired vaporizers shall be piped to a point outside the structure or building.

6.19.3.4 Direct-fired vaporizers shall be connected to the liquid space or to the liquid and vapor space of the ASME container.

6.19.3.5 A manually operated shutoff valve shall be installed in each connection of the ASME container supplying the vaporizer.

6.19.3.6 Direct-fired vaporizers of any capacity shall be located in accordance with Table 6.19.3.6.

6.19.4 Installation of Tank Heaters.

6.19.4.1 Tank heaters shall be installed only on aboveground ASME containers and shall be located in accordance with Table 6.19.4.1 with respect to the nearest important building, group of buildings, or line of adjoining property that can be built upon.

6.19.4.2 If the tank heater is gas fired, an automatic shutoff shall be provided on the fuel supply (including the pilot) that will operate if the ASME container pressure exceeds 75 percent of the maximum design pressure specified in Table 5.2.4.2 or if the liquid level in the ASME container falls below the top of the tank heater.

6.19.4.3 If the tank heater is of the electric immersion type, the heater shall be automatically de-energized when the pressure or level conditions specified in 6.19.4.2 are reached.

6.19.4.4 If the tank heater is similar in operation to an indirect-fired vaporizer, the flow of the heat transfer fluid shall be automatically interrupted under the pressure or temperature conditions specified in 6.19.4.2 and the heat source shall comply with 6.19.2.8 and 6.19.2.11.

Table 6.19.3.6 Minimum Separation Distances Between Direct-Fired Vaporizers and Exposures

Exposure	Minimum Distance Required	
	ft	m
Container	10	3.0
Container shutoff valves	15	4.6
Point of transfer	15	4.6
Nearest important buildings or group of buildings or line of adjoining property that can be built	25	7.6
Nearest Chapter 10 building or room housing gas–air mixer	10	3.0
Cabinet housing gas–air mixer outdoors	0	0

Note: Do not apply distances to the building in which a direct-fired vaporizer is installed.

Table 6.19.4.1 Minimum Separation Between Tank Heaters and Exposures

Container Water Capacity		Minimum Distance Required	
gal	m^3	ft	m
≤500	≤1.9	10	3.0
501–2000	1.9–7.6	25	7.6
2001–30,000	7.6–114	50	15
30,001–70,000	114–265	75	23
70,001–90,000	265–341	100	30.5
90,001–120,000	341–454	125	38.1

6.19.4.5 If a point of transfer is located within 15 ft (4.6 m) of a direct-gas-fired tank heater, the heater burner and pilot shall be shut off during the product transfer and a caution notice shall be displayed immediately adjacent to the filling connections and shall read as follows:

> **CAUTION:** A gas-fired device that contains a source of ignition is connected to this container. Burner and pilot must be shut off before filling the container.

6.19.5 Installation of Vaporizing Burners.

6.19.5.1 Vaporizing burners shall be installed outside of buildings.

6.19.5.2 The minimum distance between any container and a vaporizing burner shall be in accordance with Table 6.19.5.2.

6.19.5.3 Manually operated positive shutoff valves shall be located at the containers to shut off all flow to the vaporizing burners.

6.19.6 Installation of Waterbath Vaporizers.

6.19.6.1 If a waterbath vaporizer is electrically heated and all electrical equipment is designed for Class I, Group D locations, the unit shall be treated as indirect-fired and shall be installed in accordance with 6.19.2.

6.19.6.2 All other waterbath vaporizers shall be treated as direct-fired vaporizers and shall be installed in accordance with 6.19.3.

Table 6.19.5.2 Minimum Separation Distance Between Containers and Vaporizing Burners

Container Water Capacity		Minimum Distance Required	
gal	m^3	ft	m
≤500	≤1.9	10	3.0
501–2000	1.9–7.6	25	7.6
>2000	>7.6	50	15.0

6.19.7 Installation of Electric Vaporizers. Electric vaporizers, whether direct immersion or indirect immersion, shall be treated as indirect-fired and shall be installed in accordance with 6.19.2.

6.19.8 Installation of Gas–Air Mixers.

6.19.8.1 Piping and equipment installed with a gas–air mixer shall comply with 6.8.1, 6.8.3, and 6.12.

6.19.8.2 Where used without a vaporizer, a mixer shall be installed outdoors or in a building complying with Chapter 10.

6.19.8.3 Where used with an indirect-fired vaporizer, a mixer shall be installed in accordance with one of the following:

(1) In an outdoor location
(2) In the same compartment or room with the vaporizer
(3) In a building complying with Chapter 10
(4) In a location that is both remote from the vaporizer and in accordance with 6.19.2

6.19.8.4 Where used with a direct-fired vaporizer, a mixer shall be installed as follows:

(1) With a listed or approved mixer in a common cabinet with the vaporizer outdoors in accordance with 6.19.3.6
(2) Outdoors on a common skid with the vaporizer in accordance with 6.19.3
(3) Adjacent to the vaporizer to which it is connected in accordance with 6.19.3
(4) In a building complying with Chapter 10 without a direct-fired vaporizer in the same room

6.20 Ignition Source Control.

6.20.1 Scope.

6.20.1.1 This section shall apply to the minimization of ignition of flammable LP-Gas–air mixtures resulting from the normal or accidental release of nominal quantities of liquid or vapor from LP-Gas systems installed and operated in accordance with this code.

6.20.1.2* The installation of lightning protection equipment shall not be required on LP-Gas storage containers.

6.20.1.3* Grounding and bonding shall not be required on LP-Gas systems.

6.20.2 Electrical Equipment.

6.20.2.1 Electrical equipment and wiring installed in unclassified areas shall be in accordance with NFPA 70, *National Electrical Code*, for nonclassified locations.

6.20.2.2* Fixed electrical equipment and wiring installed within a classified area specified in Table 6.20.2.2 shall be installed in accordance with NFPA 70, *National Electrical Code*.

Table 6.20.2.2 Electrical Area Classification

Part	Location	Extent of Classified Area[a]	Equipment Shall be Approved for *National Electrical Code*, Class I[a], Group D[b]
A	Unrefrigerated containers other than cylinders and ASME vertical containers of less than 1000 lb (454 kg) water capacity	Within 15 ft (4.6 m) in all directions from connections, except connections otherwise covered in Table 6.20.2.2	Division 2
B	Refrigerated storage containers	Within 15 ft (4.6 m) in all directions from connections otherwise covered in Table 6.20.2.2	Division 2
		Area inside dike to the level of the top of the dike	Division 2
C[c]	Tank vehicle and tank car loading and unloading	Within 5 ft (1.5 m) in all directions from connections regularly made or disconnected for product transfer	Division 1
		Beyond 5 ft (1.5 m) but within 15 ft (4.6 m) in all directions from a point where connections are regularly made or disconnected and within the cylindrical volume between the horizontal equator of the sphere and grade	Division 2
D	Gauge vent openings other than those on cylinders and ASME vertical containers of less than 1000 lb (454 kg) water capacity	Within 5 ft (1.5 m) in all directions from point of discharge	Division 1
		Beyond 5 ft (1.5 m) but within 15 ft (4.6 m) in all directions from point of discharge	Division 2
E	Relief device discharge other than those on cylinders and ASME vertical containers of less than 1000 lb (454 kg) water capacity and vaporizers	Within direct path of discharge	Note: Fixed electrical equipment should preferably not be installed.
F[c]	Pumps, vapor compressors, gas–air mixers and vaporizers (other than direct-fired or indirect-fired with an attached or adjacent gas-fired heat source)		
	Indoors without ventilation	Entire room and any adjacent room not separated by a gastight partition	Division 1
		Within 15 ft (4.6 m) of the exterior side of any exterior wall or roof that is not vaportight or within 15 ft (4.6 m) of any exterior opening	Division 2
	Indoors with ventilation	Entire room and any adjacent room not separated by a gastight partition	Division 2
	Outdoors in open air at or above grade	Within 15 ft (4.6 m) in all directions from this equipment and within the cylindrical volume between the horizontal equator of the sphere and grade	Division 2
G	Vehicle fuel dispenser	Entire space within dispenser enclosure, and 18 in. (460 mm) horizontally from enclosure exterior up to an elevation 4 ft (1.2 m) above dispenser base; entire pit or open space beneath dispenser	Division 1
		Up to 18 in. (460 mm) above ground within 20 ft (6.1 m) horizontally from any edge of enclosure (Note: For pits within this area, see part H of this table.)	Division 2

Table 6.20.2.2 *Continued*

Part	Location	Extent of Classified Area[a]	Equipment Shall be Approved for *National Electrical Code*, Class I[a], Group D[b]
H	Pits or trenches containing or located beneath LP-Gas valves, pumps, vapor compressors, regulators, and similar equipment		
	Without mechanical ventilation	Entire pit or trench	Division 1
		Entire room and any adjacent room not separated by a gastight partition	Division 2
		Within 15 ft (4.6 m) in all directions from pit or trench when located outdoors	Division 2
	With mechanical ventilation	Entire pit or trench	Division 2
		Entire room and any adjacent room not separated by a gastight partition	Division 2
		Within 15 ft (4.6 m) in all directions from pit or trench when located outdoors	Division 2
I	Special buildings or rooms for storage of cylinders	Entire room	Division 2
J	Pipelines and connections containing operational bleeds, drips, vents, or drains	Within 5 ft (1.5 m) in all directions from point of discharge	Division 1
		Beyond 5 ft (1.5 m) from point of discharge, same as part F of this table	
K[c]	Cylinder filling		
	Indoors with ventilation	Within 5 ft (1.5 m) in all directions from a point of transfer	Division 1
		Beyond 5 ft (1.5 m) and entire room	Division 2
	Outdoors in open air	Within 5 ft (1.5 m) in all directions from a point of transfer	Division 1
		Beyond 5 ft (1.5 m) but within 15 ft (4.6 m) in all directions from point of transfer and within the cylindrical volume between the horizontal equator of the sphere and grade	Division 2
L	Piers and wharves	Within 5 ft (1.5 m) in all directions from connections regularly made or disconnected for product transfer	Division 1
		Beyond 5 ft (1.5 m) but within 15 ft (4.6 m) in all directions from a point where connections are regularly made or disconnected and within the cylindrical volume between the horizontal equator of the sphere and the vessel deck	Division 2

[a]The classified area shall not extend beyond an unpierced wall, roof, or solid vaportight partition.
[b] See Article 500 Hazardous (Classified) Locations, in NFPA 70, *National Electrical Code*, for definitions of classes, groups, and divisions.
[c]See A.6.20.2.2.

6.20.2.3* The provisions of 6.20.2.2 shall apply to vehicle fuel operations.

6.20.2.4 The provisions of 6.20.2.2 shall not apply to fixed electrical equipment at residential or commercial installations of LP-Gas systems or to systems covered by Section 6.21.

6.20.2.5 Fired vaporizers, calorimeters with open flames, and other areas where open flames are present either intermittently or constantly shall not be considered electrically classified areas.

6.20.2.6 Electrical equipment installed on LP-Gas cargo tank vehicles shall comply with Section 9.2.

6.20.3 Other Sources of Ignition.

6.20.3.1 Open flames or other sources of ignition shall not be used or installed in pump houses, cylinder filling rooms, or other similar locations.

6.20.3.2 Direct-fired vaporizers or indirect-fired vaporizers attached or installed adjacent to gas-fired heat sources shall not be installed in pump houses or cylinder filling rooms.

6.20.3.3 Open flames, cutting or welding tools, portable electric tools, and extension lights capable of igniting LP-Gas shall not be installed or used within classified areas specified in Table 6.20.2.2.

6.20.3.4* Open flames or other sources of ignition shall not be prohibited where LP-Gas facilities have been purged of all liquid and vapor.

6.21 LP-Gas Systems on Vehicles (Other Than Engine Fuel Systems).

6.21.1* Application. Section 6.21 shall apply to the following:

(1) Nonengine fuel systems on all vehicles
(2) Installations served by exchangeable (removable) cylinder systems and by permanently mounted containers

6.21.2 Nonapplication. Section 6.21 shall not apply to the following:

(1) Systems installed on mobile homes
(2) Systems installed on recreational vehicles
(3) Cargo tank vehicles, cargo tank vehicles (trailers and semitrailers), and similar units used to transport LP-Gas as cargo, which are covered by Chapter 9
(4) LP-Gas engine fuel systems on the vehicles, which are covered by Chapter 11

6.21.3 Container Installation Requirements.

6.21.3.1 Containers shall comply with 6.21.3.1(A) through 6.21.3.1(F).

Table 6.21.3.1 Maximum Capacities of Individual LP-Gas Containers Installed on LP-Gas Highway Vehicles

	Maximum Container Water Capacity	
Vehicle	gal	m^3
Passenger vehicle	200	0.8
Nonpassenger vehicle	300	1.1
Road surfacing vehicle	1000	3.8
Cargo tank vehicle	Not limited by this code	

(A) ASME mobile containers shall have a MAWP of 250 psig (1.7 Mpag) if constructed prior to April 1, 2001, or 312 psig (2.2 MPag) if constructed on or after April 1, 2001.

(B) Cylinders installed on recreational vehicles or on other vehicles shall be constructed for at least a 240 psig (1.6 MPag) service pressure.

(C) ASME mobile containers installed on recreational vehicles or on other vehicles shall be constructed for at least a 312 psig (2.2 MPag) MAWP.

(D) LP-Gas fuel containers used on passenger-carrying vehicles shall not exceed 200 gal (0.8 m^3) aggregate water capacity.

(E) The capacity of individual LP-Gas containers on highway vehicles shall be in accordance with Table 6.21.3.1.

(F) Containers designed for stationary service only and not in compliance with the container appurtenance protection requirements of 5.2.6 shall not be used.

6.21.3.2 ASME containers and cylinders utilized for the purposes covered by Section 6.21 shall not be installed, transported, or stored (even temporarily) inside any vehicle covered by Section 6.21, except for ASME containers installed in accordance with 6.21.3.4(I), Chapter 9, or DOT regulations.

6.21.3.3 The LP-Gas supply system, including the containers, shall be installed either on the outside of the vehicle or in a recess or cabinet vaportight to the inside of the vehicle but accessible from and vented to the outside, with the vents located near the top and bottom of the enclosure and 3 ft (1 m) horizontally away from any opening into the vehicle below the level of the vents.

6.21.3.4 Containers shall be mounted securely on the vehicle or within the enclosing recess or cabinet.

(A) Containers shall be installed with road clearance in accordance with 11.7.3.

(B) Fuel containers shall be mounted to prevent jarring loose and slipping or rotating, and the fastenings shall be designed and constructed to withstand, without permanent visible deformation, static loading in any direction equal to four times the weight of the container filled with fuel.

(C) Where containers are mounted within a vehicle housing, the securing of the housing to the vehicle shall comply with this provision. Any removable portions of the housing or cabinet shall be secured while in transit.

(D) Field welding on containers shall be limited to attachments to nonpressure parts such as saddle plates, wear plates, or brackets applied by the container manufacturer.

(E) All container valves, appurtenances, and connections shall be protected to prevent damage from accidental contacts with stationary objects, from loose objects, stones, mud, or ice thrown up from the ground or floor, and from damage due to overturn or similar vehicular accident.

(F) Permanently mounted ASME containers shall be located on the vehicle to provide this protection.

(G) Cylinders shall have permanent protection for cylinder valves and connections.

(H) Where cylinders are located on the outside of a vehicle, weather protection shall be provided.

(I) Containers mounted on the interior of passenger-carrying vehicles shall be installed in compliance with Section 11.8. Pressure relief valve installations for such containers shall comply with 11.7.5.

6.21.3.5 Cylinders installed on portable tar kettles alongside the kettle, on the vehicle frame, or on road surface heating equipment shall be protected from radiant or convected heat from open flame or other burners by the use of a heat shield or by the location of the cylinder(s) on the vehicle. In addition, the following shall apply:

(1) Cylinder valves shall be closed when burners are not in use.
(2) Cylinders shall not be refilled while burners are in use as provided in 7.2.3.2(B).

6.21.4 Installation of Container Appurtenances.

6.21.4.1 Container appurtenances shall be installed in accordance with the following:

(1) Pressure relief valve installation on ASME containers installed in the interior of vehicles complying with Section 11.8 shall comply with 11.7.5.

(2) Pressure relief valve installations on ASME containers installed on the outside of vehicles shall comply with 11.7.5 and 6.21.3.3.
(3) Main shutoff valves on containers for liquid and vapor shall be readily accessible.
(4) Cylinders shall be designed to be filled in either the vertical or horizontal position, or if they are the universal type, they are permitted to be filled in either position.
(5) All container inlets, outlets, or valves installed in container inlets or outlets, except pressure relief devices and gauging devices, shall be labeled to designate whether they communicate with the vapor or liquid space.
(6) Containers from which only vapor is to be withdrawn shall be installed and equipped with connections to minimize the possibility of the accidental withdrawal of liquid.

6.21.4.2 Regulators shall be installed in accordance with 6.7.2 and 6.21.4.2(A) through 6.21.4.2(E).

(A) Regulators shall be installed with the pressure relief vent opening pointing vertically downward to allow for drainage of moisture collected on the diaphragm of the regulator.

(B) Regulators not installed in compartments shall be equipped with a durable cover designed to protect the regulator vent opening from sleet, snow, freezing rain, ice, mud, and wheel spray.

(C) If vehicle-mounted regulators are installed at or below the floor level, they shall be installed in a compartment that provides protection against the weather and wheel spray.

(D) Regulator compartments shall comply with the following:

(1) The compartment shall be of sufficient size to allow tool operation for connection to and replacement of the regulators(s).
(2) The compartment shall be vaportight to the interior of the vehicle.
(3) The compartment shall have a 1-in.^{2} (650-mm^2) minimum vent opening to the exterior located within 1 in. (25 mm) of the bottom of the compartment.
(4) The compartment shall not contain flame or spark-producing equipment.

(E) A regulator vent outlet shall be at least 2 in. (51 mm) above the compartment vent opening.

6.21.5 Piping.

6.21.5.1 Piping shall be installed in accordance with 6.8.3 and 6.21.5.1(A) through 6.21.5.1(M).

(A) Steel tubing shall have a minimum wall thickness of 0.049 in. (1.2 mm).

(B) A flexible connector shall be installed between the regulator outlet and the piping system to protect against expansion, contraction, jarring, and vibration strains.

(C) Flexibility shall be provided in the piping between a cylinder and the gas piping system or regulator.

(D) Flexible connectors shall be installed in accordance with 6.8.7.

(E) Flexible connectors of more than 36 in. (0.9 m) overall length, or fuel lines that incorporate hose, shall be used only with the approval of the authority having jurisdiction.

(F) The piping system shall be designed, installed, supported, and secured to minimize the possibility of damage due to vibration, strains, or wear and to preclude any loosening while in transit.

(G) Piping shall be installed in a protected location.

(H) Where piping is installed outside the vehicle, it shall be installed as follows:

(1) Piping shall be under the vehicle and below any insulation or false bottom.
(2) Fastening or other protection shall be installed to prevent damage due to vibration or abrasion.
(3) At each point where piping passes through sheet metal or a structural member, a rubber grommet or equivalent protection shall be installed to prevent chafing.

(I) Gas piping shall be installed to enter the vehicle through the floor directly beneath or adjacent to the appliance served.

(J) If a branch line is installed, the tee connection shall be located in the main gas line under the floor and outside the vehicle.

(K) Exposed parts of the piping system either shall be of corrosion-resistant material or shall be coated or protected to minimize exterior corrosion.

(L) Hydrostatic relief valves shall be installed in isolated sections of liquid piping as provided in Section 6.11.

(M) Piping systems, including hose, shall be pressure tested and proven free of leaks in accordance with Section 6.12.

6.21.5.2 There shall be no fuel connection between a tractor and trailer or other vehicle units.

6.21.6 Equipment Installation. Equipment shall be installed in accordance with Section 6.15 and 6.21.6.1 and 6.21.6.2.

6.21.6.1 Installation shall be made in accordance with the manufacturer's recommendations and, in the case of approved equipment, as provided in the approval.

6.21.6.2 Equipment installed on vehicles shall be protected against vehicular damage as provided for container appurtenances and connections in 6.21.3.4(C).

6.21.7 Appliance Installation.

6.21.7.1 Subsection 6.21.7 shall apply to the installation of all appliances on vehicles. It shall not apply to engines.

6.21.7.2 All appliances covered by this subsection installed on vehicles shall be approved.

6.21.7.3 Where the device or appliance is designed to be in operation while the vehicle is in transit, such as a cargo heater or cooler, means to stop the flow of gas in the event of a line break, such as an excess-flow valve, shall be installed.

6.21.7.4 All gas-fired heating appliances shall be equipped with safety shutoffs in accordance with 5.18.7(A) except those covered in 6.18.2.8(2).

6.21.7.5 Gas-fired heating appliances, other than ranges and illuminating appliances installed on vehicles intended for human occupancy, shall be designed or installed to provide for a complete separation of the combustion system from the atmosphere inside the vehicle.

6.21.7.6* Where unvented type heaters that are designed to protect cargo are used on vehicles not intended for human occupancy, provisions shall be made to provide air from the outside for combustion and dispose of the products of combustion to the outside.

6.21.7.7 Appliances installed in the cargo space of a vehicle shall be readily accessible whether the vehicle is loaded or empty.

6.21.7.8 Appliances shall be constructed or otherwise protected to minimize possible damage or impaired operation due to cargo shifting or handling.

6.21.7.9 Appliances shall be located so that a fire at any appliance will not block egress of persons from the vehicle.

6.21.7.10 A permanent caution plate shall be provided, affixed to either the appliance or the vehicle outside of any enclosure and adjacent to the container(s), and shall include the following items:

CAUTION

(1) Be sure all appliance valves are closed before opening container valve.
(2) Connections at the appliances, regulators, and containers shall be checked periodically for leaks with soapy water or its equivalent.
(3) Never use a match or flame to check for leaks.
(4) Container valves shall be closed when equipment is not in use.

6.21.8 General Precautions. Mobile units containing hotplates and other cooking equipment, including mobile kitchens and catering vehicles, shall be provided with at least one approved portable fire extinguisher rated in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*, at not less than 10-B:C. Where fire extinguishers have more than one letter classification, they can be considered to satisfy the requirements of each letter class.

6.21.9 Parking, Servicing, and Repair.

6.21.9.1 Vehicles with LP-Gas fuel systems mounted on them for purposes other than propulsion shall be permitted to be parked, serviced, or repaired inside buildings in accordance with the following:

(1) The fuel system shall be leak-free, and the container(s) shall not be filled beyond the limits specified in Chapter 7.
(2) The container shutoff valve shall be closed, except that the container shutoff valve shall not be required to be closed when fuel is required for test or repair.
(3) The vehicle shall not be parked near sources of heat, open flames, or similar sources of ignition, or near unventilated pits.

6.21.9.2 Vehicles having containers with water capacities larger than 300 gal (1.1 m^3) shall comply with the requirements of Section 9.7.

6.22 Vehicle Fuel Dispenser and Dispensing Stations.

6.22.1 Application.

6.22.1.1 Section 6.22 includes location, installation, and operation of vehicle fuel dispensers and dispensing stations.

6.22.1.2 The provisions of Sections 6.2 and 6.3, as modified by Section 6.22, shall apply.

6.22.2 Location.

6.22.2.1 Location of vehicle fuel dispensers and dispensing stations shall be in accordance with Table 6.5.3.

6.22.2.2 Vehicle fuel dispensers and dispensing stations shall be located away from pits in accordance with Table 6.5.3 with no drains or blow-offs from the unit directed toward or within 15 ft (4.6 m) of a sewer system's opening.

6.22.3 General Installation Provisions.

6.22.3.1 Vehicle fuel dispensers and dispensing stations shall be installed in accordance with the manufacturer's installation instructions.

6.22.3.2 Vehicle fuel dispensers and dispensing stations shall not be located within a building, except as allowed in Chapter 10.

6.22.3.3 Where a vehicle fuel dispenser is installed under a weather shelter or canopy, the area shall be ventilated and shall not be enclosed for more than 50 percent of its perimeter.

6.22.3.4 Control for the pump used to transfer LP-Gas through the unit into containers shall be provided at the device in order to minimize the possibility of leakage or accidental discharge.

6.22.3.5 An excess-flow check valve or a differential back pressure valve shall be installed in or on the dispenser at the point at which the dispenser hose is connected to the liquid piping.

6.22.3.6 Piping and the dispensing hose shall be provided with hydrostatic relief valves in accordance with Section 6.11.

6.22.3.7 Protection against trespassing and tampering shall be in accordance with 6.16.5.

6.22.3.8 A manual shutoff valve and an excess-flow check valve shall be located in the liquid line between the pump and dispenser inlet where the dispensing device is installed at a remote location and is not part of a complete storage and dispensing unit mounted on a common base.

6.22.3.9 All dispensers either shall be installed on a concrete foundation or shall be part of a complete storage and dispensing unit mounted on a common base and installed in accordance with 6.6.3.1(G). Protection against physical damage shall be provided for dispensers.

6.22.3.10 A listed quick-acting shutoff valve shall be installed at the discharge end of the transfer hose.

6.22.3.11 An identified and accessible switch or circuit breaker shall be installed at a location not less than 20 ft (6.1 m) or more than 100 ft (30.5 m) from the dispensing device(s) to shut off the power in the event of a fire, accident, or other emergency.

6.22.3.12 The markings for the switches or breakers shall be visible at the point of liquid transfer.

6.22.4 Installation of Vehicle Fuel Dispensers.

6.22.4.1 Hoses shall comply with the following:

(1) Hose length shall not exceed 18 ft (5.5 m) unless approved by the authority having jurisdiction.
(2) All hoses shall be listed.
(3) When not in use, hoses shall be secured to protect them from damage.

6.22.4.2 A listed emergency breakaway device complying with UL 567, *Standard Pipe Connectors for Flammable and Combustible Liquids and LP-Gas,* and designed to retain liquid on both sides of the breakaway point, or other devices affording equivalent protection approved by the authority having jurisdiction, shall be installed.

6.22.4.3 Dispensing devices for LP-Gas shall be located as follows:

(1) Conventional systems shall be at least 10 ft (3.0 m) from any dispensing device for Class I liquids.

(2) Low-emission transfer systems in accordance with Section 6.24 shall be at least 5 ft (1.5 m) from any dispensing device for Class I liquids.

6.23 Fire Protection.

6.23.1 Application. Section 6.23 applies to fire protection for LP-Gas facilities.

6.23.2* Planning.

6.23.2.1 The planning for the response to incidents including the inadvertent release of LP-Gas, fire, or security breach shall be coordinated with local emergency response agencies.

6.23.2.2 Planning shall include consideration of the safety of emergency personnel, workers, and the public.

6.23.3* Protection of ASME Containers.

6.23.3.1 Fire protection shall be provided for installations with an aggregate water capacity of more than 4000 gal (15.1 m^3) and of ASME containers on roofs.

6.23.3.2 The modes of fire protection shall be specified in a written product release prevention and incident preparedness review.

6.23.3.3 The review shall be submitted by the owner, operator, or their designee to the authority having jurisdiction and local emergency responders.

6.23.3.4 The review shall be updated when storage capacity or transfer system is modified.

6.23.3.5 A review shall be an evaluation of the total product control system, such as the emergency shutoff and internal valves equipped for remote closure and automatic shutoff using thermal (fire) actuation pullaway protection, where installed, and the optional requirements of Section 6.24.

6.23.3.6 Where a written fire safety analysis exists, an incident prevention review shall not be required.

6.23.3.7 If in the preparation of the incident prevention review it is determined that a hazard to adjacent structures exists that exceeds the protection provided by the provisions of the code, special protection shall be provided in accordance with 6.23.5.

6.23.4 Other Protection Requirements.

6.23.4.1 Roadways or other means of access for emergency equipment, such as fire department apparatus, shall be provided.

6.23.4.2 Each industrial plant, bulk plant, and distributing point shall be provided with at least one approved portable fire extinguisher having a minimum capacity of 18 lb (8.2 kg) of dry chemical with a B:C rating. Where fire extinguishers have more than one letter classification, they can be considered to satisfy the requirements of each letter class.

6.23.4.3* LP-Gas fires shall not be extinguished until the source of the burning gas has been shut off.

6.23.4.4 Emergency controls shall be conspicuously marked, and the controls shall be located so as to be readily accessible in emergencies.

6.23.5 Special Protection.

6.23.5.1* If insulation is used, it shall be capable of limiting the container temperature to not over 800°F (427°C) for a minimum of 50 minutes as determined by test with insulation applied to a steel plate and subjected to a test flame substantially over the area of the test plate.

6.23.5.2 The insulation system shall be inherently resistant to weathering and the action of hose streams.

6.23.5.3 If mounding is utilized, the provisions of 6.6.6.3 shall be required.

6.23.5.4 If burial is utilized, the provisions of 6.6.6.1 shall be required.

6.23.6 Water Spray Systems.

6.23.6.1 If water spray fixed systems and monitors are used, they shall comply with NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection.*

6.23.6.2 Where water spray fixed systems and monitors are used, they shall be automatically actuated by fire responsive devices and shall also have a capability for manual actuation.

6.23.6.3 Where monitor nozzles are used, they shall be located and arranged so that all container surfaces that can be exposed to fire shall be wetted.

6.24 Alternate Provisions for Installation of ASME Containers.

6.24.1 Scope. Section 6.24 applies to alternate provisions for the location and installation of underground and mounded ASME containers that incorporate the use of redundant fail-safe product control measures and low emission transfer concepts for the purpose of enhancing safety and to mitigate distance and special protection requirements.

6.24.2 Spacing Requirements.

6.24.2.1 Where all the provisions of Section 6.24 are complied with, the minimum distances from important buildings and the line of adjoining property that can be built upon to underground and mounded ASME containers of 2001 gal through 30,000 gal (7.6 m^3 through 114 m^3) water capacity shall be reduced to 10 ft (3.0 m).

6.24.2.2 Distances for all underground and mounded ASME containers shall be measured from the container surface.

6.24.2.3 No part of an underground ASME container shall be less than 10 ft (3 m) from a building or line of adjoining property that can be built upon, and no part of a mounded ASME container that is installed above grade shall be less than 5 ft (1.5 m) from a building or line of adjoining property that can be built upon.

6.24.3 ASME Container Appurtenances. The provisions in 6.24.3.1 through 6.24.3.5 shall be required for ASME containers of 2001 gal through 30,000 gal (7.6 m^3 through 114 m^3) water capacity referenced in Section 6.24.

6.24.3.1 All liquid withdrawal openings and all vapor withdrawal openings that are 1¼ in. (3.2 cm) or larger shall be equipped with an internal valve.

6.24.3.2 The internal valves shall remain closed except during periods of operation.

6.24.3.3 Internal valves shall be equipped for remote closure and automatic shutoff through thermal (fire) actuation.

6.24.3.4 A positive manual shutoff valve shall be installed as close as practical to each internal valve.

6.24.3.5 All liquid and vapor inlet openings shall be equipped in accordance with 6.23.1 through 6.23.3.4 or shall be equipped with a backflow check valve that is designed for the intended application and a positive manual shutoff valve installed as close as practical to the backflow check valve.

6.24.4 Redundant Fail-Safe Product Control.

6.24.4.1 At cargo tank vehicle and railroad tank car transfer points, protection shall be provided in accordance with Section 6.10 using approved emergency shutoff valves or backflow check valves or a combination of the two.

6.24.4.2 Automatic system shutdown of all primary valves (internal valves and emergency shutoff valves) shall be provided through thermal (fire) actuation and in the event of a hose pull-away.

6.24.4.3 Remote shutdown capability, including power supply for the transfer equipment and all primary valves (internal and emergency shutoff), shall be provided.

(A) A remote shutdown station shall be installed within 15 ft (4.6 m) of the point of transfer.

(B) At least one additional remote shutdown station shall be installed not less than 25 ft (7.6 m) or more than 100 ft (30.5 m) from the transfer point.

(C) Emergency remote shutdown stations shall be identified as such by a sign incorporating the words "Propane" and "Emergency Shutoff" in block letters of not less than 2 in. (5.1 cm) in height on a background of contrasting color to the letters. The sign shall be visible from the point of transfer.

6.24.5 Low Emission Transfer. The transfer distance requirements of Table 6.5.3 and 6.22.4.3 shall be reduced by one-half where the installation is in accordance with 6.24.5.

6.24.5.1 Transfer into ASME containers on vehicles shall meet the provisions of 6.24.5.1(A) through 6.24.5.1(D).

(A) The delivery valve and nozzle combination shall mate with the filler valve in the receiving container in such a manner that, when they are uncoupled following a transfer of product, not more than 4 cc (0.24 in.^{3}) of product (liquid equivalent) is released to the atmosphere.

(B) Fixed maximum liquid level gauges shall not be used to determine the maximum permitted filling limit at a low emission transfer site.

(C) The maximum permitted filling limit shall be determined by an overfilling prevention device or other approved means.

(D) Where fixed maximum liquid level gauges are installed, a label shall be placed near the gauge providing the following instructions: "Do not use this fixed maximum liquid level gauge at low emission transfer stations."

6.24.5.2 Transfer into stationary ASME containers shall meet the provisions of 6.24.5.2(A) through 6.24.5.2(F).

(A) Where transfer is made through a hose of nominal 1-in. (2.5-cm) size or smaller, the delivery valve and nozzle combination shall not contain an interstitial volume greater than 4 cc (0.24 in.^{3}).

(B) Where transfer is made through hose larger than 1 in. (2.5 cm) nominal size, no more than 15 cc (0.91 in.^{3}) of LP-Gas (liquid equivalent) shall be released to the atmosphere during the transfer operation including the uncoupling of the transfer hose.

(C) Fixed maximum liquid level gauges on low emission transfer systems shall be installed and used to verify the (function) accuracy of liquid level gauges or other liquid level gauging devices.

(D) Fixed maximum liquid level gauges shall not be used in the routine filling of low emission transfer systems.

(E) The use of a float gauge or other approved nonventing device for containers of 2001 gal (7.6 m^3) or larger water capacity shall be the only means for determining the maximum filling limit.

(F) The maximum filling limit for containers of less than 2001 gal (7.6 m^3) water capacity in low emission transfer systems shall be controlled through the use of an overfilling prevention device or other device approved for this service.

Chapter 7 LP-Gas Liquid Transfer

7.1* Scope.

7.1.1 This chapter applies to transfers of liquid LP-Gas from one container to another wherever this transfer involves connections and disconnections in the transfer system or the venting of LP-Gas to the atmosphere.

7.1.2 This chapter also applies to operational safety and methods for determining the quantity of LP-Gas permitted in containers.

7.2 Operational Safety.

7.2.1 Transfer Personnel.

7.2.1.1 Transfer operations shall be conducted by qualified personnel meeting the provisions of Section 4.4.

7.2.1.2 At least one qualified person shall remain in attendance at the transfer operation from the time connections are made until the transfer is completed, shutoff valves are closed, and lines are disconnected.

7.2.1.3 Transfer personnel shall exercise precaution to ensure that the LP-Gases transferred are those for which the transfer system and the containers to be filled are designed.

7.2.2 Filling and Evacuating Containers.

7.2.2.1 Transfer of LP-Gas to and from a container shall be accomplished only by qualified persons trained in proper handling and operating procedures meeting the requirements of Section 4.4 and in emergency response procedures.

7.2.2.2 When noncompliance with Section 5.2 and Section 5.7 is found, the container owner and user shall be notified in writing.

7.2.2.3 Injection of compressed air, oxygen, or any oxidizing gas into containers to transfer LP-Gas liquid shall be prohibited.

7.2.2.4 When evacuating a container owned by others, the qualified person(s) performing the transfer shall not inject any material other than LP-Gas into the container.

7.2.2.5 Valve outlets on cylinders of 108 lb (49 kg) water capacity [nominal 45 lb (20 kg) propane capacity] or less shall be equipped with an effective seal such as a plug, cap, listed quick-closing coupling, or a listed quick-connect coupling.

7.2.2.6 Valve outlet seals shall be in place whenever the cylinder is not connected for use.

7.2.2.7 Nonrefillable (disposable) and new unused cylinders shall not be required to be equipped with valve outlet seals.

7.2.2.8 Containers shall be filled only after determination that they comply with the design, fabrication, inspection, marking, and requalification provisions of this code.

7.2.2.9 "Single trip," "nonrefillable," or "disposable" cylinders shall not be refilled with LP-Gas.

7.2.2.10 Containers shall comply with the following with regard to service or design pressure requirements:

(1) The service pressure marked on the cylinder shall be not less than 80 percent of the vapor pressure of the LP-Gas for which the cylinder is designed at 130°F (54.4°C).
(2) The minimum design pressure for ASME containers shall be in accordance with Table 5.2.4.2.

7.2.2.11 Transfer of refrigerated product shall be made only into systems that are designed to accept refrigerated product.

7.2.2.12 A container shall not be filled if the container assembly does not meet the requirements for continued service.

7.2.2.13 Transfer hoses larger than ½-in. (12-mm) internal diameter shall not be used for making connections to individual cylinders being filled indoors.

7.2.3 Arrangement and Operation of Transfer Systems.

7.2.3.1 Public access to areas where LP-Gas is stored and transferred shall be prohibited except where necessary for the conduct of normal business activities.

7.2.3.2 Sources of ignition shall be turned off during transfer operations, while connections or disconnections are made, or while LP-Gas is being vented to the atmosphere.

(A) Internal combustion engines within 15 ft (4.6 m) of a point of transfer shall be shut down while such transfer operations are in progress, with the exception of the following:

(1) Engines of LP-Gas cargo tank vehicles constructed and operated in compliance with Chapter 9 while such engines are driving transfer pumps or compressors on these vehicles to load containers in accordance with 6.5.4
(2) Engines installed in buildings as provided in Section 11.12

(B) Smoking, open flame, portable electrical tools, and extension lights capable of igniting LP-Gas shall not be permitted within 25 ft (7.6 m) of a point of transfer while filling operations are in progress.

(C) Metal cutting, grinding, oxygen–fuel gas cutting, brazing, soldering, or welding shall not be permitted within 35 ft (10.7 m) of a point of transfer while filling operations are in progress.

(D) Materials that have been heated above the ignition temperature of LP-Gas shall be cooled before that transfer is started.

(E) Sources of ignition shall be turned off during the filling of any LP-Gas container on the vehicle.

7.2.3.3 Cargo tank vehicles unloading into storage containers shall be at least 10 ft (3.0 m) from the container and so positioned that the shutoff valves on both the truck and the container are readily accessible.

7.2.3.4 The cargo tank vehicle shall not transfer LP-Gas into dispensing station storage while parked on a public way.

7.2.3.5 Transfers to containers serving agricultural or industrial equipment requiring refueling in the field shall comply with 7.2.3.5(A) and 7.2.3.5(B).

(A)* Where the intake of air-moving equipment is less than 50 ft (15 m) from a point of transfer, it shall be shut down while containers are being refilled.

(B) Equipment employing open flames or equipment with integral containers shall be shut down while refueling.

7.2.3.6 During the time railroad tank cars are on sidings for loading or unloading, the following shall apply:

(1) A caution sign, with wording such as "STOP. TANK CAR CONNECTED" shall be placed at the active end(s) of the siding while the car is connected as required by DOT regulations.
(2) Wheel chocks shall be placed to prevent movement of the car in either direction.

7.2.3.7 Where a hose or swivel-type piping is used for loading or unloading railroad tank cars, it shall be protected as follows:

(1) An emergency shutoff valve shall be installed at the railroad tank car end of the hose or swivel-type piping where flow into or out of the railroad tank car is possible.
(2) An emergency shutoff valve or a backflow check valve shall be installed on the railroad tank car end of the hose or swivel piping where flow is only into the railroad tank car.

7.2.3.8 Where cargo tank vehicles are filled directly from railroad tank cars on a private track with nonstationary storage tanks involved, the following requirements shall be met:

(1) Transfer protection shall be provided in accordance with Section 6.10.
(2) Ignition source control shall be in accordance with Section 6.20.
(3) Control of ignition sources during transfer shall be provided in accordance with 7.2.3.2.
(4) Fire extinguishers shall be provided in accordance with 6.23.4.2.
(5) Transfer personnel shall meet the provisions of 7.2.1.
(6) Cargo tank vehicles shall meet the requirements of 7.2.3.
(7) The points of transfer shall be located in accordance with Table 6.5.3 with respect to exposures.
(8) Provision for anchorage and breakaway shall be provided on the cargo tank vehicle side for transfer from a railroad tank car directly into a cargo tank vehicle.

7.2.4 Hose Inspection.

7.2.4.1 Hose assemblies shall be observed for leakage or for damage that could impair their integrity before each use.

7.2.4.2 These hose assemblies shall be inspected at least annually.

7.2.4.3 Inspection of pressurized hose assemblies shall include the following:

(1) Damage to outer cover that exposes reinforcement
(2) Kinked or flattened hose
(3) Soft spots or bulges in hose
(4) Couplings that have slipped on the hose, are damaged, have missing parts, or have loose bolts
(5) Leakage other than permeability leakage

7.2.4.4 Hose assemblies shall be replaced, repaired, or continued in service based on the results of this inspection.

7.2.4.5 Leaking or damaged hose shall be immediately repaired or removed from service.

7.3 Venting LP-Gas to the Atmosphere.

7.3.1 General. LP-Gas in either liquid or vapor form shall not be vented to the atmosphere unless it is vented under the following conditions:

(1) Venting of LP-Gas shall be permitted where the maximum flow from fixed liquid level, rotary, or slip tube gauges does not exceed that from a No. 54 drill orifice.

(2) Venting of LP-Gas between shutoff valves before disconnecting the liquid transfer line from the container shall be permitted.
(3) Venting of LP-Gas, where necessary, shall be permitted to be performed by the use of bleeder valves.
(4) Venting of LP-Gas shall be permitted for the purposes described in 7.3.1(1) and 7.3.1(2) within structures designed for container filling in accordance with Chapter 10.
(5) Venting of LP-Gas listed liquid transfer pumps using such vapor as a source of energy shall be permitted where the rate of discharge does not exceed the discharge from a No. 31 drill size orifice.
(6) Venting of LP-Gas for purging in accordance with 7.3.2 shall be permitted.
(7) Venting of LP-Gas shall be permitted for emergencies.
(8) Venting of LP-Gas vapor utilized as the pressure source in remote shutdown systems for internal valves and emergency shutoff valves shall be permitted.

7.3.2 Purging.

7.3.2.1 Venting of gas from containers for purging or for other purposes shall be accomplished in accordance with 7.3.2.2 through 7.3.2.4.

7.3.2.2 Venting of cylinder indoors shall only occur in structures designed and constructed for cylinder filling in accordance with 6.5.1 and Chapter 10 and with 7.3.2.2(A) through 7.3.2.2(C):

(A) Piping shall be installed to convey the vented product outdoors at least 3 ft (1 m) above the highest point of any building within 25 ft (7.6 m).

(B) Only vapors shall be exhausted to the atmosphere.

(C) If a vent manifold is used to allow for the venting of more than one cylinder at a time, each connection to the vent manifold shall be equipped with a backflow check valve.

7.3.2.3 Venting of containers outdoors shall be performed under conditions that result in rapid dispersion of the product being released.

7.3.2.4 If conditions are such that venting into the atmosphere cannot be accomplished safely, LP-Gas shall be burned at least a distance of 25 ft (7.6 m) from combustibles.

7.4 Quantity of LP-Gas in Containers.

7.4.1 Application. Section 7.4 applies to the maximum permissible LP-Gas content of containers and the methods of verifying this quantity. *(See Annex F.)*

7.4.2 LP-Gas Capacity of Containers.

7.4.2.1 The capacity of an LP-Gas container shall be determined either by weight in accordance with 7.4.2.2 or by volume in accordance with 7.4.2.3.

7.4.2.2* The maximum filling limit by weight of LP-Gas in a container shall be in accordance with Table 7.4.2.2.

7.4.2.3* The maximum permitted volume of LP-Gas in a container shall be in accordance with Table 7.4.2.3(a), Table 7.4.2.3(b), and Table 7.4.2.3(c).

7.4.3 General Provisions for the Volumetric Method of Filling Containers.

7.4.3.1 The volumetric method shall be limited to the following containers that are designed and equipped for filling by volume:

Table 7.4.2.2 Maximum Filling Limit by Weight of LP-Gas Containers (Percent of Marked Water Capacity in Pounds)

	Aboveground Containers		
Specific Gravity at 60°F (15.6°C)	0 to 1200 U.S. gal (0 to 4.5 m^3) Total Water Capacities, %	Over 1200 U.S. gal (over 4.5 m^3) Total Water Capacities, %	Underground Containers All Capacities, %
0.496–0.503	41	44	45
0.504–0.510	42	45	46
0.511–0.519	43	46	47
0.520–0.527	44	47	48
0.528–0.536	45	48	49
0.537–0.544	46	49	50
0.545–0.552	47	50	51
0.553–0.560	48	51	52
0.561–0.568	49	52	53
0.569–0.576	50	53	54
0.577–0.584	51	54	55
0.585–0.592	52	55	56
0.593–0.600	53	56	57

(1) Cylinders of less than 200 lb (91 kg) water capacity that are not subject to DOT jurisdiction
(2) Cylinders of 200 lb (91 kg) water capacity or more
(3) Cargo tanks or portable tanks complying with DOT specifications MC-330, MC-331, or DOT 51
(4) ASME and API-ASME containers complying with 5.2.1.1 or 5.2.4.2

7.4.3.2 Where used, the volumetric method shall be in accordance with 7.4.3.2(A) through 7.4.3.2(C).

(A) If a fixed maximum liquid level gauge or a variable liquid level gauge without liquid volume temperature correction is used, the liquid level indicated by these gauges shall be computed based on the maximum permitted filling limit when the liquid is at 40°F (4°C) for aboveground containers or at 50°F (10°C) for underground containers.

(B) When a variable liquid level gauge is used and the liquid volume is corrected for temperature, the maximum permitted liquid level shall be in accordance with Table 7.4.2.3(a), Table 7.4.2.3(b), and Table 7.4.2.3(c).

(C) ASME containers with a water capacity of 1200 gal (4.54 m^3) or less filled by the volumetric method shall be gauged in accordance with 7.4.3.2(A), utilizing the fixed maximum liquid level gauge, except that containers fabricated on or before December 31, 1965, shall be exempt from this provision.

7.4.3.3 Where containers are to be filled volumetrically by a variable liquid level gauge in accordance with 7.4.3.2(B), provisions shall be made for determining the liquid temperature.

7.4.4* Overfilling.

7.4.4.1 An overfilling prevention device shall not be the primary means to determine when a cylinder is filled to the maximum allowable filling limit.

7.4.4.2 Other means specified in this chapter shall be used to prevent the overfilling of cylinders.

Table 7.4.2.3(a) Maximum Permitted LP-Gas Volume (Percent of Total Container Volume): Aboveground Containers 0 to 1200 gal (0 to 4.5 m³)

Liquid Temperature		Specific Gravity												
°F	°C	0.496 to 0.503	0.504 to 0.510	0.511 to 0.519	0.520 to 0.527	0.528 to 0.536	0.537 to 0.544	0.545 to 0.552	0.553 to 0.560	0.561 to 0.568	0.569 to 0.576	0.577 to 0.584	0.585 to 0.592	0.593 to 0.600
–50	–45.6	70	71	72	73	74	75	75	76	77	78	79	79	80
–45	–42.8	71	72	73	73	74	75	76	77	77	78	79	80	80
–40	–40	71	72	73	74	75	75	76	77	78	79	79	80	81
–35	–37.2	71	72	73	74	75	76	77	77	78	79	80	80	81
–30	–34.4	72	73	74	75	76	76	77	78	78	79	80	81	81
–25	–31.5	72	73	74	75	76	77	77	78	79	80	80	81	82
–20	–28.9	73	74	75	76	76	77	78	79	79	80	81	81	82
–15	–26.1	73	74	75	76	77	77	78	79	80	80	81	82	83
–10	–23.3	74	75	76	76	77	78	79	79	80	81	81	82	83
–5	–20.6	74	75	76	77	78	78	79	80	80	81	82	82	83
0	–17.8	75	76	76	77	78	79	79	80	81	81	82	83	84
5	–15	75	76	77	78	78	79	80	81	81	82	83	83	84
10	–12.2	76	77	77	78	79	80	80	81	82	82	83	84	84
15	–9.4	76	77	78	79	80	80	81	81	82	83	83	84	85
20	–6.7	77	78	78	79	80	80	81	82	83	84	84	84	85
25	–3.9	77	78	79	80	80	81	82	82	83	84	84	85	85
30	–1.1	78	79	79	80	81	81	82	83	83	84	85	85	86
35	1.7	78	79	80	81	81	82	83	83	84	85	85	86	86
40*	4.4	79	80	81	81	82	82	83	84	84	85	86	86	87
45	7.8	80	80	81	82	82	83	84	84	85	85	86	87	87
50	10	80	81	82	82	83	83	84	85	85	86	86	87	88
55	12.8	81	82	82	83	84	84	85	85	86	86	87	87	88
60	15.6	82	82	83	84	84	85	85	86	86	87	87	88	88
65	18.3	82	83	84	84	85	85	86	86	87	87	88	88	89
70	21.1	83	84	84	85	85	86	86	87	87	88	88	89	89
75	23.9	84	85	85	85	86	86	87	87	88	88	89	89	90
80	26.7	85	85	86	86	87	87	87	88	88	89	89	90	90
85	29.4	85	86	87	87	88	88	88	89	89	89	90	90	91
90	32.2	86	87	87	88	88	88	89	89	90	90	90	91	91
95	35	87	88	88	88	89	89	89	90	90	91	91	91	92
100	37.8	88	89	89	89	89	90	90	90	91	91	92	92	92
105	40.4	89	89	90	90	90	90	91	91	91	92	92	92	93
110	43	90	90	91	91	91	91	92	92	92	92	93	93	93
115	46	91	91	92	92	92	92	92	92	93	93	93	94	94
120	49	92	92	93	93	93	93	93	93	93	94	94	94	94
125	51.5	93	94	94	94	94	94	94	94	94	94	94	95	95
130	54	94	95	95	95	95	95	95	95	95	95	95	95	95

*See 7.4.3.2(A).

Table 7.4.2.3(b) Maximum Permitted LP-Gas Volume (Percent of Total Container Volume): Aboveground Containers Over 1200 gal (0 to 4.5 m³)

Liquid Temperature		Specific Gravity												
°F	°C	0.496 to 0.503	0.504 to 0.510	0.511 to 0.519	0.520 to 0.527	0.528 to 0.536	0.537 to 0.544	0.545 to 0.552	0.553 to 0.560	0.561 to 0.568	0.569 to 0.576	0.577 to 0.584	0.585 to 0.592	0.593 to 0.600
–50	–45.6	75	76	77	78	79	80	80	81	82	83	83	84	85
–45	–42.8	76	77	78	78	79	80	81	81	82	83	84	84	85
–40	–40	76	77	78	79	80	80	81	82	83	83	84	85	85
–35	–37.2	77	78	78	79	80	81	82	82	83	84	84	85	86
–30	–34.4	77	78	79	80	80	81	82	83	83	84	85	85	86
–25	–31.5	78	79	79	80	81	82	82	83	84	84	85	86	86
–20	–28.9	78	79	80	81	81	82	83	83	84	85	85	86	87
–15	–26.1	79	79	80	81	82	82	83	84	85	85	86	87	87
–10	–23.3	79	80	81	82	82	83	84	84	85	86	86	87	87
–5	–20.6	80	81	81	82	83	83	84	85	85	86	87	87	88
0	–17.8	80	81	82	82	83	84	84	85	86	86	87	88	88
5	–15	81	82	82	83	84	84	85	86	86	87	87	88	89
10	–12.2	81	82	83	83	84	85	85	86	87	87	88	88	89
15	–9.4	82	83	83	84	85	85	86	87	87	88	88	89	90
20	–6.7	82	83	84	85	85	86	86	87	88	88	89	89	90
25	–3.9	83	84	84	85	86	86	87	88	88	89	89	90	90
30	–1.1	83	84	85	86	86	87	87	88	89	89	90	90	91
35	1.7	84	85	86	86	87	87	88	89	89	90	90	91	91
40*	4.4	85	86	86	87	87	88	88	89	90	90	91	91	92
45	7.8	85	86	87	87	88	88	89	89	90	91	91	92	92
50	10	86	87	87	88	88	89	90	90	91	91	92	92	92
55	12.8	87	88	88	89	89	90	90	91	91	92	92	92	93
60	15.6	88	88	89	89	90	90	91	91	92	92	93	93	93
65	18.3	88	89	90	90	91	91	91	92	92	93	93	93	94
70	21.1	89	90	90	91	91	91	92	92	93	93	94	94	94
75	23.9	90	91	91	91	92	92	92	93	93	94	94	94	95
80	26.7	91	91	92	92	92	93	93	93	94	94	95	95	95
85	29.4	92	92	93	93	93	93	94	94	95	95	95	96	96
90	32.2	93	93	93	94	94	94	95	95	95	95	96	96	96
95	35	94	94	94	95	95	95	95	96	96	96	96	97	97
100	37.8	94	95	95	95	95	96	96	96	96	97	97	97	98
105	40.4	96	96	96	96	96	97	97	97	97	97	98	98	98
110	43	97	97	97	97	97	97	97	98	98	98	98	98	99
115	46	98	98	98	98	98	98	98	98	98	99	99	99	99

*See 7.4.3.2(A).

Table 7.4.2.3(c) Maximum Permitted LP-Gas Volume (Percent of Total Container Volume): All Underground Containers

Liquid Temperature		Specific Gravity												
°F	°C	0.496 to 0.503	0.504 to 0.510	0.511 to 0.519	0.520 to 0.527	0.528 to 0.536	0.537 to 0.544	0.545 to 0.552	0.553 to 0.560	0.561 to 0.568	0.569 to 0.576	0.577 to 0.584	0.585 to 0.592	0.593 to 0.600
–50	–45.6	77	78	79	80	80	81	82	83	83	84	85	85	86
–45	–42.8	77	78	79	80	81	82	82	83	84	84	85	86	87
–40	–40	78	79	80	81	81	82	83	83	84	85	86	86	87
–35	–37.2	78	79	80	81	82	82	83	84	85	85	86	87	87
–30	–34.4	79	80	81	81	82	83	84	84	85	86	86	87	88
–25	–31.5	79	80	81	82	83	83	84	85	85	86	87	87	88
–20	–28.9	80	81	82	82	83	84	84	85	86	86	87	88	88
–15	–26.1	80	81	82	83	84	84	85	86	86	87	87	88	89
–10	–23.3	81	82	83	83	84	85	85	86	87	87	88	88	89
–5	–20.6	81	82	83	84	84	85	86	86	87	88	88	89	89
0	–17.8	82	83	84	84	85	85	86	87	87	88	89	89	90
5	–15	82	83	84	85	85	86	87	87	88	88	89	90	90
10	–12.2	83	84	85	85	86	86	87	88	88	89	90	90	91
15	–9.4	84	84	85	86	86	87	88	88	89	89	90	91	91
20	–6.7	84	85	86	86	87	88	88	89	89	90	90	91	91
25	–3.9	85	86	86	87	87	88	89	89	90	90	91	91	92
30	–1.1	85	86	87	87	88	89	89	90	90	91	91	92	92
35	1.7	86	87	87	88	88	89	90	90	91	91	92	92	93
40	4.4	87	87	88	88	89	90	90	91	91	92	92	93	93
45	7.8	87	88	89	89	90	90	91	91	92	92	93	93	94
50*	10	88	89	89	90	90	91	91	92	92	93	93	94	94
55	12.8	89	89	90	91	91	91	92	92	93	93	94	94	95
60	15.6	90	90	91	91	92	92	92	93	93	94	94	95	95
65	18.3	90	91	91	92	92	93	93	94	94	94	95	95	96
70	21.1	91	91	92	93	93	93	94	94	94	95	95	96	96
75	23.9	92	93	93	93	94	94	94	95	95	95	96	96	97
80	26.7	93	93	94	94	94	95	95	95	96	96	96	97	97
85	29.4	94	94	95	95	95	95	96	96	96	97	97	97	98
90	32.2	95	95	95	95	96	96	96	97	97	97	98	98	98
95	35	96	96	96	96	97	97	97	97	98	98	98	98	99
100	37.8	97	97	97	97	97	98	98	98	98	99	99	99	99
105	40.4	98	98	98	98	98	98	98	99	99	99	99	99	99

*See 7.4.3.2(A).

Chapter 8 Storage of Cylinders Awaiting Use, Resale, or Exchange

8.1 Scope.

8.1.1 The provisions of this chapter apply to the storage of cylinders of 1000 lb (454 kg) water capacity or less, whether filled, partially filled, or empty as follows:

(1) At consumer sites or dispensing stations, where not connected for use
(2) In storage for resale or exchange by dealer or reseller

8.1.2 This chapter does not apply to new or unused cylinders.

8.1.3 This chapter does not apply to cylinders stored at bulk plants.

8.2 General Provisions.

8.2.1 General Location of Cylinders.

8.2.1.1 Cylinders in storage shall be located to minimize exposure to excessive temperature rises, physical damage, or tampering.

8.2.1.2 Cylinders in storage having individual water capacity greater than 2.7 lb (1.1 kg) [nominal 1 lb (0.45 kg) LP-Gas capacity] shall be positioned so that the pressure relief valve is in direct communication with the vapor space of the cylinder.

8.2.1.3 Cylinders stored in buildings in accordance with Section 8.3 shall not be located near exits, stairways, or in areas normally used, or intended to be used, for the safe egress of occupants.

8.2.1.4 If empty cylinders that have been in LP-Gas service are stored indoors, they shall be considered as full cylinders for the purposes of determining the maximum quantities of LP-Gas permitted by 8.3.1, 8.3.2.1, and 8.3.3.1.

8.2.1.5 Cylinders shall not be stored on roofs.

8.2.2 Protection of Valves on Cylinders in Storage.

8.2.2.1 Cylinder valves shall be protected as required by 5.2.6.1 and 7.2.2.5.

8.2.2.2 Screw-on-type caps or collars shall be in place on all cylinders stored, regardless of whether they are full, partially full, or empty, and cylinder outlet valves shall be closed.

8.2.2.3 Valve outlets on cylinders less than 108 lb (49 kg) water capacity [nominal 45 lb (20 kg) propane capacity] shall be plugged, capped, or sealed in accordance with 7.2.2.5.

8.3 Storage Within Buildings.

8.3.1 Storage of cylinders in buildings shall be in accordance with Table 8.3.1(a) or Table 8.3.1(b) or the requirements of Section 8.3.

8.3.2 Storage Within Buildings Frequented by the Public and in Residential Occupancies.

8.3.2.1 The quantity of LP-Gas in cylinders stored or displayed shall not exceed 200 lb (91 kg) in buildings frequented by the public.

8.3.2.2 The cylinders shall not exceed a water capacity of 2.7 lb (1.1 kg) [nominal 1 lb (0.45 kg) LP-Gas].

8.3.2.3 Storage in restaurants and at food service locations of 10 oz (283 g) butane nonrefillable containers shall be limited to no more than 24 containers and an additional twenty-four 10 oz (283 g) butane nonrefillable containers stored in another location within the building where constructed with at least a 2-hour fire wall protection.

8.3.3 Storage Within Buildings Not Frequented by the Public.

8.3.3.1 The maximum quantity of LP-Gas allowed in one storage location shall not exceed 735 lb (334 kg) water capacity [nominal 300 lb (136 kg) LP-Gas capacity].

8.3.3.2 Where additional storage locations are required on the same floor within the same building, they shall be separated by a minimum of 300 ft (91.4 m).

8.3.3.3 Storage beyond the limitations described in 8.3.3.2 shall comply with 8.3.4.

8.3.3.4 Cylinders carried as part of the service equipment on highway mobile vehicles shall not be part of the total storage capacity in the requirements of 8.3.3.1, where such vehicles are stored in private garages and carry no more than three cylinders with a total aggregate capacity per vehicle not exceeding 100 lb (45.4 kg) of LP-Gas.

8.3.3.5 Cylinder valves shall be closed when not in use.

8.3.4 Storage Within Special Buildings or Rooms.

8.3.4.1 The maximum quantity of LP-Gas stored in special buildings or rooms shall be 10,000 lb (4540 kg).

8.3.4.2 Special buildings or rooms for storing LP-Gas cylinders shall not be located where the buildings or rooms adjoin the line of property occupied by schools, churches, hospitals, athletic fields, or other points of public gathering.

8.3.4.3 The construction of all such special buildings and rooms shall comply with Chapter 10 and the following:

(1) Vents to the outside only shall be provided at both the top and bottom of the building and shall be located at least 5 ft (1.5 m) from any building opening.
(2) The entire area shall be classified for purposes of ignition source control in accordance with Section 6.20.

8.3.5 Storage Within Residential Buildings. Storage of cylinders within a residential building, including the basement or any storage area in a common basement storage area in multiple-family buildings and attached garages, shall be limited to cylinders each with a maximum water capacity of 2.7 lb (1.2 kg) and shall not exceed 5.4 lb (2.4 kg) aggregate water capacity for smaller cylinders per each living space unit.

8.4 Storage Outside of Buildings.

8.4.1* Location of Storage Outside of Buildings.

8.4.1.1 Storage outside of buildings for cylinders awaiting use, resale, or part of a cylinder exchange point shall be located as follows:

(1) At least 5 ft (1.5 m) from any doorway or opening in a building frequented by the public where occupants have at least two means of egress as defined by NFPA *101*, *Life Safety Code*
(2) At least 10 ft (3 m) from any doorway or opening in a building or sections of a building that has only one means of egress
(3) At least 20 ft (6.1 m) from any automotive service station fuel dispenser

Table 8.3.1(a) Maximum Allowable Storage Quantities of LP-Gas in Other Than Industrial, Storage, and Mercantile Occupancies

Occupancy	Assembly	Educational	Day Care	Health Care	Ambulatory Health Care	Detention and Correctional	One- and Two-Family Dwellings	Lodging or Rooming House	Hotel and Dormitory	Residential Board and Care	Apartment	Business
Maximum Allowable Quantity:												
Storage (state units: lbs, gals, etc.)	2	2	2	2	2	2	2 lb	2 lb	2	2 lb	2	2
MAQ increases for:							Max 1 lb cylinders			1 lb cyl		
Total incl. cabinets	2	2	2	2	2	2	2 lb	2 lb	2	2	2	2
Total for suppression	2	2	2	2	2	2	2 lb	2 lb	2	2	2	2
Total for both cabinets and suppression	0	2	2	2	2	2	2	2	2	2	2	2
Attended catered food service per 58 in 10 oz max cylinders	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb
			15 lb	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb
Add'l 10 oz cylinders w/2 hr fire wall	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb	15 lb
Other												
Total (including threshold) for other	20 lb	20 lb	0	5 lb								
	Flame effects NFPA 160. Add'l 20 lb units with 20 ft sep.	In labs not in classrooms. Add'l 20 lb units with 20 ft sep.		In labs only. Add'l 5 lb units with 20 ft sep.						Amts. per dwelling		

8.4.1.2 Distances from cylinders in storage outside buildings shall be in accordance with Table 8.4.1.2 with respect to the following:

(1) Nearest important building or group of buildings
(2) Line of adjoining property that can be built upon
(3) Busy thoroughfares or sidewalks
(4) Line of adjoining property occupied by schools, churches, hospitals, athletic fields, or other points of public gathering
(5) Dispensing station

8.4.1.3 Cylinders in the filling process shall not be considered to be in storage.

8.4.2 Protection of Cylinders.

8.4.2.1 Cylinders at a location open to the public shall be protected by either of the following:

(1) An enclosure in accordance with 6.16.5.2
(2) A lockable ventilated metal locker or rack that prevents tampering with valves and pilferage of the cylinders

8.4.2.2* Protection against vehicle impact shall be provided in accordance with good engineering practice where vehicle traffic is expected at the location.

8.4.3 Alternate Location and Protection of Storage. Where the provisions of 8.4.1 and 8.4.2.1 are impractical at construction sites or at buildings or structures undergoing major renovation or repairs, alternate storage of cylinders shall be acceptable to the authority having jurisdiction.

8.5* Fire Protection.

8.5.1 Storage locations, where the aggregate quantity of propane stored is in excess of 720 lb (327 kg), shall be provided with at least one approved portable fire extinguisher having a minimum capacity of 18 lb (9.2 kg) dry chemical with B:C rating.

Table 8.3.1(b) Maximum Allowable Storage Quantities of LP-Gas in Mercantile, Industrial, and Storage Occupancies

Occupancy	Mercantile	Industrial	Storage
Maximum Allowable Quantity: Storage (state units: lbs, gals, etc.)	200 (1 lb max/cyl.)	300	300
MAQ increases for: Total (including threshold) for cabinets	200	300	300
Total (including threshold) for suppression	200	300	300
Total (including threshold) for both cabinets and suppression	200	300	300
Total (including threshold) for other (describe)		Add'l 300 lb	10,000 lb
		300 ft separation	In special rooms or bldgs per Chapter 10

Table 8.4.1.2 Distances from Cylinders in Storage and Exposures

Quantity of LP-Gas Stored		Horizontal Distance to …					
		(1) and (2)		(3) and (4)		(5)	
lb	kg	ft	m	ft	m	ft	m
≤720	≤227	0	0	0	0	5	1.5
721 to 2500	227+ to 1134	0	0	10	3	10	3
2501 to 6000	1134+ to 2721	10	3	10	3	10	3
6001 to 10,000	2721+ to 4540	20	6.1	20	6.1	20	6.1
>10,000	>4540	25	7.6	25	7.6	25	7.6

8.5.2 The required fire extinguisher shall be located no more than 50 ft (15 m) from the storage location. Where fire extinguishers have more than one letter classification, they can be considered to satisfy the requirements of each letter class.

Chapter 9 Vehicular Transportation of LP-Gas

9.1 Scope.

9.1.1 This chapter applies to containers, container appurtenances, piping, valves, equipment, and vehicles used in the transportation of LP-Gas, as follows:

(1) Transportation of cylinders
(2) Transportation in cargo tank vehicles, whether fabricated by mounting cargo tanks on conventional truck or trailer chassis or constructed as integral cargo units in which the container constitutes in whole, or in part, the stress member of the vehicle frame
(3) *Transfer equipment and piping, and the protection of such equipment and the container appurtenances against overturn, collision, or other vehicular accidents

9.1.2 This chapter does not apply to the following:

(1) Cylinders and related equipment incident to their use on vehicles as covered in Section 6.21 and Chapter 11
(2) Vehicles and procedures under the jurisdiction of DOT
(3) The transportation of LP-Gas containers on vehicles where the containers are used to fuel the vehicle or appliances located on the vehicle as covered in Section 6.21, Section 11.14, and Section 11.15
(4) *LP-Gas systems used for engine fuel

9.2 Electrical Requirements. Only electrical lighting shall be used with the vehicles covered by this chapter. Wiring shall be insulated and protected from physical damage.

9.3 Transportation in Portable Containers.

9.3.1 Application. Section 9.3 shall apply to the vehicular transportation of portable containers filled with LP-Gas delivered as "packages," including containers built to DOT cylinder specifications and other portable containers.

9.3.2 Transportation of Cylinders.

9.3.2.1 Cylinders having an individual water capacity not exceeding 1000 lb (454 kg) [nominal 420 lb (191 kg) LP-Gas capacity], when filled with LP-Gas, shall be transported in accordance with the requirements of Section 9.3.

9.3.2.2 Cylinders shall be constructed as provided in Section 5.3 and equipped in accordance with Section 5.3 for transportation as cylinders.

9.3.2.3 The quantity of LP-Gas in cylinders shall be in accordance with Chapter 7.

9.3.2.4 Cylinder valves shall comply with the following:

(1) Valves of cylinders shall be protected in accordance with 5.2.6.1.
(2) Screw-on-type protecting caps or collars shall be secured in place.
(3) The provisions of 7.2.2.5 shall apply.

9.3.2.5 The cargo space of the vehicle shall be isolated from the driver's compartment, the engine, and its exhaust system. Open-bodied vehicles shall be considered to be in compliance with this provision.

(A) Closed-bodied vehicles having separate cargo, driver, and engine compartments shall also be considered to be in compliance with this provision.

(B) Closed-bodied vehicles such as passenger cars, vans, and station wagons shall not be used for transporting more than 215 lb (98 kg) water capacity [nominal 90 lb (41 kg) LP-Gas capacity] but not more than 108 lb (49 kg) water capacity [nominal 45 lb (20 kg) LP-Gas capacity] per cylinder unless the driver and engine compartments are separated from the cargo space by a vaportight partition that contains no means of access to the cargo space.

9.3.2.6 Cylinders and their appurtenances shall be determined to be leak-free before being loaded into vehicles.

9.3.2.7 Cylinders shall be loaded into vehicles with flat floors or equipped with racks for holding cylinders.

9.3.2.8 Cylinders shall be fastened in position to minimize the possibility of movement, tipping, and physical damage.

9.3.2.9 Cylinders being transported by vehicles shall be positioned in accordance with Table 9.3.2.9.

Table 9.3.2.9 Orientation of Cylinders on Vehicles

Propane Capacity of Cylinder			
lb	m^3	Open Vehicles	Enclosed Spaces of Vehicles
≤45	0.17	Any position	
>45	0.17	Relief valve in communication with the vapor space	
≤4.2	0.016		Any position
>4.2	0.016		Relief valve in communication with the vapor space

9.3.2.10 Vehicles transporting cylinders where the total weight is more than 1000 lb (454 kg), including the weight of the LP-Gas and the cylinders, shall be placarded as required by DOT regulations or state law.

9.3.3 Transportation of Portable Containers of More Than 1000 lb (454 kg) Water Capacity.

9.3.3.1 Portable containers having an individual water capacity exceeding 1000 lb (454 kg) [nominal 420 lb (191 kg) LP-Gas capacity] when filled with LP-Gas shall be transported in compliance with the requirements of Section 9.3.

9.3.3.2 Portable containers shall be constructed in accordance with Section 5.7 and equipped in accordance with Section 5.3 for portable use or shall comply with DOT portable tank specifications for LP-Gas service.

9.3.3.3 The quantity of LP-Gas put into portable containers shall be in accordance with Chapter 7.

9.3.3.4 Valves and other portable container appurtenances shall be protected in accordance with 5.2.6.2.

9.3.3.5 Transportation of portable containers and their appurtenances shall be in accordance with the following:

(1) Portable containers and their appurtenances shall be leak-free before being loaded into vehicles.
(2) Portable containers shall be transported in a rack or frame or on a flat surface.
(3) Portable containers shall be fastened in a position to minimize the possibility of movement, tipping, or physical damage, relative to each other or to the supporting structure, while in transit.

9.3.3.6 Portable containers shall be transported with pressure relief devices in communication with the vapor space.

9.3.3.7 Vehicles carrying more than 1000 lb (454 kg), including the weight of the LP-Gas and the portable containers, shall be placarded as required by DOT regulations or state law.

9.3.3.8 Where portable containers complying with the requirements of Section 9.4 are installed permanently or semi-permanently on vehicles to serve as cargo tanks, so that the assembled vehicular unit can be used for making liquid deliveries to other containers at points of use, the provisions of Section 9.3 shall apply.

9.3.4 Transportation of Portable Storage Containers. ASME containers to be used as portable storage containers including movable fuel storage tenders and farm carts for temporary stationary service (normally not more than 12 months duration at any location) when moved shall contain a heel volume of 5 percent or less of the water capacity of the container.

9.3.5 Fire Extinguishers. Each truck or trailer transporting portable containers in accordance with 9.3.2 or 9.3.3 shall be equipped with at least one approved portable fire extinguisher having a minimum capacity of 18 lb (8.2 kg) dry chemical with a B:C rating. Where fire extinguishers have more than one letter classification, they can be considered to satisfy the requirements of each letter class.

9.4 Transportation in Cargo Tank Vehicles.

9.4.1 Application.

9.4.1.1 Section 9.4 applies to cargo tank vehicles used for the transportation of LP-Gas as liquid cargo.

9.4.1.2 Transfer shall be made by a pump or compressor mounted on the vehicle or by a transfer means at the delivery point.

9.4.1.3 All LP-Gas cargo tank vehicles, whether used in interstate or intrastate service, shall comply with the applicable portion of the U.S. Department of Transportation Hazardous Materials Regulations of the DOT Federal Motor Carrier Safety Regulations (49 CFR, Parts 171–180, 393, 396, and 397) and shall also comply with any added requirements of this code.

9.4.2 Cargo Tanks Mounted on, or a Part of, Cargo Tank Vehicles.

9.4.2.1 Cargo tanks mounted on, or comprising in whole or in part, the stress member used in lieu of a frame for cargo tank vehicles shall comply with DOT cargo tank vehicle specifications for LP-Gas service.

9.4.2.2 Such cargo tanks shall also comply with Section 5.7 and be equipped with appurtenances as provided in Section 5.7 for cargo service.

9.4.2.3 Liquid hose of 1½-in. (nominal size) and larger and vapor hose of 1¼-in. (nominal size) and larger shall be protected with an internal valve that complies with 5.10.4(1) and 5.10.4(2).

9.4.2.4 Where flow is only into the cargo tank, a backflow check valve or an internal valve shall be installed in the cargo tank.

9.4.3 Piping (Including Hose), Fittings, and Valves.

9.4.3.1 Pipe, tubing, pipe and tubing fittings, valves, hose, and flexible connectors shall comply with the following:

(1) Section 5.8
(2) The provisions of DOT cargo tank vehicle specifications for LP-Gas
(3) The service pressure rating specified in 5.15.1.2.

9.4.3.2 The following shall also apply to pipe, tubing, pipe and tubing fittings, valves, hose, and flexible connectors:

(1) Pipe shall be wrought iron, steel, brass, or copper in accordance with 5.8.3.1.

(2) Tubing shall be steel, brass, or copper in accordance with 5.8.3.2.
(3) Pipe and tubing fittings shall be steel, brass, copper, malleable iron, or ductile (nodular) iron suitable for use with the pipe or tubing used as specified in 9.4.3.2(1) or 9.4.3.2(2).
(4) Pipe joints shall be threaded, flanged, welded, or brazed, and fittings, where used, shall comply with 9.4.3.2(3).
(5) Where joints are threaded, or threaded and back welded, pipe and nipples shall be Schedule 80 or heavier.
(6) Copper or brass pipe and nipples shall be of equivalent strength as Schedule 80 steel pipe or heavier.
(7) Where joints are welded or brazed, the pipe and nipples shall be Schedule 40 or heavier.
(8) The pressure ratings of fittings or flanges shall comply with Table 5.15.1.2
(9) Brazed joints shall be made with a brazing material having a melting point exceeding 1000°F (538°C).
(10) Tubing joints shall be brazed using a brazing material having a melting point of at least 1000°F (538°C).

9.4.3.3 Pipe, tubing, pipe and tubing fittings, valves, hose, and flexible connectors, and complete cargo tank vehicle piping systems including connections to equipment, after assembly, shall comply with 5.15.1.2.

9.4.3.4 Valves, including shutoff valves, excess-flow valves, backflow check valves, and remotely controlled valves, used in piping shall comply with the following:

(1) DOT cargo tank vehicle specifications for LP-Gas service
(2) Section 5.10
(3) The pressure rating requirements of 5.15.1.2

9.4.3.5* Hose, hose connections, and flexible connectors shall comply with 5.8.6 and 9.4.3.1.

9.4.3.6 Flexible connectors used in the piping system to compensate for stresses and vibration shall be limited to 3 ft (1 m) in overall length and when replaced shall comply with 5.8.4.

9.4.3.7 Flexible connectors shall comply with the following:

(1) Flexible connectors assembled from rubber hose and couplings shall be permanently marked to indicate the date of installation of the flexible connector.
(2) The flexible portion of the connector shall be replaced with an unused connector within 10 years of the indicated date of installation of the connector and visually inspected before the first delivery of each day.
(3) The rubber hose portion of flexible connectors shall be replaced whenever a cargo unit is remounted on a different chassis, or whenever the cargo unit is repiped if such repiping encompasses that portion of piping in which the connector is located.
(4) Replacement shall not be required if the reinstallation or repiping is performed within 1 year of the date of assembly of the connector.

9.4.3.8 All threaded primary valves and fittings used in liquid filling or vapor equalization directly on the cargo tank of transportation equipment shall be of steel, malleable iron, or ductile iron construction.

9.4.3.9 All existing equipment shall be so equipped as described in 9.4.3.8 not later than the scheduled requalification date of the container.

9.4.4 Equipment.

9.4.4.1 LP-Gas equipment, such as pumps, compressors, meters, dispensers, regulators, and strainers, shall comply with Section 5.5 for design and construction and shall be installed in accordance with the applicable provisions of Section 6.15.

9.4.4.2 Equipment on cargo tank vehicles shall be mounted in place and connected to the piping system in accordance with the manufacturer's instructions.

9.4.4.3 Cargo tank openings whose only function is for pump bypass return shall be provided with one of the following:

(1) A positive shutoff valve capable of being secured in the open position located as close to the tank as practical in combination with a steel backflow check valve installed in the tank
(2) An internal valve with excess flow protection
(3) A valve that is specifically recommended and listed by the manufacturer for bypass return service and that meets the requirements of 6.15.2.1

9.4.4.4 Where an electric drive is used to power pumps or compressors mounted on vehicles and the energy is obtained from the electrical installation at the delivery point, the installation on the vehicle shall comply with 6.20.2.1.

9.4.4.5 Where wet hose is carried while connected to the truck's liquid pump discharge piping, an automatic device, such as a differential regulator, shall be installed between the pump discharge and the hose connection to prevent liquid discharge while the pump is not operating.

(A) Where a meter or dispenser is used, this device shall be installed between the meter outlet and the hose connection.

(B) If an excess-flow valve is used, it shall not be the exclusive means of complying with the provision of 9.4.4.5.

9.4.5 Protection of Cargo Tank Appurtenances, Piping System, and Equipment. Cargo tank appurtenances, piping, and equipment comprising the complete LP-Gas system on the cargo tank vehicle shall be mounted in position *(see 9.4.2.1 for container mounting),* shall be protected against damage, and shall be in accordance with DOT regulations.

9.4.6 Painting and Marking Cargo Tank Vehicles.

9.4.6.1 Painting of cargo tank vehicles shall comply with 49 CFR, Part 195.

9.4.6.2 Placarding and marking shall comply with 49 CFR.

9.4.7* Fire Extinguishers. Each cargo tank vehicle or tractor shall be provided with at least one approved portable fire extinguisher having a minimum capacity of 18 lb (8.2 kg) dry chemical with a B:C rating. Where fire extinguishers have more than one letter classification, they can be considered to satisfy the requirements of each letter class.

9.4.8 Chock Blocks for Cargo Tank Vehicles. Each cargo tank vehicle and trailer shall carry chock blocks, which shall be used to prevent rolling of the vehicle whenever it is being loaded or unloaded or is parked.

9.4.9 Exhaust Systems. The truck engine exhaust system shall comply with Federal Motor Carrier Safety Regulations.

9.4.10 Smoking Prohibition. No person shall smoke or carry lighted smoking material as follows:

(1) On or within 25 ft (7.6 m) of a vehicle that is containing LP-Gas liquid or vapor
(2) At points of liquid transfer
(3) When delivering or connecting to containers

9.5 Trailers, Semitrailers, and Movable Fuel Storage Tenders, Including Farm Carts.

9.5.1 Application. Section 9.5 applies to all cargo tank vehicles, other than trucks, that are parked at locations other than bulk plants.

9.5.2 Fuel Storage Tenders Including Farm Carts.

9.5.2.1 Movable fuel storage tenders including farm carts *(see 3.3.44, Movable Fuel Storage Tender)* shall comply with Section 9.5.

9.5.2.2 Where used over public ways, movable fuel storage tenders shall comply with applicable state regulations.

9.5.2.3 Movable fuel storage tenders shall be constructed in accordance with Section 5.2 and equipped with appurtenances as provided in Section 5.7.

9.5.2.4 Threaded piping shall be not less than Schedule 80, and fittings shall be designed for not less than 250 psig (1.7 MPag).

9.5.2.5 Piping, hoses, and equipment, including valves, fittings, pressure relief valves, and container accessories, shall be protected against collision or upset.

9.5.2.6 Movable fuel storage tenders shall comply with the following:

(1) Movable fuel storage tenders shall be so positioned that container pressure relief valves communicate with the vapor space.
(2) Movable fuel storage tenders shall not be filled on a public way.
(3) Movable fuel storage tenders shall contain no more than 5 percent of their water capacity in liquid form during transportation to or from the bulk plant.
(4) Movable fuel storage tenders shall be moved on the shortest practical route when transporting tenders between points of utilization.

9.6 Transportation of Stationary Containers to and from Point of Installation.

9.6.1 Application.

9.6.1.1 Section 9.6 applies to the transportation of containers designed for stationary service at the point of use and secured to the vehicle only for transportation.

9.6.1.2 Containers described in 9.6.1.1 shall be transported in accordance with 9.6.2.1.

9.6.2 Transportation of Containers.

9.6.2.1 ASME containers of 125 gal (0.5 m^3) or more water capacity shall contain no more than 5 percent of their water capacity in liquid form during transportation.

9.6.2.2 Containers shall be permitted to be transported with more LP-Gas than 5 percent of their water capacity in a liquid form but shall not exceed the maximum permitted by Section 7.4, provided that all the following conditions apply:

(1) Transportation shall be permitted only to move containers from a stationary or temporary installation to a bulk plant.
(2) Valves and fittings shall be protected by a method approved by the authority having jurisdiction to minimize the possibility of damage.
(3) Lifting lugs shall not be used to move these containers.

9.6.2.3 Containers shall be installed to minimize movement relative to each other or to the carrying vehicle while in transit, giving consideration to vehicular operation.

9.6.2.4 Valves, regulators, and other container appurtenances shall be protected against physical damage during transportation.

9.6.2.5 Pressure relief valves shall be in direct communication with the vapor space of the container.

9.7 Parking and Garaging Vehicles Used to Carry LP-Gas Cargo.

9.7.1 Application. Section 9.7 applies to the parking and garaging of vehicles used for the transportation of LP-Gas.

9.7.2 Parking Outdoors.

9.7.2.1 Vehicles shall not be left unattended on any street, highway, avenue, or alley, except for necessary absences from the vehicle associated with drivers' normal duties, including stops for meals and rest stops during the day or night, except as follows:

(1) This requirement shall not apply in an emergency.
(2) This requirement shall not apply to vehicles parked in accordance with 9.7.2.3 and 9.7.2.4.

9.7.2.2 Vehicles shall not be parked in congested areas.

9.7.2.3 Where vehicles are parked off the street in uncongested areas, they shall be at least 50 ft (15 m) from any building used for assembly, institutional, or multiple residential occupancy.

9.7.2.4 Where vehicles carrying portable containers or cargo tank vehicles of 3500 gal (13 m^3) water capacity or less are parked on streets adjacent to the driver's residence in uncongested residential areas, the parking locations shall be at least 50 ft (15 m) from a building used for assembly, institutional, or multiple residential occupancy.

9.7.3 Parking Indoors.

9.7.3.1 Cargo tank vehicles parked in any public garage or building shall have LP-Gas liquid removed from the following:

(1) Cargo tank
(2) Piping
(3) Pump
(4) Meter
(5) Hoses
(6) Related equipment

9.7.3.2 Vehicles used to carry portable containers shall not be moved into any public garage or building for parking until all portable containers have been removed from the vehicle.

9.7.3.3 The pressure in the delivery hose and related equipment shall be reduced to approximately atmospheric.

9.7.3.4 All valves shall be closed before the vehicle is moved indoors. Delivery hose or valve outlets shall be plugged or capped before the vehicle is moved indoors.

9.7.3.5 Vehicles carrying or containing LP-Gas shall only be parked in buildings complying with Chapter 10 and located on premises owned or under the control of the operator of such vehicles where the following provisions are met:

(1) The public shall be excluded from such buildings.
(2) Floor level ventilation shall be provided in all parts of the building where such vehicles are parked.
(3) Leaks in the vehicle LP-Gas systems shall be repaired before the vehicle is moved indoors.
(4) Primary shutoff valves on cargo tanks and other LP-Gas containers on the vehicle (except propulsion engine fuel containers) shall be closed and delivery hose outlets plugged or capped to contain system pressure before the vehicle is moved indoors.

(5) Primary shutoff valves on LP-Gas propulsion engine fuel containers shall be closed while the vehicle is parked.
(6) No LP-Gas container shall be located near a source of heat or within the direct path of hot air being blown from a blower-type heater.
(7) LP-Gas containers shall be gauged or weighed to determine that they are not filled beyond the maximum filling limit according to Section 7.4.

9.7.3.6 Where vehicles are serviced or repaired indoors, the following shall apply:

(1) When it is necessary to move a vehicle into any building located on premises owned or operated by the operator of such vehicle for service on engine or chassis, the provisions of 9.7.3.5 shall apply.
(2) When it is necessary to move a vehicle carrying or containing LP-Gas into any public garage or repair facility for service on the engine or chassis, the provisions of 9.7.3.1 shall apply, or the driver or a qualified representative of an LP-Gas operator shall be in attendance at all times while the vehicle is indoors, and the following shall apply:
   (a) Leaks in the vehicle LP-Gas systems shall be repaired before the vehicle is moved indoors.
   (b) Primary shutoff valves on cargo tanks, portable containers, and other LP-Gas containers installed on the vehicle (other than propulsion engine fuel containers) shall be closed.
   (c) LP-Gas liquid shall be removed from the piping, pump, meter, delivery hose, and related equipment and the pressure therein reduced to approximately atmospheric before the vehicle is moved inside.
   (d) Delivery hose or valve outlets shall be plugged or capped before the vehicle is moved indoors.
   (e) No container shall be located near a source of heat or within the direct path of hot air blown from a blower or from a blower-type heater.
   (f) LP-Gas containers shall be gauged or weighed to determine that they are not filled beyond the maximum filling capacity in accordance with Section 7.4.

9.7.3.7 If repair work or servicing is to be performed on a cargo tank vehicle system, all LP-Gas shall be removed from the cargo tank and piping, and the system shall be thoroughly purged before the vehicle is moved indoors.

Chapter 10 Buildings or Structures Housing LP-Gas Distribution Facilities

10.1 Scope.

10.1.1 Application. This chapter applies to the construction, ventilation, and heating of structures, parts of structures, and rooms housing LP-Gas systems where specified by other parts of the code.

10.1.2 Nonapplication. This chapter does not apply to buildings constructed or converted before December 31, 1972.

10.2 Separate Structures or Buildings.

10.2.1 Construction of Structures or Buildings.

10.2.1.1 Separate buildings or structures shall be one story in height and shall have walls, floors, ceilings, and roofs constructed of noncombustible materials.

10.2.1.2 Either of the following shall apply to the construction of exterior walls, ceilings, and roofs:

(1) Exterior walls and ceilings shall be of lightweight material designed for explosion venting.
(2) Walls or roofs of heavy construction, such as solid brick masonry, concrete block, or reinforced concrete construction, shall be provided with explosion venting windows that have an explosion venting area of at least 1 ft^2 (0.1 m^2) for each 50 ft^3 (1.4 m^3) of the enclosed volume.

10.2.1.3 The floor of separate structures shall not be below ground level.

10.2.1.4 Any space beneath the floor shall be of solid fill, or the perimeter of the space shall be left entirely unenclosed.

10.2.2 Structure or Building Ventilation. The structure shall be ventilated using air inlets and outlets, the bottom of which shall be not more than 6 in. (150 mm) above the floor, and ventilation shall be provided in accordance with the following:

(1) Where mechanical ventilation is used, the rate of air circulation shall be at least 1 $ft^3/min \cdot ft^2$ (0.3 $m^3/min \cdot m^2$) of floor area.
(2) Outlets shall discharge at least 5 ft (1.5 m) from any opening into the structure or any other structure.
(3) Where natural ventilation is used, each exterior wall shall be provided with one opening for each 20 ft (6.1 m) of length.
(4) Each opening shall have a minimum size of 50 $in.^2$ (32,250 mm^2), and the total of all openings shall be at least 1 $in.^2/ft^2$ (6900 mm^2/m^2) of floor area.

10.2.3 Structure or Building Heating. Heating shall be by steam or hot water radiation or other heating transfer medium, with the heat source located outside of the building or structure *(see Section 6.20),* or by electrical appliances listed for Class I, Group D, Division 2 locations, in accordance with NFPA 70, *National Electrical Code.*

10.3 Attached Structures or Rooms Within Structures.

10.3.1 Construction of Attached Structures.

10.3.1.1 Attached structures shall be spaces where 50 percent or less of the perimeter of the enclosed space is comprised of common walls.

10.3.1.2 Attached structures shall comply with 10.2.1.

10.3.1.3 Common walls of structures shall have the following features:

(1) A fire resistance rating of at least 1 hour
(2) Where openings are required in common walls for rooms used only for storage of LP-Gas, 1½ hour (B) fire doors
(3) A design that withstands a static pressure of at least 100 lb/ft^2 (4.8 kPa)

10.3.1.4 Where the building to which the structure is attached is occupied by operations or processes having a similar hazard, the provisions of 10.3.1.3 shall not apply.

10.3.1.5 Ventilation and heating shall comply with 10.2.2 and 10.2.3.

10.3.2 Construction of Rooms Within Structures.

10.3.2.1 Rooms within structures shall be spaces where more than 50 percent of the perimeter of the space enclosed is comprised of common walls.

10.3.2.2 Rooms within structures shall be located in the first story and shall have at least one exterior wall with unobstructed free vents for freely relieving explosion pressures.

10.3.2.3 Walls, floors, ceilings, or roofs of the rooms shall be constructed of noncombustible materials.

10.3.2.4 Exterior walls and ceilings shall be of lightweight material designed for explosion venting.

10.3.2.5 Walls and roofs of heavy construction (such as solid brick masonry, concrete block, or reinforced concrete construction) shall be provided with explosion venting windows or panels that have an explosion venting area of at least 1 ft^2 (0.1 m^2) for each 50 ft^3 (1.4 m^3) of the enclosed volume.

10.3.2.6* Walls and ceilings common to the room and to the building within which it is located shall have the following features:

(1) A fire resistance rating of at least 1 hour
(2) Where openings are required in common walls for rooms used only for storage of LP-Gas, 1½ hour (B) fire doors
(3) A design that withstands a static pressure of at least 100 lb/ft^2 (4.8 kPa)

10.3.2.7 Where the building to which the structure is attached is occupied by operations or processes having a similar hazard, the provisions of 10.3.1.3 shall not apply.

10.3.2.8 Ventilation and heating shall comply with 10.2.2 and 10.2.3.

Chapter 11 Engine Fuel Systems

11.1 Scope.

11.1.1* This chapter applies to engine fuel systems using LP-Gas in internal combustion engines, including containers, container appurtenances, carburetion equipment, piping, hose and fittings, and their installation.

11.1.2* This chapter shall apply to the installation of fuel systems supplying engines used to propel all motor vehicles.

11.1.3 This chapter applies to garaging of vehicles where such systems are installed.

11.2 Training. Each person engaged in installing, repairing, filling, or otherwise servicing an LP-Gas engine fuel system shall be trained in the necessary procedures.

11.3 Containers.

11.3.1* Container Design.

11.3.1.1 Containers shall be designed, fabricated, tested, and marked in accordance with the regulations of the U.S. Department of Transportation (DOT) or the "Rules for Construction of Unfired Pressure Vessels," Section VIII, Division I of the ASME *Boiler and Pressure Vessel Code,* for aboveground service applicable at the date of manufacture.

11.3.1.2 Adherence to applicable ASME Code case interpretations and addenda shall be considered as compliance with the ASME Code.

11.3.1.3 Containers that have been involved in a fire and that show no distortion shall be requalified for continued service in accordance with the code under which they were constructed before being reused.

11.3.1.4 Cylinders shall be designed and constructed for at least 240 psi (1.6 MPa) service pressure.

11.3.1.5 Cylinders shall be requalified in accordance with DOT regulations.

11.3.1.6 Engine fuel containers shall be of either the permanently installed or exchangeable type.

11.3.2 Container Design Pressure. ASME engine fuel and mobile containers shall have the following minimum design pressure:

(1) 250 psig (1.7 MPag) or 312 psig (2.2 MPag) where required if constructed prior to April 1, 2001.
(2) 312 psig (2.2 MPag) if constructed on or after April 1, 2001.
(3) ASME containers installed in enclosed spaces on vehicles and all engine fuel containers for industrial trucks, buses (including school buses), recreational vehicles, and multipurpose passenger vehicles shall be constructed with a design pressure of at least 312 psig.

11.3.3 Container Repairs and Alteration.

11.3.3.1 Repair or alterations of containers shall comply with the regulations, rules, or code under which the container was fabricated.

11.3.3.2 Field welding on containers shall be limited to attachments to nonpressure containing parts, such as the following:

(1) Saddle pads
(2) Wear plates
(3) Lugs
(4) Brackets installed by the container manufacturer

11.3.3.3 Containers showing excessive denting, bulging, gouging, or corrosion shall be removed from service.

11.3.4 ASME Container Nameplate.

11.3.4.1 A stainless steel metal nameplate shall be attached to the ASME container and shall be located to remain visible after the container is installed.

11.3.4.2 The nameplate shall be attached in such a way as to minimize corrosion of the nameplate or its fastening means and not cause corrosion of the container.

11.3.4.3 The nameplate shall include the following information:

(1) Service for which the container is designed
(2) Name and address of container manufacturer or trade name of container
(3) Water capacity of container in pounds or U.S. gallons
(4) Design pressure in pounds per square inch (psi)
(5) The wording "This container shall not contain a product having a vapor pressure in excess of 215 psi (1.5 MPa) at 100°F (37.8°C)."
(6) Tare weight of container fitted for service in order for containers to be filled by weight
(7) Outside surface area in square feet
(8) Year of manufacture
(9) Shell thickness, head thickness
(10) OL (overall length), OD (outside diameter), HD (head design)
(11) Manufacturer's serial number
(12) ASME Code symbol

11.3.5 Container Capacity.

11.3.5.1 The maximum capacity of individual LP-Gas containers installed on highway vehicles shall be in accordance with Table 6.21.3.1.

11.3.5.2 Containers larger than 30 gallons (0.1 m^3) water capacity shall be equipped for filling into the vapor space.

11.3.6 Container Connections.

11.3.6.1 The connections for pressure relief valves shall communicate directly with the vapor space of the container and shall not reduce the relieving capacity of the relief device.

11.3.6.2 The connection for the pressure relief valve shall be internally piped to the uppermost point practical in the vapor space of the container if the connection is located at any position other than the uppermost point practical in the vapor space of the container.

11.3.6.3 The container openings shall be labeled on the container or valves connected to the container opening to designate whether they communicate with the vapor or liquid space.

11.3.6.4 Labels shall not be required on openings for pressure relief valves and gauging devices.

11.3.7* Container Corrosion Protection. Engine fuel containers constructed of steel shall be painted to retard corrosion.

11.4 Container Appurtenances.

11.4.1 General Requirements for Appurtenances.

11.4.1.1 Container appurtenances (such as valves and fittings) shall comply with Section 5.7 and 11.4.1.2 through 11.4.1.15.

11.4.1.2 Container appurtenances subject to working pressures in excess of 125 psig (0.9 MPag) shall be rated for a working pressure of at least 250 psig (1.7 MPag).

11.4.1.3 Manual shutoff valves shall be designed to provide positive closure under service conditions and shall be equipped with an internal excess-flow check valve designed to close automatically at the rated flows of vapor or liquid specified by the manufacturers.

11.4.1.4 Double backflow check valves shall comply with the following:

(1) Be of the spring-loaded type
(2) Close when flow is either stopped or reversed
(3) Be installed in the fill opening on the container for either remote or direct filling

11.4.1.5 Containers shall be fabricated so they can be equipped with a fixed maximum liquid level gauge as follows:

(1) The fixed maximum liquid level gauge shall be capable of indicating the maximum permitted filling level in accordance with 7.4.2.2.
(2) Fixed maximum liquid level gauges in the container shall be designed so the bleeder valve maximum opening to the atmosphere is not larger than a No. 54 drill size.
(3) The container fixed maximum liquid level gauge opening and the remote bleeder valve opening shall not be larger than a No. 54 drill size where the bleeder valve is installed at a location remote from the container.

11.4.1.6 Systems complying with the provisions of 6.24.3 shall have a water- and weather-resistant label placed near the bleeder valve with the following text: "Do not use fixed maximum liquid level gauge at low emission transfer stations."

11.4.1.7 ASME containers shall be equipped with full internal or flush-type full internal pressure relief valves conforming with applicable requirements of UL 132, *Standard on Safety Relief Valves for Anhydrous Ammonia and LP-Gas,* or other equivalent pressure relief valve standards.

(A) Fusible plugs shall not be used.

(B) The start-to-leak setting of such pressure relief valve, with relation to the design pressure of the container, shall be in accordance with Table 5.7.2.4(A).

11.4.1.8 Permanently mounted ASME containers shall be equipped with a valve or combination of valves in the liquid outlet connection that has manual shutoff, excess flow, and automatic closure features. The valve assembly shall prevent the flow of fuel when the engine is not in an operating mode even if the ignition switch is in the "on" position. This requirement shall not apply to industrial and forklift trucks.

11.4.1.9 Pressure relief valves shall be marked with the following:

(1) The pressure in psig (MPag) at which the valve is set to start to leak
(2) The rated relieving capacity in cubic feet per minute of air at 60°F (15.6°C) and 14.7 psia (an absolute pressure of 0.1 MPa)
(3) The manufacturer's name and catalog number

11.4.1.10 Cylinders shall be equipped with full internal or flush-type full internal pressure relief valves in accordance with DOT regulations.

11.4.1.11 A float gauge, if used, shall be designed and approved for use with LP-Gas.

11.4.1.12 A solid steel plug shall be installed in unused openings.

11.4.1.13 Containers fabricated after January 1, 1984, for use as engine fuel containers on vehicles shall be equipped or fitted with an overfilling prevention device.

11.4.1.14 Where an overfilling prevention device is installed on the container or exterior of the compartment and remote filling is used, a double backflow check valve shall be installed in the container fill valve opening.

11.4.1.15 Where an overfilling prevention device is installed on an engine fuel container, venting of gas through a fixed maximum liquid level gauge during normal filling shall not be required.

11.5 Carburetion Equipment.

11.5.1 Pressure. Carburetion equipment subject to working pressures in excess of 125 psig (0.9 MPag) shall be designed for a working pressure of 250 psig (1.7 MPag) or for the design pressure of the container where the design pressure of the container is greater than 250 psig (1.7 MPag).

11.5.2 Vaporizers.

11.5.2.1 Vaporizers shall be fabricated of materials resistant to corrosion by LP-Gas under service conditions.

11.5.2.2 Vaporizers shall be designed for engine fuel service.

11.5.2.3 Vaporizers subjected to container pressure shall have a design pressure of 250 psig (1.7 MPag) or the design pressure of the container where the design pressure of the container is greater than 250 psig (1.7 MPag).

11.5.2.4 Vaporizers shall be marked with the design pressure of the fuel containing portion in psig (MPag). The marking shall be visible when the vaporizer is installed.

11.5.2.5 The vaporizer shall not be equipped with a fusible plug.

11.5.2.6 Each vaporizer shall be capable of having the water or heating fluid drained from the engine cooling system drain or water hoses or shall have a valve or plug located at or near the lowest portion of the section occupied by the water or other heating fluid to allow drainage of the water or heating fluid.

11.5.2.7 Where engine exhaust gases are used as a direct source of heat to vaporize the fuel, the materials of construction of those parts of the vaporizer in contact with the exhaust gases shall be resistant to corrosion by these gases and the vaporizer system shall be designed to prevent a pressure in excess of 200 psig (1.4 MPag).

11.5.2.8 Devices that supply heat directly to the fuel container shall be equipped with an automatic device to cut off the supply of heat before the pressure in the container reaches 200 psig (1.4 MPag).

11.5.3 Fuel Shutoff Valve.

11.5.3.1 An automatic shutoff valve shall be provided in the fuel system as close as practical to the inlet of the gas regulator.

11.5.3.2 The valve shall prevent flow of fuel to the carburetor when the engine is not running even if the ignition switch is in the on position.

11.5.3.3 Atmospheric-type regulators (zero governors) shall not be considered as automatic shutoff valves for this purpose.

11.6 Piping, Hose, and Fittings.

11.6.1 Piping.

11.6.1.1 Piping materials shall be wrought iron or steel (black or galvanized), brass, or copper and shall comply with the following specifications:

(1) Wrought-iron pipe — ASME B 36.10M, *Welded and Seamless Wrought Steel Pipe*
(2) Steel pipe — ASTM A 53, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless*
(3) Steel pipe — ASTM A 106, *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*
(4) Brass pipe — ASTM B 43, *Standard Specification for Seamless Red Brass Pipe, Standard Sizes*
(5) Copper pipe — ASTM B 42, *Standard Specification for Seamless Copper Pipe, Standard Sizes*
(6) Steel tubing — ASTM A 539, *Standard Specification for Electric-Resistance-Welded Coiled Steel Tubing for Gas Fuel Oil Lines,* with a minimum wall thickness of 0.049 in.
(7) Copper tubing, Type K or L — ASTM B 88, *Standard Specification for Seamless Copper Water Tube*
(8) Copper tubing — ASTM B 280, *Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service*
(9) Brass tubing — ASTM B 135, *Standard Specification for Seamless Brass Tube*

11.6.1.2 Cast-iron pipe fittings shall not be used.

11.6.1.3 Pipe used for LP-Gas vapor in excess of 125 psi (0.9 MPa) or for LP-Gas liquid shall be Schedule 80 or heavier.

11.6.1.4 Pipe used for LP-Gas vapor at pressures of 125 psi (0.9 MPa) or less shall be Schedule 40 or heavier.

11.6.2 Fittings.

11.6.2.1 Fittings shall be steel, brass, copper, malleable iron, or ductile iron.

11.6.2.2 Pipe joints in wrought iron, steel, brass, or copper pipe shall be screwed, welded, or brazed.

11.6.2.3 Tubing joints in steel, brass, or copper tubing shall be flared, brazed, or made up with approved gas tubing fittings.

11.6.2.4 Fittings used with liquid LP-Gas or with vapor LP-Gas at operating pressures over 125 psig (0.9 MPag) shall be designed for a working pressure of at least 250 psig (1.7 MPag) or the design pressure of the container, whichever is greater.

11.6.2.5 Fittings for use with vapor LP-Gas at pressures in excess of 5 psig (34.5 kPag) and not in excess of 125 psig (0.9 MPag) shall be designed for a working pressure of 125 psig (0.9 MPag).

11.6.2.6 Brazing filler material shall have a melting point exceeding 1000°F (538°C).

11.6.3 Hose, Hose Connections, and Flexible Connectors.

11.6.3.1 Hose, hose connections, and flexible connectors used for conveying LP-Gas liquid or vapor at pressures in excess of 5 psig (34.5 kPag) shall be fabricated of materials resistant to the action of LP-Gas both as liquid and vapor and shall be of reinforced construction.

11.6.3.2 Hose that can be exposed to container pressure shall be designed for a working pressure of 350 psig (2.4 MPag) with a safety factor of 5 to 1, and the reinforcement shall be of corrosion-resistant material.

11.6.3.3 Hose that operates at lower than container pressure shall be designed for its maximum anticipated operating pressure.

11.6.3.4 Hose shall be continuously marked with LP-GAS, PROPANE, 350 PSI WORKING PRESSURE and the manufacturer's name or trademark. Each installed piece of hose shall contain at least one such marking.

11.6.3.5 Hose assemblies, after the application of couplings, shall have a design capability to withstand a pressure of not less than 700 psig (4.8 MPag). If a pressure test is performed, such assemblies shall be pressure tested at 120 percent of the maximum working pressure [350 psig (24 MPag) minimum] of the hose.

11.6.3.6 Hose used for vapor service at 5 psig (34.5 kPag) or less shall be constructed of material resistant to the action of LP-Gas.

11.6.3.7 Hose in excess of 5 psig (34.5 kPag) service pressure and quick connectors shall be approved for this application by the authority having jurisdiction.

11.7 Installation of Containers and Container Appurtenances.

11.7.1 Location of Containers.

11.7.1.1 Containers shall be located to minimize the possibility of damage to the container and its fittings.

11.7.1.2 Where containers are located in the rear of the vehicle, they shall be protected.

11.7.1.3 Containers located less than 18 in. (460 mm) from the exhaust system, the transmission, or a heat-producing component of the internal combustion engine shall be shielded by a vehicle frame member or by a noncombustible baffle with an air space on both sides of the frame member or baffle.

11.7.1.4 After a container is permanently installed on a vehicle, container markings shall be readable either directly or with a portable lamp and mirror.

11.7.2 Protection of Containers and Appurtenances.

11.7.2.1 Container valves, appurtenances, and connections shall be protected to prevent damage due to accidental contacts with stationary objects or from stones, mud, or ice and from damage due to an overturn or similar vehicular accident.

11.7.2.2 Protection of container valves, appurtenances, and connections shall be provided by one of the following:

(1) By locating the container so that parts of the vehicle furnish the necessary protection
(2) By the use of a fitting guard furnished by the manufacturer of the container
(3) By other means to provide equivalent protection

11.7.3 Container Clearances.

11.7.3.1 Containers shall not be mounted directly on roofs or ahead of the front axle or beyond the rear bumper of the vehicles.

11.7.3.2 No part of a container or its appurtenances shall protrude beyond the sides or top of the vehicle.

11.7.3.3 Containers shall be installed with as much road clearance as practical.

11.7.3.4 Clearance shall be measured to the bottom of the container or the lowest fitting, support, or attachment on the container or its housing, if any, whichever is lowest, as follows *(see Figure 11.7.3.4)*.

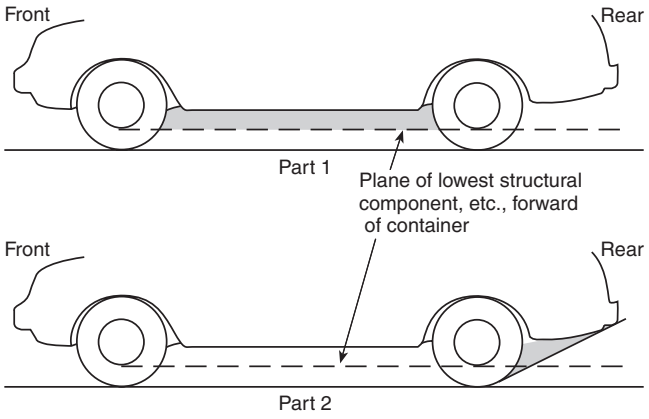

FIGURE 11.7.3.4 Container Installation Clearances.

11.7.3.5 Containers installed between axles shall comply with 11.7.3.6 or shall be not lower than the lowest point forward of the container on the following points:

(1) The lowest structural component of the body as illustrated in Figure 11.7.3.4
(2) The lowest structural component of the frame or subframe
(3) The lowest point on the engine
(4) The lowest point of the transmission (including the clutch housing or torque converter housing, as applicable)

11.7.3.6 Containers installed behind the rear axle and extending below the frame shall comply with 11.7.3.7 or shall be not lower than the lowest of the following points and surfaces:

(1) Containers shall not be lower than the lowest point of a structural component of the body, engine, transmission (including clutch housing or torque converter housing, as applicable) forward of the container.
(2) Containers shall not be lower than lines extending rearward from each wheel at the point where the wheels contact the ground directly below the center of the axle to the lowest and most rearward structural interference as illustrated in the bottom diagram of Figure 11.7.3.4.

11.7.3.7 Where an LP-Gas container is substituted for the fuel container installed by the original manufacturer of the vehicle, the LP-Gas container either shall fit within the space in which the original fuel container was installed or shall comply with 11.7.3.5 or 11.7.3.6.

11.7.4 Container Installation.

11.7.4.1 Fuel containers shall be installed to prevent jarring loose and slipping or rotating, and the fastenings shall be designed and constructed to withstand without permanent deformation static loading in any direction equal to four times the weight of the container filled with fuel.

11.7.4.2 Welding for the repair or alterations of containers shall comply with 11.3.3.3.

11.7.4.3 Main shutoff valves on a container for liquid and vapor shall be readily accessible without the use of tools, or other equipment shall be provided to shut off the container valves.

11.7.5 Pressure Relief Valve Discharge System.

11.7.5.1 The pressure relief valve discharge from fuel containers on vehicles other than industrial (and forklift) trucks shall be in accordance with the following:

(1) It shall be directed upward or downward within 45 degrees of vertical.
(2) It shall not directly impinge on the vehicle fuel container(s), the exhaust system, or any other part of the vehicle.
(3) It shall not be directed into the interior of the vehicle.

11.7.5.2 Where the pressure relief valve discharge must be piped away, the pipeaway system shall have a breakaway adapter.

(A) The breakaway adapter shall have a melting point of not less than 1500°F (816°C).

(B) The adapter either shall be an integral part of the pressure relief valve or shall be a separate adapter attached directly to the pressure relief valve.

(C) The pipeaway system shall have a length of nonmetallic hose.

(D) The nonmetallic hose shall be as short as practical and shall be able to withstand the downstream pressure from the relief valve in the full open position, and the hose shall be fabricated of materials resistant to the action of LP-Gas.

(E) Where hose is used to pipe away the relief valve discharge on containers installed on the outside of the vehicle, the breakaway adapter and any attached fitting shall deflect the relief valve discharge upward or downward within 45 degrees

of vertical and shall meet the other requirements of 11.7.5.1 without the hose attached. If an additional fitting is necessary to meet this requirement, it shall have a melting point not less than 1500°F (816°C).

(F) The pipeaway system shall have a protective cover to minimize the possibility of the entrance of water or dirt into either the relief valve or its discharge system.

(G) No portion of the system shall have an internal diameter less than the internal diameter of the recommended breakaway adapter.

(H) The breakaway adapter either shall be threaded for direct connection to the relief valve and shall not interfere with the operation of the relief valve or shall be an integral part of the pressure relief valve. It shall break away without impairing the function of the relief valve.

(I) The pipeaway system connections shall be mechanically secured and shall not depend on adhesives or sealing compounds and shall not be routed between a bumper system and the vehicle body.

(J) Where a pipeaway system is not required, the pressure relief valve shall have a protective cover in accordance with 11.7.5.2.

11.8 Installation in the Interior of Vehicles.

11.8.1 Installation of Containers and Appurtenances.

11.8.1.1 Installation of containers in the interior of vehicles shall comply with either 11.8.1.2 or 11.8.1.3.

11.8.1.2* The container and its appurtenances shall be installed in an enclosure that is securely mounted to the vehicle.

(A) The enclosure shall be gastight with respect to driver or passenger compartments and to any space containing radio transmitters or other spark-producing equipment.

(B) The enclosure shall be vented to the outside of the vehicle.

11.8.1.3 The container appurtenances and their connections shall be installed in an enclosure that is securely mounted on the container.

(A) The appurtenances and their connections shall be installed in an enclosure that is gastight with respect to the driver or passenger compartments or with any space carrying radio transmitters or other spark-producing equipment.

(B) The enclosure shall be vented to the outside of the vehicle.

11.8.1.4 Fuel containers shall be installed and fitted so that no gas from fueling and gauging operations can be released inside of the passenger or luggage compartments by permanently installing a remote filling device (single or double backflow check filler valve) and a fixed maximum liquid level gauging device to the outside of the vehicle.

11.8.1.5 Enclosures, structures, seals, and conduits used to vent enclosures shall be designed and fabricated of durable materials and shall be designed to resist damage, blockage, or dislodgement through movement of articles carried in the vehicle or by the closing of luggage compartment enclosures or vehicle doors and shall require the use of tools for removal.

11.9 Pipe and Hose Installation.

11.9.1 General Requirements.

11.9.1.1 The piping system shall be designed, installed, supported, and secured in such a manner as to minimize damage due to expansion, contraction, vibration, strains, and wear.

11.9.1.2 Piping (including hose) shall be installed in a protected location.

11.9.1.3 If piping is installed outside the vehicle, it shall be under the vehicle and below any insulation or false bottom.

11.9.1.4 Fastening or other protection shall be installed to prevent damage due to vibration or abrasion.

11.9.1.5 At each point where piping passes through sheet metal or a structural member, a rubber grommet or equivalent protection shall be installed to prevent chafing.

11.9.1.6 Fuel line piping that must pass through the floor of a vehicle shall be installed to enter the vehicle through the floor directly beneath or adjacent to the container.

11.9.1.7 If a branch fuel line is required, the tee connection shall be in the main fuel line under the floor and outside the vehicle.

11.9.1.8 Where liquid service lines of two or more individual containers are connected together, a spring-loaded backflow check valve or equivalent shall be installed in each of the liquid lines prior to the point where the liquid lines tee together to prevent the transfer of LP-Gas from one container to another.

11.9.1.9 Exposed parts of the piping system shall be of corrosion-resistant material or shall be protected to minimize exterior corrosion.

11.9.1.10 Piping systems, including hose, shall be tested and proven free of leaks at not less than normal operating pressure.

11.9.1.11 There shall be no fuel connection between a tractor and trailer or other vehicle units.

11.9.2 Hydrostatic Relief Valves.

11.9.2.1 A hydrostatic relief valve or device providing pressure-relieving protection shall be installed in each section of piping (including hose) in which liquid LP-Gas can be isolated between shutoff valves so as to relieve to the atmosphere.

11.9.2.2 Hydrostatic relief valves shall have a pressure setting not less than 400 psig (2.8 MPag) or more than 500 psig (3.5 MPag).

11.10 Equipment Installation.

11.10.1 Protection Against Damage.

11.10.1.1 Equipment installed on vehicles shall be protected against vehicular damage in accordance with 11.7.1.

11.10.1.2 The gas regulator and the automatic shutoff valve shall be installed as follows:

(1) An approved automatic shutoff valve in compliance with 11.5.3 shall be installed in the fuel system.
(2) Approved automatic pressure reducing equipment shall be installed between the fuel supply container and the carburetor.

11.11 Marking.

11.11.1 Label Requirements. Each over-the-road general-purpose vehicle powered by LP-Gas shall be identified with a weather-resistant diamond-shaped label located on an exterior vertical or near vertical surface on the lower right rear of the vehicle (on the trunk lid of a vehicle so equipped but not on the bumper of any vehicle) inboard from any other markings.

11.11.2 Label Size.

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

11.11.2.2* The marking shall consist of a border and the word PROPANE [1 in. (25 mm) minimum height centered in the diamond] in silver or white reflective luminous material on a black background.

11.12 Industrial (and Forklift) Trucks Powered by LP-Gas.

11.12.1 Scope. Section 11.12 applies to LP-Gas installation on industrial trucks (including forklift trucks), both to propel them and to provide the energy for their materials-handling attachments.

11.12.2 Industrial Truck Cylinders.

11.12.2.1 Cylinders shall be designed, constructed, or fitted for installation and filling in either the vertical or horizontal position or, if of the universal type, in either position.

11.12.2.2 The cylinder shall be in the design position while being filled or, if of the universal type, shall be filled in either position.

11.12.2.3 The fixed maximum liquid level gauge shall indicate the maximum permitted filling level in either position.

11.12.2.4 The pressure relief valves shall be in direct communication with the vapor space of the cylinder in either position.

11.12.2.5 The cylinder vapor or liquid withdrawal valves shall function in either position.

11.12.2.6 The cylinder pressure relief valve discharge shall be directed upward within 45 degrees of vertical and otherwise shall not impinge on the cylinder, the exhaust system, or any other part of the industrial truck.

11.12.2.7 The discharge opening shall be provided with a protective cover to minimize the possibility of the entry of water or any extraneous matter.

11.12.3 Hose. Hose 60 in. (1.5 m) in length or less shall not be required to be of stainless steel wire braid construction.

11.12.4 Operations. The operation of industrial trucks (including forklift trucks) powered by LP-Gas engine fuel systems shall comply with the following.

11.12.4.1 Industrial trucks shall be refueled outdoors.

11.12.4.2 Where cylinders are exchanged indoors, the fuel piping system shall be equipped to minimize the release of fuel when cylinders are exchanged, in accordance with either of the following:

(1) Using an approved quick-closing coupling in the fuel line
(2) Closing the shutoff valve at the fuel cylinder and allowing the engine to run until the fuel in the line is exhausted

11.12.4.3 Where LP-Gas–fueled industrial trucks are used in buildings or structures, the following shall apply:

(1) The number of fuel cylinders on such a truck shall not exceed two.
(2) The use of industrial trucks in buildings frequented by the public, including those times when such buildings are occupied by the public, shall require the approval of the authority having jurisdiction.
(3) The total water capacity of the fuel cylinders on an individual truck shall not exceed 105 lb (48 kg) [nominal 45 lb (20 kg) LP-Gas capacity].
(4) Trucks shall not be parked and left unattended in areas occupied by or frequented by the public without the approval of the authority having jurisdiction. If left unattended with approval, the cylinder shutoff valve shall be closed.
(5) In no case shall trucks be parked and left unattended in areas of excessive heat or near sources of ignition.

11.12.4.4 All cylinders used in industrial truck service (including forklift truck cylinders) shall have the cylinder pressure relief valve replaced by a new or unused valve within 12 years of the date of manufacture of the cylinder and every 10 years thereafter.

11.13 General Provisions for Vehicles Having Engines Mounted on Them (Including Floor Maintenance Machines).

11.13.1 Scope.

11.13.1.1 Section 11.13 applies to the installation of equipment on vehicles that supply LP-Gas as a fuel for engines installed on these vehicles.

11.13.1.2 Vehicles include floor maintenance and any other portable mobile unit, whether the engine is used to propel the vehicle or is mounted on it for other purposes.

11.13.2 General Requirements.

11.13.2.1 Industrial trucks (including forklift trucks) and other engines on vehicles operating in buildings other than those used exclusively to house engines shall have an approved automatic shutoff valve installed in the fuel system.

11.13.2.2 The source of air for combustion shall be isolated from the driver and passenger compartment, ventilating system, or air-conditioning system on the vehicle.

11.13.2.3 Non-self-propelled floor maintenance machinery (floor polishers, scrubbers, buffers) and other similar portable equipment shall be listed.

(A) A label shall be affixed to the machinery or equipment, with the label facing the operator, with the text denoting that the cylinder or portion of the machinery or equipment containing the cylinder shall be stored in accordance with Chapter 8.

(B) The use of floor maintenance machines in buildings frequented by the public, including the times when such buildings are occupied by the public, shall require the approval of the authority having jurisdiction.

11.14 Engine Installation Other than on Vehicle.

11.14.1 General.

11.14.1.1 The use of portable engines in buildings shall be limited to emergencies.

11.14.1.2 Air for combustion and cooling shall be supplied.

11.14.1.3 Exhaust gases shall be discharged to a point outside the building or to an area in which they will not constitute a hazard.

11.14.1.4 Where atmospheric-type regulators (zero governors) are used on engines operated only outdoors, a separate automatic shutoff valve shall not be required.

11.14.1.5 Engines used to drive portable pumps and compressors or pumps shall be equipped in accordance with 5.15.6.

11.15 Garaging of Vehicles. Where vehicles with LP-Gas engine fuel systems mounted on them and general-purpose vehicles propelled by LP-Gas engines are stored or serviced inside garages, the following conditions apply:

(1) The fuel system shall be leak-free.
(2) The container shall not be filled beyond the limits specified in Chapter 7.
(3) The container shutoff valve shall be closed when the vehicle or the engine is being repaired, except when the engine is required to operate. Containers equipped with an automatic shutoff valve as specified in 11.4.1.8 satisfy this requirement.
(4) The vehicle shall not be parked near sources of heat, open flames, or similar sources of ignition, or near inadequately ventilated pits.

Chapter 12 Refrigerated Containers

12.1 Construction and Design of Refrigerated Containers.

12.1.1 Container Material and Construction Requirements.

12.1.1.1 Containers designed to operate at greater than 15 psig (103 kPag) shall be designed and constructed in accordance with the ASME *Boiler and Pressure Vessel Code*, Section VIII, except that construction using joint efficiencies listed in Table UW 12, Column C, shall not be permitted.

12.1.1.2 Materials used in refrigerated containers shall be selected from those included in the following:

(1) ASME *Boiler and Pressure Vessel Code*, Section VIII (materials that maintain their integrity at the boiling temperature of the liquid stored)
(2) API Standard 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks,* Appendix R or Appendix Q

12.1.1.3 Containers designed to operate at below 15 psig (103 kPag) shall be in accordance with API Standard 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks,* including Appendix R.

12.1.1.4 Where austenitic stainless steels or nonferrous materials are used, API Standard 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks,* Appendix Q, shall be used in the selection of materials.

12.1.1.5 All new construction shall incorporate on any bottom or side penetrations that communicate with the liquid space of the container either an internal emergency shutoff valve or a back check valve. Any emergency shutoff valve shall be incorporated into a facility emergency shutdown system and be capable of being operated remotely.

12.1.2 Container Design Temperature and Pressure.

12.1.2.1 The maximum allowable working pressure shall include a margin above the operating pressure.

12.1.2.2 Design Temperature and Pressure.

12.1.2.3 The positive margin for design pressure of ASME containers shall be at least 5 percent of the absolute vapor pressure of the LP-Gas at the design storage temperature. The margin (both positive and vacuum) for low-pressure API Standard 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*, vessels shall include the following:

(1) The control range of the boil-off handling system
(2) The effects of flash or vapor collapse during filling operations
(3) The flash that can result from withdrawal pump recirculation
(4) The normal range of barometric pressure changes

12.1.2.4 The design temperature for those parts of a refrigerated LP-Gas container that are in contact with the liquid or refrigerated vapor shall be equal to or lower than the boiling point of the product to be stored at atmospheric pressure. A temperature allowance shall be made for the composition of the liquid to be stored when it is flashed into the vapor space of a tank.

12.2 Marking on Refrigerated LP-Gas Containers.

12.2.1 Each refrigerated LP-Gas container shall be identified by the attachment of a nameplate on the outer covering.

12.2.2 The nameplate shall be in accordance with API Standard 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks,* Section 6.

12.3 Container Installation.

12.3.1 Wind Loading.

12.3.1.1 The design wind loading on refrigerated LP-Gas containers shall be in accordance with the projected area at various height zones above ground in accordance with ASCE 7, *Minimum Design Loads for Buildings and Other Structures*.

12.3.1.2 Design wind speeds shall be based on a mean occurrence interval of 100 years.

12.3.2 Seismic Loading.

12.3.2.1 The design seismic loading on refrigerated LP-Gas containers shall be in accordance with ASCE 7, *Minimum Design Loads for Buildings and Other Structures*.

12.3.2.2 A seismic analysis of the proposed installation shall be made that meets the approval of the authority having jurisdiction.

12.3.3 Piping.

12.3.3.1 All piping that is part of a refrigerated LP-Gas container and refrigerated LP-Gas systems, including transfer and process piping, shall be in accordance with ASME B 31.3, *Process Piping*.

12.3.3.2 The container piping shall include the following:

(1) All piping internal to the container
(2) All piping within the insulation spaces
(3) All external piping attached or connected to the container up to the first circumferential external joint of the piping

12.3.3.3 Inert gas purge systems wholly within the insulation spaces shall be exempt from the provision in 12.3.3.1.

12.3.3.4 Gaskets used to retain LP-Gas in containers shall be resistant to the action of LP-Gas.

12.3.3.5 Gaskets shall be of metal or other material confined in metal, including spiral-wound metal gaskets, having a melting point over 1500°F (816°C) or shall be protected against fire exposure.

12.3.3.6 When a flange is opened, the gasket shall be replaced.

12.3.4 Foundations.

12.3.4.1 Refrigerated aboveground containers shall be installed on foundations that have been engineered with consideration for soil conditions and loadings.

12.3.4.2* Prior to the start of design and construction of the foundation, a subsurface investigation shall be conducted by a soils engineer. Foundations shall be designed by an engineer who is experienced in foundations and soils.

12.3.4.3 Where product storage is at less than 30°F (1.1°C), the foundation and the tank bottom shall comply with the following:

(1) The foundation design and the container bottom insulation shall prevent damage to the tank from frost heave.
(2) If the refrigerated LP-Gas tank under bottom foundation and insulation are in contact with the soil, and the soil temperature can be less than 32°F (0°C), a heating system shall be installed to prevent the soil temperature from going below 32°F (0°C).
(3) The under-tank heating system shall be designed to permit both functional and performance monitoring.
(4) The under-tank temperature shall be observed and logged at least weekly.
(5) Where there is a discontinuity in the foundation, such as bottom piping, the heating system in that zone shall be designed for the discontinuity.
(6) The under-tank heating systems shall be installed so that any heating elements or temperature sensors used for control can be replaced while the tank is in service.
(7) Provisions shall be incorporated to minimize the effects of moisture accumulation in the conduit and other forms of deterioration within the conduit or heating element.

12.3.4.4 The refrigerated LP-Gas container foundation shall be periodically monitored for settlement during the life of the facility.

12.3.4.5 The monitoring shall include construction, hydrostatic testing, commissioning, and operation.

12.3.4.6 Any settlement in excess of that anticipated in the design shall be investigated, and corrective action shall be taken if appropriate.

12.3.4.7 For a tank having a double wall design, the bottom of the outer wall and the refrigerated LP-Gas container under-tank insulation shall be above the groundwater table or protected from contact with groundwater at all times. It shall also be protected from floodwaters.

12.3.4.8 Where two or more containers are sited in a common dike, the tank foundations shall be constructed of material resistant to the effects of refrigerated LP-Gas and the temperature to which they will be exposed.

12.3.4.9 If the foundation of a refrigerated LP-Gas container is designed to provide air circulation in lieu of a heating system, the foundation and insulating material under the bottom of the container shall be constructed of materials that are resistant to the effects of refrigerated LP-Gas and the temperatures to which they will be exposed.

12.3.4.10 The material in contact with the bottom of the container shall be selected to minimize corrosion.

12.4 Refrigerated LP-Gas Container Instruments and Controls.

12.4.1 Gauging Devices.

12.4.1.1 Each refrigerated LP-Gas container shall be equipped with at least two independent liquid level gauging devices.

12.4.1.2 Liquid level gauging devices shall be installed so that they can be replaced without taking the container out of service.

12.4.1.3 The refrigerated LP-Gas container shall be provided with an audible and visual high–liquid level alarm.

12.4.1.4 The alarm shall be set so that the operator will have sufficient time based on the maximum allowable filling rate to stop the flow without exceeding the maximum permissible filling height.

12.4.1.5 The alarm shall be located so that it is visible and audible to the personnel who control the filling.

12.4.1.6 A high–liquid level flow cutoff device shall not be a substitute for the alarm.

12.4.2 High–Liquid Level Device.

12.4.2.1 The refrigerated LP-Gas container shall be equipped with a high–liquid level flow cutoff device that is independent from all gauges.

12.4.2.2 Refrigerated LP-Gas containers of 70,000 gal (265 m^3) or less, if attended during the filling operation, shall be permitted to be equipped with liquid trycocks in lieu of the high–liquid level alarm, and manual flow cutoff shall be permitted.

12.4.2.3 Each refrigerated LP-Gas container shall be provided with temperature-indicating devices that assist in controlling cooldown rates when placing the tank in service and monitoring product temperatures during operations.

12.4.3 Pressure and Vacuum Control.

12.4.3.1 Provisions shall be made to maintain the container pressure within the limits set by the design specifications by releasing or admitting gas as needed. Provision for admission and release of gas shall be by any means compatible with the gas handling facilities in the plant.

12.4.3.2 The option of gas admission (or other gas or vapor if so designed) through the vacuum relief valves provided in API Standard 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*, paragraph 7.2.3, shall not be permitted.

12.5 Refrigerated LP-Gas Container Impoundment.

12.5.1 Each refrigerated LP-Gas container shall be located within an impoundment that complies with Section 12.5.

12.5.2 Enclosed drainage channels for LP-Gas shall be prohibited.

12.5.3 Enclosure of container downcomers used to conduct spilled LP-Gas away from materials subject to failure upon exposure to liquid LP-Gas shall be permitted.

12.5.4 Impoundment for refrigerated LP-Gas containers shall have a volumetric holding capacity, with an allowance made for the displacement of snow accumulation, other containers, or equipment that is equal to the total liquid volume of the largest container served, assuming that container is full to the high–liquid level flow cutoff device.

12.5.5 Where more than one container is installed in a single impoundment and if an outside container wall is used as a spill containment dike, the material shall be selected to withstand exposure to the temperature of refrigerated LP-Gas liquid.

12.5.6 Impoundment structures and any penetrations thereof shall be designed to withstand the full hydrostatic head of the impounded LP-Gas and the effects of the product composition and the resulting autorefrigeration temperatures.

12.5.7 These structures shall also be nonporous and resistant to natural forces such as wind, rain, and fire.

12.5.8 Impoundment structures shall also be nonporous and resistant to natural forces such as wind, rain, and fire.

12.5.9 Provisions shall be made to clear rain or other water from the impounding area.

12.5.9.1 Where automatically controlled sump pumps are used, they shall be equipped with an automatic shutoff device that prevents their operation when exposed to LP-Gas temperatures.

12.5.9.2 LP-Gas vapors shall not exceed 25 percent of the lower flammable limit or other approved methods of LP-Gas liquid or vapor detection.

12.5.9.3 Gravity drainage utilizing piping penetrations through or below impoundment dikes shall not be permitted.

12.5.10 If the container impounding area is an earthen dike system, the area topography of the impounding area floor shall be graded away from the container to prevent the accumulation of liquid under or around the container.

12.5.10.1 The grading shall move the spilled liquid to the toe of the dike system and as far away from the container as possible.

12.5.10.2 The grading shall move the spilled liquid to a subimpoundment basin that is capable of holding the quantity of liquid spilled from line rupture, flange leak, or a source other than container failure.

12.5.10.3 The duration of the incident shall be the amount of time that automatic systems or plant personnel could effect emergency procedures and stop the leak. The subimpoundment basin shall be located as far away from the container as possible.

12.6 Inspection and Testing of Refrigerated LP-Gas Containers and Systems.

12.6.1 During construction and prior to the initial operation or commissioning, each refrigerated LP-Gas container and system shall be inspected or tested in accordance with the provisions of this code and the codes and standards referenced herein.

12.6.2 The inspections or tests required shall be conducted by the operator or a third-party engineering, scientific, recognized insurance, or inspection organization.

12.6.3 Each inspector shall be qualified in accordance with the code or standard that is applicable to the test or inspection being performed.

12.6.4 After acceptance tests are completed, there shall be no field welding on the LP-Gas containers except where allowed by the code under which the container was fabricated.

12.6.5 Retesting shall be required only if the retest tests the element affected and is necessary to demonstrate the adequacy of the repair or modification.

12.7 Container Siting.

12.7.1 Spacing of refrigerated LP-Gas containers designed to operate at greater than 15 psi (103 kPa) from occupied buildings, storage containers for flammable or combustible liquids, and lines of adjoining property that can be built upon shall be in accordance with Table 12.7.1.

12.7.2 Spacing of refrigerated LP-Gas containers that operate at below 15 psi (103 kPa) from occupied buildings, storage containers for flammable or combustible liquids, and lines of adjoining property that can be built upon shall be in accordance with Table 12.7.2.

Table 12.7.1 Minimum Distances

Water Capacity per Container		Aboveground Containers	
gal	m^3	ft	m
≤70,000	≤265	75	23
70,001–90,000	265–341	100	30
90,001–120,000	341–454	125	38
120,001–200,000	454–757	200	61
200,001–1,000,000	757–3785	300	91
>1,000,000	>3785	400	122

Table 12.7.2 Minimum Distances

Water Capacity per Container		Aboveground Containers	
gal	m^3	ft	m
≤70,000	≤265	75	25
>70,000	>265	100	30

12.7.3 The edge of a dike, impoundment, or drainage system that is intended for a refrigerated LP-Gas container shall be 100 ft (31 m) or more from a property line that can be built upon, a public way, or a navigable waterway.

12.7.4 Nonrefrigerated LP-Gas containers or flammable liquid tanks shall not be located within dikes or impoundments enclosing refrigerated LP-Gas containers.

12.7.5 Refrigerated LP-Gas containers shall not be installed one above the other.

12.7.6 The minimum distance between aboveground refrigerated LP-Gas containers shall be one-half the diameter of the larger container.

12.7.7 The ground within 25 ft (7.6 m) of any aboveground refrigerated LP-Gas container and all ground within a dike, impoundment, or drainage area shall be kept clear of readily ignitable materials such as weeds and long, dry grass.

12.8 Relief Devices.

12.8.1 General.

12.8.1.1 All containers shall be equipped with pressure and vacuum relief devices in accordance with Section 12.8.

12.8.1.2 Relief devices shall communicate directly with the atmosphere. Vacuum relieving devices shall be installed if the container can be exposed to a lower vacuum than the container is designed for.

12.8.1.3 Inlet and outlet piping connections to relief devices shall be included in the selection and sizing of relief devices.

12.8.1.4 A manually operated full opening stop valve shall be installed between each pressure and vacuum safety relief valve and the LP-Gas container.

12.8.1.5 All stop valves installed between a relief valve and a container shall be lockable or sealable in the fully open position.

12.8.1.6 A sufficient number of pressure and vacuum relief valves shall be installed on the LP-Gas container to allow each relief valve to be isolated individually while maintaining the full relieving capacities required.

12.8.1.7 Where only one relief device is required, either a full port opening three-way valve shall be installed between the container and two relief devices, or separate stop valves shall be beneath each relief device.

12.8.1.8 Stop valves under individual safety relief valves shall be locked or sealed when opened and shall not be opened or closed except by an authorized person.

12.8.1.9 No more than one stop valve shall be closed at one time.

12.8.1.10 Safety relief valve discharge stacks or vents shall be designed and installed to prevent an accumulation of water, ice, snow, or other foreign matter and shall discharge vertically upward.

12.8.1.11 All refrigerated storage container pressure and vacuum relief devices shall be tested or replaced at intervals not to exceed 5 years.

12.8.2 Pressure Relief Device Sizing. The pressure relief devices shall be sized to relieve the flow capacity determined for the largest single contingency or any reasonable and probable combination of contingencies that follow:

(1) Fire exposure
(2) Operational upset, such as failure of a control device
(3) Other circumstances resulting from equipment failures and operating errors
(4) Vapor displacement during filling
(5) Flash vaporization during filling, as a result of filling, or as a consequence of mixing of products of different compositions
(6) Loss of refrigeration
(7) Heat input from pump recirculation
(8) Drop in barometric pressure

12.8.3 Vacuum Relief Device Sizing.

12.8.3.1 The vacuum relief devices shall be sized to relieve the flow capacity determined for the largest single contingency or any reasonable and probable combination of contingencies that follow:

(1) Withdrawal of liquid or vapor at the maximum rate
(2) Rise in barometric pressure
(3) Reduction in vapor space pressure as a result of filling with subcooled liquid

12.8.3.2 Reduction in the vacuum relief capacity to allow for the rate of vaporization resulting from minimum normal heat gain to the contents of the container shall be allowed.

12.8.3.3 No vacuum relief capacity credit shall be allowed for gas-repressuring or vapor make-up systems.

12.8.4 Fire Exposure Sizing.

12.8.4.1 The pressure-relieving capacity required for fire exposure shall be computed by the following formula:

$$W = 34{,}500\frac{F}{L}A^{0.82} + \frac{H_n}{L}$$

where:
W = relieving capacity in lb/hr or product vapor at relieving conditions.
F = environmental factor from Table 12.8.4.1.
L = latent heat of vaporization of the stored liquid at the relieving pressure and temperature, in Btu/lb.
A = exposed wetted surface area of the container in ft^2. In the case of large containers, the exposed wetted area is the area up to a height of 30 ft above grade.
H_n = normal heat leak in refrigerated tanks in Btu/hr.

Table 12.8.4.1 Environmental Factors

Basis	*F* Factor
Base container	1.0
Water application facilities	1.0
Depressuring and emptying facilities	1.0
Underground container	0
Insulation or thermal protection	$F = \frac{U(1660 - T_f)}{34{,}500}$
Insulation or thermal protection (metric)	$F = \frac{U(904 - T_f)}{71{,}000}$

Note: U is the overall heat transfer coefficient Btu/(hr × ft^2 × °F) [W/(m^2 × °C)] of the insulation system using the mean value for the temperature range from T_f to +1660°F (904°C). T_f is the temperature of vessel content at relieving conditions, °F (°C).

12.8.4.2 Where credit for insulation is taken in sizing of a relief valve for fire exposure, the insulation shall comply with the following:

(1) Resist dislodgment by fire-fighting equipment
(2) Be noncombustible
(3) Not decompose at temperatures up to 1000°F

12.8.4.3 If the insulation does not meet the criteria of 12.8.4.2, no credit for the insulation shall be taken.

12.8.4.4 The equivalent airflow for relieving capacity shall be calculated by the following equation:

$$\text{SCFM (air)} = 3.09W\left(\frac{ZT}{M}\right)^{0.5}$$

where:
SCFM (air) = equivalent airflow in standard ft^3/min
W = relieving capacity of product vapor at relieving conditions, lb/hr
Z = compressibility factor product vapor at relieving conditions
T = absolute temperature of product vapor at relieving conditions, °R
M = product vapor molecular weight

Chapter 13 Marine Shipping and Receiving

13.1 Scope. This chapter applies to the transfer of LP-Gas between marine vessels and shore facilities.

13.2 Piers.

13.2.1 Design and Construction.

13.2.1.1* Design, construction, and operation of piers, docks, and wharves shall comply with relevant regulations and the requirements of the authorities having jurisdiction.

13.2.1.2 General cargo, flammable liquids, or compressed gases, other than ships' general stores for the LP-Gas tank vessel, shall not be handled over a pier or dock within 100 ft (30.5 m) of the point of transfer connection while LP-Gas or other flammable liquids are being transferred.

13.2.1.3 Trucks and other motorized vehicles shall be prohibited on the pier or dock within 100 ft (30.5 m) of the transfer connection while transfer operations are in progress.

13.2.1.4 Authorized parking areas, if provided for in the waterfront area, shall be marked.

13.2.1.5 Warning signs or barricades shall be used to indicate when transfer operations are in progress.

13.2.1.6 Unauthorized individuals shall not be allowed access to the waterfront area while the LP-Gas vessel is alongside the pier or dock.

13.2.1.7 Security personnel shall restrict the entry of visitors, delivery trucks, and service personnel to those authorized by the facility operator.

13.2.1.8 The shore mooring equipment shall be designed and maintained to safely hold the vessel to the pier or dock.

13.2.1.9 All electrical equipment and wiring installed on the pier or dock shall comply with 6.20.2.1 and 6.20.2.2.

13.2.1.10 If the terminal conducts transfers between sunset and sunrise, the pier or dock area shall have a lighting system that illuminates the following:

(1) Transfer connection area
(2) Control valves
(3) Storage containers
(4) Other equipment
(5) Walkways, fire fighting, and other emergency areas

13.2.1.11 All lighting shall be located or shielded so that it is not confused with any aids to navigation and does not interfere with navigation on the adjacent waterway.

13.2.1.12 Welding and cutting shall be in accordance with NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*.

13.2.1.13 Smoking shall be prohibited in all areas other than conspicuously marked, designated areas.

13.2.1.14 Medical first aid equipment and fire extinguishers shall be available at the shore facility. This equipment shall be in accordance with the following:

(1) Extinguishers shall be ready for use at all times.
(2) Emergency equipment shall be positioned and ready to operate prior to the start of the transfer operation.
(3) The locations of all fire extinguishers shall be marked and readily accessible.

13.2.2 Transfer Operations.

13.2.2.1 Prior to the start of the transfer, warning signs, as shown in Figure 13.2.2.1, shall be placed in the marine transfer area, visible from the shoreline and berth areas. The warning signs shall read as follows:

WARNING
DANGEROUS CARGO
NO VISITORS
NO SMOKING
NO OPEN LIGHT

FIGURE 13.2.2.1 Warning Signs to be Placed in Marine Transfer Area.

13.2.2.2 A portable LP-Gas detector calibrated to detect LP-Gas shall be readily available for use at the berth.

13.2.2.3 Portable electrical equipment used within 100 ft (30.5 m) of the transfer connection while transfer operations are in progress either shall be listed for Class I, Division 1 or shall be intrinsically safe.

13.2.2.4 When the transfer operation is completed (secured) and the transfer piping is disconnected, the equipment used shall be in compliance with 6.20.2.1 and 6.20.2.2.

13.2.2.5 The following life safety equipment shall be positioned on the berth and be ready for immediate use while personnel are working on the berth or a vessel is alongside:

(1) Life rings with attendant rope of sufficient length
(2) Approved fire blanket
(3) Flotation vests or immersion suits suitable for the water temperature at the berth and the personnel involved in the work

13.3 Pipelines.

13.3.1* Pipelines shall be located on the dock or pier so that they are not exposed to damage from vehicular traffic or other possible cause of physical damage.

13.3.1.1 Underwater pipelines shall be located or protected so that they are not exposed to damage from marine traffic.

13.3.1.2 The locations of underwater pipelines shall be posted or identified in accordance with federal regulations.

13.3.2 Isolation valving and bleed connections shall be provided at the loading or unloading manifold for both liquid and vapor return lines so that hoses and arms can be blocked off, drained or pumped out, and depressurized before disconnecting.

13.3.2.1 Liquid isolation valves and vapor valves 8 in. (20 mm) and larger in size shall be equipped with powered operators in addition to means for manual operation.

13.3.2.2 Power-operated valves shall be capable of being closed from a remote control station located at least 50 ft (15 m) from the manifold area, as well as locally.

13.3.2.3 Unless the valve will automatically fail closed on loss of power, the valve actuator and its power supply within 50 ft

(15 m) of the valve shall be protected against operational failure due to fire exposure of at least 10 minutes.

13.3.2.4 Valves shall be located at the point of hose or arm connection to the manifold.

13.3.2.5 In addition to the isolation valves at the manifold, each vapor return and liquid transfer line shall be provided with a readily accessible isolation valve located on shore near the approach to the pier or dock.

13.3.2.6 Where more than one line exists, the valves shall be grouped in one location.

13.3.2.7 Valves shall be identified as to their service.

13.3.2.8 Valves 8 in. (20 mm) and larger in size shall be equipped with power operators.

13.3.2.9 Means for manual operation of valves shall be provided.

13.3.3 Pipelines used for liquid unloading only shall be provided with a check valve located at the manifold adjacent to the manifold isolation valve.

13.3.4 All pipelines, conduits, and other conductive lines on the berth capable of carrying an electrical charge shall be equipped with insulating flanges or other means to electrically isolate them from stray currents and the rest of the terminal.

13.3.5 If a stray current (bonding) cable is not used between the facility and the vessel, insulating flanges shall be installed in the pipe risers to the off-loading connections between the vessel and the shore facility.

13.3.6 All shore facilities shall provide a low-resistance stray current (bonding) cable to be connected to the vessels.

13.3.6.1 Electrical continuity between the vessel and the berth shall be verified prior to transfer operations.

13.3.6.2 The cable shall be connected to the vessel prior to the connection of the unloading hoses/arms and shall remain connected until after the hoses/arms have been disconnected.

13.4 Inspections Prior to Transfer.

13.4.1* Prior to starting transfer operations, the officer in charge of the vessel transfer operation and the person in charge of the shore facility shall inspect their respective facilities.

13.4.1.1 The inspection shall ensure that all cargo transfer equipment and hoses have been maintained and tested and are in operating condition.

13.4.1.2 Following this inspection, the officers in charge shall meet to discuss the transfer procedures, and, when ready, each will notify the other that each facility is ready in all respects to start transfer operations.

13.4.2 The shore facility transfer system shall be equipped with a remotely operated emergency shutdown system.

13.4.3 A facilities emergency procedures manual shall be readily available and shall contain the following information:

(1) LP-Gas release response and emergency shutdown procedures
(2) Telephone number for all emergency response organizations, U.S. Coast Guard, emergency medical facilities, and hospital(s)
(3) Description and location of the facility fire systems and emergency equipment

13.4.4 A facilities standard operating procedures manual shall be readily available and shall contain the following information:

(1) Procedures for startup, operation, and shutdown of the transfer system and equipment
(2) Procedures for cooling down the transfer hose and line where refrigerated LP-Gas is transferred
(3) Telephone numbers for all emergency response organizations, U.S. Coast Guard, emergency medical facilities, and hospital(s)
(4) Description, location, and operational guidelines for the facility fire systems and emergency equipment

13.4.5 Each transfer operation shall be conducted in accordance with the operations manual.

13.4.6 At the completion of the transfer, and prior to disconnect of the transfer hose or arm, the transfer connection shall be purged of all liquid and depressurized. The liquid and vapor pressure shall be returned either to the vessel or to the shore facility. LP-Gas shall not be vented to the atmosphere.

Chapter 14 Operations and Maintenance

14.1* Scope. This chapter includes requirements related to the operations and maintenance of bulk plant, industrial plant, refrigerated, marine, and pipeline LP-Gas systems. If stated elsewhere in the code, operation and maintenance requirements are referenced to those sections.

14.2 Operating Requirements.

14.2.1* Operating Procedures.

14.2.1.1 The procedures required in 14.2.1 shall address all aspects of LP-Gas transfer, as appropriate for the facility, including inspection of hoses and fittings and connection and disconnection procedures.

14.2.1.2 Operating procedures shall include operator actions to be taken if flammable concentrations of flammable liquids or gases are detected in the facility using fixed detectors, portable detectors, operating malfunctions, or human senses.

14.2.1.3 Operating procedures for vaporizers shall include maintenance of vaporization rate, pressure control, and temperature. Procedures shall include specific actions to be taken when parameters exceed normal operating limits and criteria for emergency shutdown.

14.2.1.4 In facilities where propane is stored as a refrigerated liquid, operating procedures shall include monitoring of liquid temperature and pressure and procedures to be taken if these exceed operating limits. These procedures shall minimize the release of flammable gases to the atmosphere.

14.2.1.5 Each facility shall prepare and maintain written operating procedure manuals that contain the written operating procedures required by 14.2.1 in a common location or locations.

14.2.2 Content of Operating Procedures.

14.2.2.1 Written procedures shall be the basis for conducting activities associated with the systems referenced above. Operating procedures shall be updated whenever a change occurs that affects the operation of a system and prior to its startup. The written procedures shall address the requirements in 14.2.2.2 and 14.2.2.3, where applicable.

14.2.2.2* General operating procedures shall include the following:

(1) General procedures *(See 13.4.3 and 13.4.4)*
(2) Combustible material *(See 6.4.5.2 and 6.6.5.2)*
(3) Sources of ignition *[See 6.20.3, 6.21.9.1(3), 7.2.3.2, and 9.4.10]*
(4) Signage and markings *[See 5.2.1.1, 5.7.6.5, 5.7.8.3, 5.7.8.8, 5.7.11.5, 6.4.5.11, 6.9.5, 6.10.6, 6.10.10(2), 6.22.3.11, 6.23.4.4, 6.24.4.3(C), 6.24.5.1(B), 7.2.3.6, 9.3.2.10, 9.3.3.7, 9.4.6, 11.3.4, Section 11.11, and 13.2.1.14]*
(5) Containers *(See 5.7.6.3, Section 6.6, 6.24.3.1, 7.2.3.1, 7.3.2, 7.3.2.2, 7.3.2.3, 7.3.2.4, 7.4.2, 7.4.3, 8.2.1, and 9.3.2.4)*
(6) Security and access *(See 7.2.3.1)*
(7) Fire response *(See 6.23.4.3)*

14.2.2.3 Loading and unloading procedures shall include the following:

(1) Hoses *(See 6.22.4, 7.2.4, and 13.4.6)*
(2) Chocks *[See 7.2.3.6(2) and 9.4.8]*
(3) Fire extinguishers *(See 6.23.4.2, Section 8.5, 9.4.7, and 13.2.1.14)*
(4) Sources of ignition *[See 7.2.3.2, 7.2.3.5, 7.2.3.8(2), 7.2.3.8(3), and 9.4.10]*
(5) Personnel *(See 7.2.1)*
(6) Containers *(See 5.2.2.1, 5.2.2.2, 7.2.2.1, 7.2.2.2, 7.2.2.3, 7.2.2.4, 7.2.2.5, 7.2.2.6, 7.2.2.8, 7.2.2.9, 7.2.2.12, 7.2.3.3, 9.3.2.6, 9.3.2.7, and 9.3.2.8)*
(7) Signage *(See 7.2.3.6)*
(8) Security and access *(See 7.2.3.1)*
(9) Fire response *(See 6.23.4.3 and 6.23.4.4)*
(10) Ammonia contamination *(See Section 4.5)*

14.3 Maintenance.

14.3.1 Maintenance Procedures. Written maintenance procedures shall be the basis for maintaining the mechanical integrity of LP-Gas systems.

14.3.1.1 Procedures shall be updated whenever a change occurs that affects the maintenance of a system.

14.3.1.2 Persons who perform maintenance on these LP-Gas systems shall be trained in the hazards of the system and in the maintenance and testing procedures applicable to the installation.

14.3.1.3 Any maintenance contractor shall ensure that each contract maintenance employee is so trained or under the immediate supervision of such a trained person to perform the maintenance procedures.

14.3.1.4 The written procedures shall address the following requirements, where applicable:

(1) Corrosion control *[See 5.2.1.4, 6.6.1.4, 6.6.3.5, Section 6.14, 6.6.6.1(I), 6.6.6.2(1), 6.6.6.3(1), and 6.6.6.3(4)]*
(2) Physical protection *(See 5.7.10.2, 6.6.1.2, and 6.22.3.9)*
(3) Hoses *(See 6.23.4.1, 7.2.4, and 9.4.3.7)*
(4) Piping *(See 6.8.3.10, and 6.10.7)*
(5) Appurtenances *(See 6.7.2.4, and 6.10.9)*
(6) Containers *(See 5.2.1.2, 5.2.3.1, 5.2.3.2, 5.7.1.4, 5.7.7.4, 12.3.3.4 , 12.3.4.3(4), 12.3.4.4, and 12.3.4.6)*
(7) Cylinders *(See 5.2.3.1)*

14.3.2 Maintenance Manuals.

14.3.2.1 Maintenance manuals for all equipment at the facility shall be kept at the facility and shall be available to maintenance personnel. Manuals for normally unattended facilities shall be permitted to be stored at a location where they will be accessible for maintenance personnel servicing the unattended location.

14.3.2.2 Maintenance manuals shall include routine inspections and preventative maintenance procedures and schedules.

14.3.2.3 Each facility shall maintain a record of all maintenance of fixed equipment used to store and transfer LP-Gas. Maintenance records for normally unattended facilities shall be maintained at the unattended facility or at another location.

14.3.2.4 Maintenance records shall be made available to the authority having jurisdiction during normal office hours.

14.3.2.5 Maintenance records shall be retained for the life of the equipment.

14.3.3 Maintenance of Fire Protection Equipment.

14.3.3.1 Facilities shall prepare and implement a maintenance program for all plant fire protection equipment.

14.3.3.2 Maintenance activities on fire protection equipment shall be scheduled so that a minimum of equipment is taken out of service at any time and is returned to service in a reasonable period of time.

14.3.3.3 Water-based automatic fire-extinguishing systems shall be maintained in accordance with NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.*

14.3.3.4 Portable fire extinguishers shall be maintained in accordance with NFPA 10, *Standard for Portable Fire Extinguishers.*

Chapter 15 Pipe and Tubing Sizing Tables

15.1 Tables for Sizing Pipe and Tubing. When the pipe sizing method of 6.8.2.2 is used, either Table 15.1(a) through Table 15.1(q), or other approved piping tables shall be used to size piping systems. For SI units, 1 ft^3 = 0.028 m^3, 1 ft = 0.305 m, 1 in. water column = 2.49 kPa, 1 psi = 6.894 kPa, and 1000 Btu/hr = 0.203 kW.

Table 15.1(a) Pipe Sizing Between First-Stage and Second-Stage Regulators: Nominal Pipe Size, Schedule 40

Pipe Length (ft)	½ in. 0.622	¾ in. 0.824	1 in. 1.049	1¼ in. 1.38	1½ in. 1.61	2 in. 2.067	3 in. 3.068	3½ in. 3.548	4 in. 4.026
30	1843	3854	7259	14904	22331	43008	121180	177425	247168
40	1577	3298	6213	12756	19113	36809	103714	151853	211544
50	1398	2923	5507	11306	16939	32623	91920	134585	187487
60	1267	2649	4989	10244	15348	29559	83286	121943	169877
70	1165	2437	4590	9424	14120	27194	76622	112186	156285
80	1084	2267	4270	8767	13136	25299	71282	104368	145393
90	1017	2127	4007	8226	12325	23737	66882	97925	136417
100	961	2009	3785	7770	11642	22422	63176	92499	128859
150	772	1613	3039	6240	9349	18005	50733	74280	103478
200	660	1381	2601	5340	8002	15410	43421	63574	88564
250	585	1224	2305	4733	7092	13658	38483	56345	78493
300	530	1109	2089	4289	6426	12375	34868	51052	71120
350	488	1020	1922	3945	5911	11385	32078	46967	65430
400	454	949	1788	3670	5499	10591	29843	43694	60870
450	426	890	1677	3444	5160	9938	28000	40997	57112
500	402	841	1584	3253	4874	9387	26449	38725	53948
600	364	762	1436	2948	4416	8505	23965	35088	48880
700	335	701	1321	2712	4063	7825	22047	32280	44969
800	312	652	1229	2523	3780	7279	20511	30031	41835
900	293	612	1153	2367	3546	6830	19245	28177	39253
1000	276	578	1089	2236	3350	6452	18178	26616	37078
1500	222	464	875	1795	2690	5181	14598	21373	29775
2000	190	397	748	1537	2302	4434	12494	18293	25483

Note: Maximum undiluted propane capacities listed are based on a gauge pressure of 10 psi first stage setting and 1 psi pressure drop. Capacities in 1000 Btu/hr.

Table 15.1(b) Pipe Sizing Between 2-psi Service Regulator and Line Pressure Regulator: Nominal Pipe Size, Schedule 40

Pipe Length (ft)	½ in. 0.622	¾ in. 0.824	1 in. 1.049	1¼ in. 1.380	1½ in. 1.610	2 in. 2.067	3 in. 3.068	3½ in. 3.548	4 in. 4.026
10	2687	5619	10585	21731	32560	62708	176687	258696	360385
20	1847	3862	7275	14936	22378	43099	121436	177800	247690
30	1483	3101	5842	11994	17971	34610	97517	142780	198904
40	1269	2654	5000	10265	15381	29621	83462	122201	170236
50	1125	2352	4431	9098	13632	26253	73971	108305	150877
60	1019	2131	4015	8243	12351	23787	67023	98132	136706
70	938	1961	3694	7584	11363	21884	61660	90280	125767
80	872	1824	3436	7055	10571	20359	57363	83988	117002
90	819	1712	3224	6620	9918	19102	53822	78803	109779
100	773	1617	3046	6253	9369	18043	50840	74437	103697
150	621	1298	2446	5021	7524	14490	40826	59776	83272
200	531	1111	2093	4298	6439	12401	34942	51160	71270
250	471	985	1855	3809	5707	10991	30968	45342	63166
300	427	892	1681	3451	5171	9959	28060	41083	57233
350	393	821	1546	3175	4757	9162	25814	37796	52653
400	365	764	1439	2954	4426	8523	24015	35162	48984
450	343	717	1350	2771	4152	7997	22533	32991	45960
500	324	677	1275	2618	3922	7554	21284	31164	43413
600	293	613	1155	2372	3554	6844	19285	28236	39336
700	270	564	1063	2182	3270	6297	17742	25977	36188
800	251	525	989	2030	3042	5858	16506	24167	33666
900	236	493	928	1905	2854	5496	15487	22675	31588
1000	222	465	876	1799	2696	5192	14629	21419	29838
1500	179	374	704	1445	2165	4169	11747	17200	23961
2000	153	320	602	1237	1853	3568	10054	14721	20507

Note: Maximum undiluted propane capacities listed are based on a 2-psig setting and a 1-psi pressure drop. Capacities in 1000 Btu/hr.

Table 15.1(c) Pipe Sizing Between Second-Stage Regulator and Appliance: Nominal Pipe Size, Schedule 40

Pipe Length (ft)	½ in. 0.622	¾ in. 0.824	1 in. 1.049	1¼ in. 1.38	1½ in. 1.61	2 in. 2.067	3 in. 3.068	3½ in. 3.548	4 in. 4.026
10	291	608	1146	2353	3525	6789	19130	28008	39018
20	200	418	788	1617	2423	4666	13148	19250	26817
30	161	336	632	1299	1946	3747	10558	15458	21535
40	137	287	541	1111	1665	3207	9036	13230	18431
50	122	255	480	985	1476	2842	8009	11726	16335
60	110	231	435	892	1337	2575	7256	10625	14801
80	94	198	372	764	1144	2204	6211	9093	12668
100	84	175	330	677	1014	1954	5504	8059	11227
125	74	155	292	600	899	1731	4878	7143	9950
150	67	141	265	544	815	1569	4420	6472	9016
200	58	120	227	465	697	1343	3783	5539	7716
250	51	107	201	412	618	1190	3353	4909	6839
300	46	97	182	374	560	1078	3038	4448	6196
350	43	89	167	344	515	992	2795	4092	5701
400	40	83	156	320	479	923	2600	3807	5303

Note: Maximum undiluted propane capacities listed are based on 11 in w.c. setting and 0.5 in pressure drop.
Capacities in Btu/hr.
Source: NFPA 54, *National Fuel Gas Code*, 2002 edition, Table 12.24.

Table 15.1(d) Pipe Sizing Between First-Stage and Second-Stage Regulators: Nominal Pipe Size, Schedule 80

Pipe Length (ft)	½ in. 0.546	¾ in. 0.742	1 in. 0.957	1¼ in. 1.278	1½ in. 1.5	2 in. 1.939	3 in. 2.9	3½ in. 3.364	4 in. 3.826
30	1309	2927	5706	12185	18548	36368	104539	154295	216246
40	1121	2505	4884	10429	15875	31127	89472	132057	185079
50	993	2221	4328	9243	14069	27587	79297	117039	164032
60	900	2012	3922	8375	12748	24996	71849	106046	148625
70	828	1851	3608	7705	11728	22996	66100	97561	136733
80	770	1722	3357	7168	10911	21393	61494	90762	127204
90	723	1616	3149	6725	10237	20073	57697	85159	119351
100	683	1526	2975	6353	9670	18960	54501	80440	112738
150	548	1226	2389	5105	7765	15236	43766	64596	90533
200	469	1049	2045	4366	6646	13031	37458	55286	77484
250	416	930	1812	3870	5890	11549	33198	48999	68673
300	377	842	1642	3506	5337	10465	30080	44397	62223
350	347	775	1511	3226	4910	9627	27673	40844	57244
400	322	721	1405	3001	4568	8956	25745	37998	53255
450	303	676	1318	2816	4286	8403	24155	35652	49967
500	286	639	1245	2660	4048	7938	22817	33677	47199
600	259	579	1128	2410	3668	7192	20674	30514	42765
700	238	533	1038	2217	3375	6617	19020	28072	39344
800	222	495	966	2062	3139	6156	17694	26116	36602
900	208	465	906	1935	2946	5776	16602	24504	34342
1000	196	439	856	1828	2782	5456	15682	23146	32439
1500	158	353	687	1468	2234	4381	12593	18587	26050
2000	135	302	588	1256	1912	3750	10778	15908	22295

Notes:
(1) Maximum undiluted propane capacities listed are based on a gauge pressure of 10 psi first-stage setting and 1 psi pressure drop. Capacities in 1000 Btu/hr.
(2) To convert to capacities at a gauge pressure of 5 psi with 10 percent (0.5 psi) pressure drop, multiply values by 0.606. To convert to capacities at a gauge pressure of 15 psi with 10 percent (1.5 psi) pressure drop, multiply values by 1.380.

Table 15.1(e) Pipe Sizing Between Second-Stage Regulator and Appliance: Nominal Pipe Size, Schedule 80

Pipe Length (ft)	½ in. 0.546	¾ in. 0.742	1 in. 0.957	1¼ in. 1.278	1½ in. 1.5	2 in. 1.939	3 in. 2.9	3½ in. 3.364	4 in. 3.826
10	207	462	901	1924	2928	5741	16503	24357	34137
20	142	318	619	1322	2012	3946	11342	16740	23462
30	114	255	497	1062	1616	3169	9108	13443	18841
40	98	218	426	909	1383	2712	7795	11506	16125
50	87	193	377	805	1226	2404	6909	10197	14292
60	78	175	342	730	1111	2178	6260	9239	12949
80	67	150	292	625	951	1864	5358	7908	11083
100	59	133	259	553	842	1652	4748	7009	9823
125	53	118	230	491	747	1464	4208	6212	8706
150	48	107	208	444	677	1327	3813	5628	7888
200	41	91	178	380	579	1135	3264	4817	6751
250	36	81	158	337	513	1006	2892	4269	5983
300	33	73	143	305	465	912	2621	3868	5421
350	30	68	132	281	428	839	2411	3559	4987
400	28	63	122	261	398	780	2243	3311	4640

Note: Maximum undiluted propane capacities listed are based on a 11 in. w.c. setting and 0.5 in. w.c. pressure drop. Capacities in 1000 Btu/hr.

Table 15.1(f) Pipe Sizing Between First-Stage and Second-Stage Regulators: Outside Diameter Copper Tubing, Type K

Tubing Length (ft)	⅜ in. 0.305	½ in. 0.402	⅝ in. 0.527	¾ in. 0.652	⅞ in. 0.745
30	284	587	1193	2085	2959
40	243	502	1021	1785	2532
50	216	445	905	1582	2244
60	195	403	820	1433	2033
70	180	371	754	1319	1871
80	167	345	702	1227	1740
90	157	374	659	1151	1633
100	148	306	622	1087	1542
150	119	246	500	873	1239
200	102	210	428	747	1060
250	90	186	379	662	940
300	82	169	343	600	851
350	75	155	316	552	783
400	70	144	294	514	729
450	66	136	276	482	654
500	62	128	260	455	646
600	56	116	236	412	585
700	52	107	217	379	538
800	48	99	202	353	501
900	45	93	189	331	470
1000	43	88	179	313	444
1500	34	71	144	251	356
2000	29	60	123	215	305

Notes:

(1) Maximum undiluted propane capacities listed are based on a gauge pressure of 10 psi first-stage setting and 1 psi pressure drop. Capacities in 1000 Btu/hr.

(2) To convert to capacities at a gauge pressure of 5 psi setting with 10 percent (0.5 psi) pressure drop, multiply values by 0.606. To convert to capacities at a gauge pressure of 15 psi setting with 10 percent (1.5 psi) pressure drop, multiply values by 1.380.

Table 15.1(g) Copper Tube Sizing Between Second-Stage Regulator and Appliance: Outside Diameter Copper Tubing, Type K

Tubing Length (ft)	⅜ in. 0.305	½ in. 0.402	⅝ in. 0.527	¾ in. 0.652	⅞ in. 0.745
10	45	93	188	329	467
20	31	64	129	226	321
30	25	51	104	182	258
40	21	44	89	156	221
50	19	39	79	138	196
60	17	35	71	125	177
80	15	30	61	107	152
100	13	27	54	95	134
125	11	24	48	84	119
150	10	21	44	76	108
200	9	18	37	65	92
250	8	16	33	58	82
300	7	15	30	52	74
350	7	14	28	48	68
400	6	13	26	45	63

Note: Maximum undiluted propane capacities listed are based on an 11 in. w.c. setting and 0.5 in. w.c. pressure drop. Capacities in 1000 Btu/hr.

Table 15.1(h) Copper Tube Sizing Between First-Stage and Second-Stage Regulators

Tubing Length (ft)	Outside Diameter Copper Tubing, Type L					Tubing Length (ft)	Outside Diameter Copper Tubing, Type L				
	⅜ in. 0.315	½ in. 0.430	⅝ in. 0.545	¾ in. 0.666	⅞ in. 0.785		⅜ in. 0.315	½ in. 0.430	⅝ in. 0.545	¾ in. 0.666	⅞ in. 0.785
30	309	700	1303	2205	3394	350	82	185	345	584	898
40	265	599	1115	1887	2904	400	76	172	321	543	836
50	235	531	988	1672	2574	450	71	162	301	509	784
60	213	481	896	1515	2332	500	68	153	284	481	741
70	196	443	824	1394	2146	600	61	138	258	436	671
80	182	412	767	1297	1996	700	56	127	237	401	617
90	171	386	719	1217	1873	800	52	118	221	373	574
100	161	365	679	1149	1769	900	49	111	207	350	539
150	130	293	546	923	1421	1000	46	105	195	331	509
200	111	251	467	790	1216	1500	37	84	157	266	409
250	90	222	414	700	1078	2000	32	72	134	227	350
300	89	201	375	634	976						

Note: Maximum undiluted propane capacities listed are based on a pressure of 10 psig first-stage setting and 1 psi pressure drop. Capacities in 1000 Btu/hr.

Table 15.1(i) Copper Tube Sizing Between 2-psi Service Regulator and Line Pressure Regulator: Outside Diameter Copper Tubing, Type L

Tubing (O.D.) Tubing (I.D.) Length (ft)	⅜ in. 0.315	½ in. 0.430	⅝ in. 0.545	¾ in. 0.666	⅞ in. 0.785
10	451	1020	1900	3215	4948
20	310	701	1306	2210	3401
30	249	563	1049	1774	2731
40	213	482	898	1519	2337
50	189	427	795	1346	2071
60	171	387	721	1219	1877
70	157	356	663	1122	1727
80	146	331	617	1044	1606
90	137	311	579	979	1507
100	130	294	547	925	1424
150	104	236	439	743	1143
200	89	202	376	636	979
250	79	179	333	563	867
300	72	162	302	511	786
350	66	149	278	470	723
400	61	139	258	437	673
450	58	130	242	410	631
500	54	123	229	387	596
600	49	111	207	351	540
700	45	102	191	323	497
800	42	95	177	300	462
900	40	89	167	282	434
1000	37	84	157	266	410
1500	30	68	126	214	329
2000	26	58	108	183	282

Note: Maximum undiluted propane capacity based on a gauge pressure setting of 2 psig and 1 psi pressure drop. Capacities in 1000 Btu/hr.

Table 15.1(j) Copper Tube Sizing Between Single-Stage or Second-Stage Regulator and Appliance: Outside Diameter Copper Tubing, Type L

Tubing Length (ft)	⅜ in. 0.315	½ in. 0.430	⅝ in. 0.545	¾ in. 0.666	⅞ in. 0.785
10	49	110	206	348	536
20	34	76	141	239	368
30	27	61	114	192	296
40	23	52	97	164	253
50	20	46	86	146	224
60	19	42	78	132	203
80	16	36	67	113	174
100	14	32	59	100	154
125	12	28	52	89	137
150	11	26	48	80	124
200	10	22	41	69	106
250	9	19	36	61	94
300	8	18	33	55	85
350	7	16	30	51	78
400	7	15	28	47	73

Note: Maximum undiluted propane capacities listed are based on an 11 in. setting and a 0.5 in. w.c. drop.

Table 15.1(k) Pipe Sizing Between First-Stage and Second-Stage Regulators: Outside Diameter Refrigeration Tubing

Tubing Length (ft)	⅜ in. 0.311	½ in. 0.436	⅝ in. 0.555	¾ in. 0.68	⅞ in. 0.785
30	299	726	1367	2329	3394
40	256	621	1170	1993	2904
50	227	551	1037	1766	2574
60	206	499	939	1600	2332
70	189	459	864	1472	2146
80	176	427	804	1370	1996
90	165	401	754	1285	1873
100	156	378	713	1214	1769
150	125	304	572	975	1421
200	107	260	490	834	1216
250	95	230	434	739	1078
300	86	209	393	670	976
350	79	192	362	616	898
400	74	179	337	573	836
450	69	168	316	538	784
500	65	158	298	508	741
600	59	144	270	460	671
700	54	132	249	424	617
800	51	123	231	394	574
900	48	115	217	370	539
1000	45	109	205	349	509
1500	36	87	165	281	409
2000	31	75	141	240	350

Notes:

(1) Maximum undiluted propane capacities listed are based on a gauge pressure of 10 psi first-stage setting and 1 psi pressure drop. Capacities in 1000 Btu/hr.

(2) To convert to capacities at a gauge pressure of 5 psi setting with 10 percent (0.5 psi) pressure drop, multiply values by 0.606. To convert to capacities at a gauge pressure of 15 psi setting with 10 percent (1.5 psi) pressure drop, multiply values by 1.380.

Table 15.1(l) Copper Tube Sizing Between Second-Stage Regulator and Appliance: Outside Diameter of Copper Refrigeration Tubing

Tubing Length (ft)	⅜ in. 0.311	½ in. 0.436	⅝ in. 0.555	¾ in. 0.68	⅞ in. 0.785
10	47	115	216	368	536
20	32	79	148	253	368
30	26	63	119	203	296
40	22	54	102	174	253
50	20	48	90	154	224
60	18	43	82	139	203
80	15	37	70	119	174
100	14	33	62	106	154
125	12	29	55	94	137
150	11	26	50	85	124
200	9	23	43	73	106
250	8	20	38	64	94
300	8	18	34	58	85
350	7	17	32	54	78
400	6	16	29	50	73

Note: Maximum undiluted propane capacities listed are based on an 11 in. w.c. setting and 0.5 in. w.c. pressure drop. Capacities in 1000 Btu/hr.

Table 15.1(m) Maximum Capacity of CSST in Thousands of Btu per Hour of Undiluted Liquefied Petroleum Gases at a Pressure of 2 psig and a Pressure Drop of 1 psi (Based on 1.52 Specific Gravity Gas)

EHD* Flow Designation	Tubing Length (ft)													
	10	25	30	40	50	75	80	110	150	200	250	300	400	500
13	426	262	238	203	181	147	140	124	101	86	77	69	60	53
15	558	347	316	271	243	196	189	169	137	118	105	96	82	72
18	927	591	540	469	420	344	333	298	245	213	191	173	151	135
19	1106	701	640	554	496	406	393	350	287	248	222	203	175	158
23	1735	1120	1027	896	806	663	643	578	477	415	373	343	298	268
25	2168	1384	1266	1100	986	809	768	703	575	501	448	411	355	319
30	4097	2560	2331	2012	1794	1457	1410	1256	1021	880	785	716	616	550
31	4720	2954	2692	2323	2072	1685	1629	1454	1182	1019	910	829	716	638

Notes:

(1) Table does not include effect of pressure drop across the line regulator. If regulator loss exceeds ½ psi (based on 13 in. w.c. outlet pressure), DO NOT USE THIS TABLE. Consult with regulator manufacturer for pressure drops and capacity factors. Pressure drops across a regulator can vary with flow rate.

(2) CAUTION: Capacities shown in table can exceed maximum capacity for a selected regulator. Consult with regulator or tubing manufacturer for guidance.

3. Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger number of bends or fittings shall be increased by an equivalent length of tubing according to the following equation: $L = 1.3n$ where L is additional length (ft) of tubing and n is the number of additional fittings or bends.

* EHD — equivalent hydraulic diameter — a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.

Source: NFPA 54, *National Fuel Gas Code*, 2002 edition, Table 12.29.

Table 15.1(n) Maximum Capacity of CSST in Thousands of Btu per Hour of Undiluted Liquefied Petroleum Gases at a Pressure of 11-in. Water Column and a Pressure Drop of 0.5-in. Water Column (Based on 1.52 Specific Gravity Gas)

EHD* Flow Designation	Tubing Length (ft)																
	5	10	15	20	25	30	40	50	60	70	80	90	100	150	200	250	300
13	72	50	39	34	30	28	23	20	19	17	15	15	14	11	9	8	8
15	99	69	55	49	42	39	33	30	26	25	23	22	20	15	14	12	11
18	181	129	104	91	82	74	64	58	53	49	45	44	41	31	28	25	23
19	211	150	121	106	94	87	74	66	60	57	52	50	47	36	33	30	26
23	355	254	208	183	164	151	131	118	107	99	94	90	85	66	60	53	50
25	426	303	248	216	192	177	153	137	126	117	109	102	98	75	69	61	57
30	744	521	422	365	325	297	256	227	207	191	178	169	159	123	112	99	90
31	863	605	490	425	379	344	297	265	241	222	208	197	186	143	129	117	107

Note: Table includes losses for four 90-degree bends and two end fittings. Tubing runs with larger numbers of bends or fittings shall be increased by an equivalent length of tubing to the following equation: $L = 1.3n$ where L is additional length (ft) of tubing and n is the number of additional fittings or bends.
* EHD — equivalent hydraulic diameter — a measure of the relative hydraulic efficiency between different tubing sizes. The greater the value of EHD, the greater the gas capacity of the tubing.
Source: NFPA 54, *National Fuel Gas Code*, 2002 edition, Table 12.28.

Table 15.1(o) Polyethylene Plastic Pipe Sizing Between First-Stage and Second-Stage Regulators: Nominal Outside Diameter (IPS)

Plastic Pipe Length (ft)	½ in. SDR 9.33 (0.660)	¾ in. SDR 11.0 (0.860)	1 in. SDR 11.00 (1.077)	1¼ in. SDR 10.00 (1.328)	1½ in. SDR 11.00 (1.554)	2 in. SDR 11.00 (1.943)
30	2143	4292	7744	13416	20260	36402
40	1835	3673	6628	11482	17340	31155
50	1626	3256	5874	10176	15368	27612
60	1473	2950	5322	9220	13924	25019
70	1355	2714	4896	8483	12810	23017
80	1261	2525	4555	7891	11918	21413
90	1183	2369	4274	7404	11182	20091
100	1117	2238	4037	6994	10562	18978
125	990	1983	3578	6199	9361	16820
150	897	1797	3242	5616	8482	15240
175	826	1653	2983	5167	7803	14020
200	778	1539	2775	4807	7259	13043
225	721	1443	2603	4510	6811	12238
250	681	1363	2459	4260	6434	11560
275	646	1294	2336	4046	6111	10979
300	617	1235	2228	3860	5830	10474
350	567	1136	2050	3551	5363	9636
400	528	1057	1907	3304	4989	8965
450	495	992	1789	3100	4681	8411
500	468	937	1690	2928	4422	7945
600	424	849	1531	2653	4007	7199
700	390	781	1409	2441	3686	6623
800	363	726	1311	2271	3429	6161
900	340	682	1230	2131	3217	5781
1000	322	644	1162	2012	3039	5461
1500	258	517	933	1616	2441	4385
2000	221	443	798	1383	2089	3753

Notes:
(1) Maximum undiluted propane capacities listed are based on a pressure of 10 psig first-stage setting and 1 psi pressure drop. Capacities in 1000 Btu/hr.
(2) Dimensions in parentheses are inside diameter.

Table 15.1(p) Polyethylene Plastic Tube Sizing Between First-Stage and Second-Stage Regulators: Nominal Outside Diameter (CTS)

Plastic Tubing Length (ft)	½ in. CTS SDR 7.00 (0.445)	1 in. CTS SDR 11.00 (0.927)
30	762	5225
40	653	4472
50	578	3964
60	524	3591
70	482	3304
80	448	3074
90	421	2884
100	397	2724
125	352	2414
150	319	2188
175	294	2013
200	273	1872
225	256	1757
250	242	1659
275	230	1576
300	219	1503
350	202	1383
400	188	1287
450	176	1207
500	166	1140
600	151	1033
700	139	951
800	129	884
900	121	830
1000	114	784
1500	92	629
2000	79	539

Notes:
(1) Maximum undiluted propane capacities listed are based on 10 psig first-stage setting and 1 psi pressure drop. Capacities in 1000 Btu/hr.
(2) Dimensions in parentheses are inside diameter.

Table 15.1(q) Polyethylene Plastic Tube Sizing Between Second-Stage Regulator and Building: Nominal Outside Diameter (CTS)

Plastic Tubing Length (ft)	½ in. CTS SDR 7.00 (0.445)	1 in. CTS SDR 11.00 (0.927)
10	121	829
20	83	569
30	67	457
40	57	391
50	51	347
60	46	314
70	42	289
80	39	269
90	37	252
100	35	238
125	31	211
150	28	191
175	26	176
200	24	164
225	22	154
250	21	145
275	20	138
300	19	132
350	18	121
400	16	113

Notes:
(1) Maximum undiluted propane capacities listed are based on 11 in. w.c. setting and a 0.5 in. w.c. pressure drop. Capacities in 1000 Btu/hr.
(2) Dimensions in parentheses are inside diameter.

Annex A Explanatory Material

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

A.1.1 *General Properties of LP-Gas.* Liquefied petroleum gases (LP-Gases), as defined in this code *(see 3.3.37)*, are gases at normal room temperature and atmospheric pressure. They liquefy under moderate pressure and readily vaporize upon release of the pressure. It is this property that permits transportation and storage of LP-Gases in concentrated liquid form, although they normally are used in vapor form.

For additional information on other properties of LP-Gases, see Annex B.

Federal Regulations. Regulations of the U.S. Department of Transportation (DOT) are referenced throughout this code. Prior to April 1, 1967, these regulations were promulgated by the Interstate Commerce Commission (ICC). The Federal Hazardous Substances Act (15 U.S.C. 1261) requires cautionary labeling of refillable cylinders of liquefied petroleum gases distributed for consumer use. They are typically 40 lb (13 kg) and less and are used with outdoor cooking appliances, portable lamps, camp stoves, and heaters. The Federal Hazardous Substances Act is administered by the U.S. Consumer Product Safety Commission under regulations codified at 16 CFR 1500, Commercial Practices, Chapter 11, "Consumer Product Safety Commission."

A.1.3.1(4) For further information on the storage and handling of LP-Gas at natural gas processing plants, refineries, and petrochemical plants, see API 2510, *Design and Construction of LP-Gas Installations.*

A.1.3.2(5) For information on the use of LP-Gas with oxygen, see NFPA 51, *Standard for the Design and Installation of Oxygen–Fuel Gas Systems for Welding, Cutting, and Allied Processes*, and ANSI Z49.1, *Safety in Welding, Cutting, and Allied Processes.*

A.1.3.2(6) Several types of LP-Gas systems are not covered by NFPA 54, *National Fuel Gas Code*, as noted. These include, but are not restricted to, most portable applications; many farm installations; vaporization, mixing, and gas manufacturing; temporary systems, for example, in construction; and systems on vehicles.

A.1.3.2(8) For information on the use of LP-Gas in vessels, see NFPA 302, *Fire Protection Standard for Pleasure and Commercial Motor Craft.*

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of

such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

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

A.3.2.3 Code. The decision to designate a standard as a "code" is based on such factors as the size and scope of the document, its intended use and form of adoption, and whether it contains substantial enforcement and administrative provisions.

A.3.2.5 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.10 Bulk Plant. Bulk plants receive gas through a variety of methods, such as railroad tank car, transport, cargo tank vehicle, gas piping, or watercraft. These plants are generally utilized for domestic, commercial, agricultural, institutional, and industrial applications, or for the storage of product awaiting delivery to the end user. A facility that transfers LP-Gas from railroad tank cars from a private track directly into cargo tank vehicles is also in this category. Such plants may have container-filling and truck loading/unloading facilities on the premises. Normally, no persons other than the plant management or plant employees have access to these facilities.

A.3.3.24 Fire Protection. *Fire prevention* covers measures directed at avoiding the inception of fire or the escalation of an incident following the accidental or inadvertent release of LP-Gas. Such measures could include product control equipment and the insulation, mounding, or burial of containers.

Fire detection covers equipment that detects the presence of fire or heat to either initiate automated operation of the product control or other process equipment or to initiate local or remote alarms.

Fire suppression covers means of supplying water or other agents providing for fire control, exposure protection, or fire extinguishment.

A.3.3.26 Flexible Connector. LP-Gas–resistant rubber and fabric (or metal), a combination of such rubber and fabric, or metal only should be used. Flexible connectors should be used where there is the need for, or the possibility of, greater relative movement between the points connected than is acceptable for rigid pipe.

A.3.3.29 Gas–Air Mixer. A gas–air mixture normally is used in industrial or commercial facilities as a substitute for another fuel gas.

A.3.3.38 Low Emission Transfer. Specifications for low-emission transfer might be employed to comply with environmental regulations or to determine certain minimum distance requirements.

A.3.3.44 Movable Fuel Storage Tender. Movable fuel storage tenders or farm carts are basically non-highway vehicles but can occasionally be moved over public roads or highways for short distances to supply fuel for farm tractors, construction machinery, and similar equipment.

A.3.3.55 Portable Container. Portable containers, designed for transportation, include "cylinders," "cargo tanks," and "portable tanks," which are defined separately in this code. Containers that are designed to be readily moved from one location of use to another but that are substantially empty of product are "portable storage containers" and are also defined separately in this code.

A.3.3.56 Portable Storage Container. Portable storage containers either have legs or other supports attached or are mounted on running gear (such as trailer or semitrailer chassis) with suitable supports that can be of the fold-down type. Such supports allow them to be placed on a reasonably firm and level surface. For large-volume, limited-duration product usage (such as at construction sites and normally for 12 months or less), portable storage containers serve as permanently installed stationary containers.

A.3.3.64.1 Automatic Changeover Regulator. An automatic changeover regulator incorporates two inlet connections and a service-reserve indicator. The system automatically changes the LP-Gas vapor withdrawal from the designated service cylinder(s) when depleted to the designated reserve cylinder(s) without interruption of service. The service reserve indicator gives a visual indication of the cylinder(s) that is supplying the system.

A.3.3.68 Special Protection. Where required in this code, special protection consists of one of the following:

(1) Applied insulating coating
(2) Mounding
(3) Burial
(4) Water spray fixed systems
(5) Fixed monitor nozzles that meet the criteria specified in this code
(6) Any means listed for this purpose

See Section 6.23 for more information on fire protection and special protection.

A.3.3.72.4 Internal Valve. An internal valve has provision for the addition of a means of remote closure. An internal valve closes when flow through the valve exceeds its rated excess-flow capacity or when pump actuation differential pressure drops to a predetermined point.

A.3.3.72.5.1 External Pressure Relief Valve. See Figure A.3.3.72.5.1.

A.3.3.72.5.2 Flush-Type Full Internal Pressure Relief Valve. See Figure A.3.3.72.5.2.

A.3.3.72.5.3 Full Internal Pressure Relief Valve. See Figure A.3.3.72.5.3.

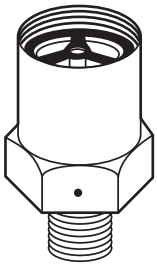

FIGURE A.3.3.72.5.1 External Pressure Relief Valve.

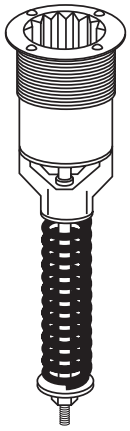

FIGURE A.3.3.72.5.2 Flush-Type Full Internal Pressure Relief Valve.

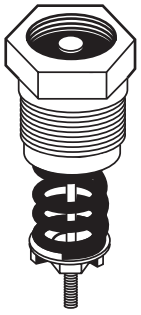

FIGURE A.3.3.72.5.3 Full Internal Pressure Relief Valve.

A.3.3.72.5.4 Internal Spring-Type Pressure Relief Valve. See Figure A.3.3.72.5.4.

A.4.2.1 It is recognized that no odorant will be completely effective as a warning agent in every circumstance.

It is recommended that odorants be qualified as to compliance with 4.2.1 by tests or experience. Where qualifying is by tests, such tests should be certified by an approved laboratory not associated with the odorant manufacturer. Experience has shown that ethyl mercaptan in the ratio of 1.0 lb (0.45 kg) per 10,000 gal (37.9 m^3) of liquid LP-Gas has been recognized as an effective odorant. Other odorants and quantities meeting the provisions of 4.2.1 may be used. Research on odorants has shown that thiophane (tetrahydrothiophene) in a ratio of at least 6.4 lb (2.9 kg) per 10,000 gal (37.9 m^3) of liquid LP-Gas might satisfy the requirements of 4.2.1.

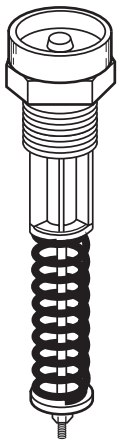

FIGURE A.3.3.72.5.4 Internal Spring-Type Pressure Relief Valve.

NOTE: Odorant research includes *A New Look at Odorization Levels for Propane Gas*, BERC/RI-77/1, United States Energy Research and Development Administration, Technical Information Center, September 1977.

A.4.2.3 Another method of determining the presence of odorant is the stain tube test. This method involves using a small hand-held pump to draw a sample across a filled glass tube and reading the length of color change. For additional information, see GPA Standard 2188, *Tentative Method for the Determination of Ethyl Mercaptan in LP-Gas Using Length of Stain Tubes,* and CAN/CGSB-3.0 No. 18.5, *Test for Ethyl Mercaptan Odorant in Propane, Field Method.* At the time of the preparation of this code, additional analytical methods were under development.

A.4.4 The term *refresher* indicates that the periodic training could be less intensive than the original training, whose primary purpose is to reinforce initial training rather than repeat it.

A.4.5 To test for the presence of ammonia, allow a moderate vapor stream of the product to be tested to escape from the container. A rotary, slip tube, or fixed level gauge is a convenient vapor source. Wet a piece of red litmus paper by pouring distilled water over it while holding it with clean tweezers. Hold the wetted litmus paper in the vapor stream from the container for 30 seconds. The appearance of any blue color on the litmus paper indicates that ammonia is present in the product.

NOTE: Since the red litmus paper will turn blue when exposed to any basic (alkaline) solution, care is required in making the test and interpreting the results. Tap water, saliva, perspiration, or hands that have been in contact with water having a pH greater than 7, or with any alkaline solution, will give erroneous results.

NOTE: For additional information on the nature of this problem and conducting the test, see NPGA Safety Bulletin 122, *Recommendations for Prevention of Ammonia Contamination of LP-Gas*, published by the National Propane Gas Association.

A.4.6 The installation of safety enhancing equipment that is not otherwise required by the code is permitted by the code. This includes any device that performs a safety-related function even though the device is designed or named to perform a required function. For example, an emergency shutoff valve

(ESV) is installed in a location where it is not required to provide all the safety functions of an ESV. Even though the installer uses it to provide a specific feature that can be common to all ESVs, the code would still not require compliance with all of the ESV provisions — for example, the closing requirements described in 5.10.4.

A.5.2.1.1 Prior to April 1, 1967, regulations of the U.S. Department of Transportation were promulgated by the Interstate Commerce Commission. In Canada, the regulations of the Canadian Transport Commission apply and are available from the Canadian Transport Commission, Union Station, Ottawa, Canada.

Construction of containers to the API-ASME *Code for Unfired Pressure Vessels for Petroleum Liquids and Gases*, has not been authorized after July 1, 1961.

A.5.2.2.1 See CGA Publication C-6, *Standard for Visual Inspection of Steel Compressed Gas Cylinders*, or C-6.3, *Guidelines for Visual Inspection and Requalification of Low Pressure Aluminum Compressed Gas Cylinders*, for further information regarding cylinder inspection.

A.5.2.4.4 ASME mobile containers constructed prior to April 1, 2001 were required to have a design pressure of 250 psig (1.7 MPag).

A.5.2.5.3 Prior to December 1, 1963, ASME containers greater than 30 gal water capacity, up to and including 2000 gal water capacity, were not required to be equipped for filling into the vapor space of the container.

A.5.2.5.4 Containers fabricated on or before July 1, 1961 were exempt from this requirement.

A.5.2.5.7 Containers fabricated on or before December 31, 1965 are exempt from this requirement.

A.5.2.8.2 The tare weight is the cylinder weight plus the weight of all permanently attached valves and other fittings but does not include the weight of protecting devices that are removed in order to load the cylinder.

A.5.2.8.3 Head design refers to the shape of the head. Shapes include hemispherical, semi-ellipsoidal, and others. *(Refer to the API-ASME Code for Unfired Pressure Vessels for Petroleum Liquids and Gases for more information.)*

A.5.7.1.2 Materials with melting points exceeding 1500°F (816°C) include steel, ductile (nodular) iron, malleable iron, or brass.

(1) Ductile iron should meet the requirements of ASTM A 395, *Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures,* or equivalent and malleable iron should meet the requirements of ASTM A 47, *Standard Specification for Ferritic Malleable Iron Castings,* or equivalent.
(2) Approved or listed variable liquid level gauges used in ontainers of 3500 gal (13.2 m^3) water capacity or less is exempt from the minimum melting point requirement.
(3) Cast iron should not be used.
(4) Nonmetallic materials should not be used for bonnets or bodies of valves or regulators.

A.5.7.5 UL 651, *Schedule 40 or 80 Rigid PVC Conduit*, listed rigid PVC electrical conduit has been designed, manufactured, and tested for use in a wide variety of operating conditions, including low temperatures and exposure to sunlight and outdoor weather. UL 651 conduit is widely available and can be purchased in hardware and electrical supply stores, where it is usually sold as electrical conduit.

A.5.7.6.2 Example: When the dip tube length marked on the cylinder is 3.8 in., use a 4.0-in. dip tube for the retrofit.

If the dip tube length is not marked on the cylinder, contact the manufacturer for the recommended dip tube length.

A.5.7.8.3 Containers fabricated on or before December 1, 1965, were exempt from this requirement.

A.5.8.5 Persons joining PE pipe should be trained under the applicable joining procedure established by the manufacturer, including the following:

(1) Appropriate training in the use of joining procedures
(2) Making a specimen joint from pipe sections joined according to the procedures
(3) Visually examining these joints during and after assembly

A.5.8.5(D) 49 CFR, Part 192.281(e), states the following:

Mechanical joints — Each compression-type mechanical joint on plastic pipe must comply with the following:

(1) The gasket material in the coupling must be compatible with the plastic.
(2) A rigid internal tubing stiffener, other than a split tubular stiffener, must be used in conjunction with the coupling.

49 CFR Part 192.283(b) states the following:

(1) Mechanical joints — Before any written procedure established under 192.273(b) is used for plastic making mechanical plastic pipe joints that are designed to withstand tensile forces, the procedure must be qualified by subjecting five specimen joints made according to the procedure to the following tensile test:
   (a) Use an apparatus for the test as specified in ASTM D 638 (except for conditioning).
   (b) The specimen must be of such length that the distance between the grips of the apparatus and the end of the stiffener does not affect the joint strength.
   (c) The speed of testing is 5.0 mm (0.2 in.) per minute, plus or minus 25 percent.
   (d) Pipe specimens less than 102 mm (4 in.) in diameter are qualified if the pipe yields to an elongation less than 25 percent or failure initiates outside the joint area.
   (e) Pipe specimens 102 mm (4 in.) and larger in diameter shall be pulled until the pipe is subjected to a tensile stress equal to or greater than the maximum thermal stress that would be produced by a temperature change of 55°C (100°F) or until the pipe is pulled from the fitting. If the pipe pulls from the fitting, the lowest value of the five test results or the manufacturer's rating, whichever is lower, must be used in the design calculations for stress.
   (f) Each specimen that fails at the grips must be retested using new pipe.
   (g) Results obtained pertain only to the outside diameter and material of the pipe tested, except where testing of a heavier wall pipe is used to qualify pipe of the same material but with a lesser wall thickness.

A.5.18.6 See NFPA 1192, *Standard on Recreational Vehicles*, for additional requirements where used on recreational vehicles.

A.5.18.7 Combustion air inlets and flue gas outlets should be included in the listing of the appliance.

A.5.19.5.8 See NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*, for ignition and combustion controls applicable to vaporizing burners associated with grain dryers.

A.6.1.1 Section 6.4 includes general provisions that are applicable to most stationary systems. Section 6.5 through Section 6.11 extend and modify Section 6.4 for systems installed for specific purposes.

A.6.1.3 This installation of safety enhancing equipment that is not otherwise required by the code is permitted by the code. This includes any device that performs a safety-related function even though the device is designed or named to perform a required function. For example, if an emergency shutoff valve (ESV) is installed in a location where it is not required, and the installation is not intended to perform the function of an ESV but to provide a function or feature that is available in the ESV, then it is not required to comply with all of the closing requirements described in 5.10.4.

A.6.4.5.3 For information on determination of flash points see NFPA 30, *Flammable and Combustible Liquids Code*.

A.6.4.5.8 Also see NFPA 50, *Standard for Bulk Oxygen Systems at Consumer Sites*, and NFPA 51, *Standard for the Design and Installation of Oxygen–Fuel Gas Systems for Welding, Cutting, and Allied Processes*, for oxygen systems, and NFPA 50A, *Standard for Gaseous Hydrogen Systems at Consumer Sites*, for gaseous hydrogen systems.

A.6.4.6 Because of the anticipated flash of nonrefrigerated LP-Gas when it is released to the atmosphere, dikes normally serve no useful purpose for nonrefrigerated installations.

A.6.4.7 The presence of such structures can create significant hazards, such as the following:

(1) Pocketing of escaping gas
(2) Interference with application of cooling water by fire departments
(3) Redirection of flames against containers
(4) Impeding the egress of personnel in an emergency

A.6.5.1 It is the intent to allow transfer of liquid into containers in open areas under canopies or roofs where 50 percent or more of the perimeter is not enclosed.

A.6.6.1.4 Generally, a light reflecting color paint is preferred unless the system is installed in an extremely cold climate.

A.6.6.6.1(G)(2) If vapor is vented too rapidly, the pressure drop due to the refrigeration of the liquid can lead to the erroneous conclusion that no liquid remains in the container.

A.6.6.6.1(K) Firm earth can be used.

A.6.6.6.3(1) Noncombustible, noncorrosive materials include vermiculite and perlite.

A.6.6.6.3(4) For information on corrosion protection of containers and piping systems, see the following:

(1) API Publication 1632, *Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems*, 1983.
(2) Underwriters Laboratories of Canada, ULC S603.1-M, *Standard for Galvanic Corrosion Protection Systems for Steel Underground Tanks for Flammable and Combustible Liquids*.
(3) National Association of Corrosion Engineers Standard RP-01-69, *Recommended Practice, Control of External Corrosion of Underground or Submerged Metallic Piping Systems*.
(4) National Association of Corrosion Engineers Standard RP-02-85, *Recommended Practice, Control of External Corrosion on Metallic Buried, Partially Buried, or Submerged Liquid Storage Systems*.
(5) Underwriters Laboratories Inc., UL 1746, *External Corrosion Protection Systems for Steel Underground Storage Tanks*.

A.6.7.3(H) Two-psi regulator systems operate with 2 psi (13.8 kPa) downstream of the 2 psi service regulators to the line pressure regulator, which reduces the pressure to an appropriate inches-of-water-column pressure.

A.6.8.1.1(4) Complete compliance with Chapter 10 for buildings or separate areas of buildings housing industrial processes and other occupancies cited in 6.8.1.4 is not always necessary, depending on the prevailing conditions. Construction of buildings or separate areas of buildings housing certain internal combustion engines is covered in NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*.

A.6.8.4.5 Polyethylene will expand or contract 1 in. (25 mm) for every 10°F (18°C) temperature change for every 100 ft (30.5 m) of pipe.

A.6.8.7.2 This is not to be construed to mean that flexible connectors must be used if provisions were incorporated in the design to compensate for these effects.

A.6.10.8 Anchorage can be accomplished by use of concrete bulkheads or equivalent anchorage or by the use of a weakness or shear fitting.

A.6.14 For information on protection of underground components see NACE RP-01-69, *Recommended Practice, Control of External Corrosion on Underground or Submerged Metallic Piping Systems*.

A.6.16.2.5 Debris and foreign material can enter a propane system from hoses and connectors used to fill containers. Using strainers or screens is one method to prevent debris from interfering with the action of valves and other components.

A.6.17.2.7 The requirement for a pilot or an electronic ignition system became effective for heaters with inputs over 50,000 Btu/hr manufactured on or after May 17, 1967.

A.6.17.9.3 The weight will be affected by the specific gravity of the LP-Gas. Weights varying from 16.0 oz (454 g) to 16.8 oz (476 g) are recognized as being within the range of what is nominal.

A.6.17.10(C) The use of LP-Gas containers inside of assembly occupancies for flame effects before a proximate audience requires compliance with this code and NFPA 160, *Standard for Flame Effects Before an Audience*. Storage of idle cylinders should be in accordance with Chapter 8. In cases where the minimum 20 ft separation distance in 6.17.10 cannot be satisfied, the authority having jurisdiction in determining equivalency can consider additional safety controls such as the following:

(1) The construction of a noncombustible line of sight barrier to protect adjacent cylinders from fire exposure
(2) The installation of piped flammable gas piping systems instead of hoses

A.6.20.1.2 For information on lightning protection, see NFPA 780, *Standard for the Installation of Lightning Protection Systems*.

A.6.20.1.3 Because liquefied petroleum gas is contained in a closed system of piping and equipment, the system need not be electrically conductive or electrically bonded for protection against static electricity. For information on grounding and bonding for protection against static electricity, see NFPA 77, *Recommended Practice on Static Electricity*.

A.6.20.2.2 When classifying the extent of hazardous area, consideration should be given to possible variations in the spotting of railroad tank cars and cargo tank vehicles at the unloading points and the effect these variations of actual spotting point can have on the point of connection.

Where specified for the prevention of fire or explosion during normal operation, ventilation is considered adequate where provided in accordance with the provisions of this code.

A.6.20.2.3 See Figure A.6.20.2.3.

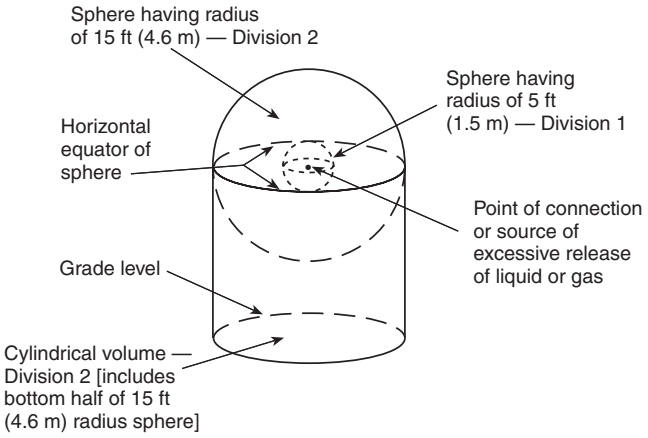

FIGURE A.6.20.2.3 Extent of Electrically Classified Area. ***(See Table 6.20.2.2.)***

A.6.20.3.4 The installation of vaporizers and vaporizing burners is covered in Section 6.19.

A.6.21.1 Typical nonengine fuel systems include those on commercial, industrial, construction, and public service vehicles such as trucks, semitrailers, trailers, portable tar kettles, road surface heating equipment, mobile laboratories, clinics, and mobile cooking units (such as catering and canteen vehicles).

A.6.21.7.6 Requirements for the design of containers are located in Section 5.2. Requirements for container appurtenances are located in Section 5.3.

A.6.23.2 The wide range in size, arrangement, and location of LP-Gas installations covered by this code precludes the inclusion of detailed fire protection provisions completely applicable to all installations. Provisions in this Section 6.23 are subject to verification or modification through analysis of local conditions.

The National Fire Protection Association, American Petroleum Institute, and National Propane Gas Association publish material, including visual aids, useful in such planning.

A.6.23.3 In recent years the concept of total product control systems has been developed. Facilities that have redundant automatic product controls systems provide a high level of confidence that propane will not be released during an emergency. Therefore, not only will the storage be protected from a fire that could lead to container rupture, but major fires at the facility would be prevented. The public would be protected, fire-fighting operations would be safer, and applications of large quantities of water would not be needed to prevent tank failure.

A fire safety analysis should include the following:

(1) The effectiveness of product control measures
(2) An analysis of local conditions of hazard within the container site
(3) Exposure to or from other properties, population density, and congestion within the site
(4) The probable effectiveness of plant fire brigades or local fire departments based on adequate water supply, response time, and training
(5) Consideration for the adequate application of water by hose stream or other method for effective control of leakage, fire, or other exposures
(6) If necessary, a designated time period for review of the fire safety analysis with local emergency response agencies to ensure preplanning and emergency response plans for the installation are current

A.6.23.4.3 LP-Gas fires should not normally be extinguished until the source of the burning gas has been shut off or can be shut off.

A.6.23.5.1 For LP-Gas fixed storage facilities of 60,000 gal (227 m^3) water capacity or less, an incident prevention review could indicate that applied insulating coatings are quite often the most practical solution for special protection. It is recommended that insulation systems be evaluated on the basis of experience or listings by an approved testing laboratory.

A.7.1 Ignition source control at transfer locations is covered in Section 6.20. Fire protection is covered in Section 6.23.

A.7.2.3.5(A) Air-moving equipment includes large blowers on crop dryers, space heaters, and some central heating equipment. Equipment employing open flames includes flame cultivators, weed burners, and tar kettles.

A.7.4.2.2 The maximum permitted filling limit in percent by weight should be as shown in Table 7.4.2.2.

A.7.4.2.3 The maximum permitted LP-Gas volume of any container depends on the size of the container, whether it is installed above ground or under ground, the specific gravity, and the temperature of the liquid. *[See Table 7.4.2.2, Table 7.4.2.3(a), Table 7.4.2.3(b), and Table 7.4.2.3(c).]*

See F.5.1.2 for the method of computing the values in Table 7.4.2.3(a), Table 7.4.2.3(b), and Table 7.4.2.3(c).

A.7.4.4 The overfilling prevention device is intended to be a backup safety device to prevent overfilling of cylinders. Other means as provided in the chapter must be used when filling containers, even if an overfilling prevention device is present and expected to stop flow into the container before the other means indicate the container is properly filled.

A.8.4.1 The filling process in 8.4.1.3 refers to the time period beginning when a cylinder or cylinders are brought to a dispensing station to be filled and ending when the last cylinder is filled and all the cylinders are removed from the filling area. This is meant to define a continuous process with the cylinders being unattended for only brief periods, such as operator breaks or lunch.

A.8.4.2.2 There are numerous effective means to provide protection against accidental vehicle impact or damage. The method selected depends upon local conditions with regard to the kinds of traffic that can be reasonably expected and the environment surrounding the location. While additional protection over and above that used to protect the building might

not be needed at some locations, others might need additional protection. Examples of such additional protection could be the following:

(1) Guard rails
(2) Steel bollards
(3) Raised sidewalks

A.8.5 See 6.23.4.3.

A.9.1.1(3) Most truck transportation of LP-Gas is subject to regulation by the U.S. Department of Transportation. Many of the provisions of this chapter are identical or similar to DOT regulations and are intended to extend these provisions to areas not subject to DOT regulation.

A.9.1.2(4) LP-Gas systems used for engine fuel are covered by Chapter 11.

A.9.4.3.5 For more information, see NPGA Safety Bulletin 114, *Guide to Hose Inspection*.

A.9.4.7 Also see NFPA 10, *Standard for Portable Fire Extinguishers*.

A.10.3.2.6 See NFPA 80, *Standard for Fire Doors and Fire Windows*.

A.11.1.1 Chapter 11 covers engine fuel systems for engines installed on vehicles for any purpose, as well as fuel systems for stationary and portable engines.

A.11.1.2 Containers for engine fuel systems can be of the permanently installed or exchange type.

A.11.3.1 Prior to April 1, 1967, these regulations were promulgated by the Interstate Commerce Commission. In Canada, the regulations of the Canadian Transport Commission apply, which are available from the Canadian Transport Commission, Union Station, Ottawa, Canada.

A.11.3.7 See A.6.6.1.4.

A.11.8.1.2 The luggage compartment (trunk) of a vehicle can constitute such an enclosure provided it meets all these requirements.

A.11.11.2.2 See Figure A.11.11.2.2.

A.12.3.4.2 See ASCE 56, *Sub-Surface Investigation for Design and Construction of Foundation for Buildings*, and API 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*, Annex C, for further information.

FIGURE A.11.11.2.2 Example of Vehicle Identification Marking.

A.13.2.1.1 Federal regulations applicable to marine terminals are contained in 33 CFR.

A.13.3.1 Refer to 49 CFR, Part 195.

A.13.4.1 For guidance refer to 33 CFR.

A.14.1 Chapter 14, Operations and Maintenance, was created to locate operating and maintenance requirements in one location for installations covered by this code. Only new operating and maintenance requirements are included in this chapter. A task force has been established to review future additions to this chapter. Users of the code are invited to submit proposals on this subject.

A.14.2.1 The procedures should address normal startup, operations, shutdown, emergency shutdown and operations, startup following a major change to the system, consequences of deviations and steps required to correct or avoid deviations, and equipment inspections.

A.14.2.2.2 The owner or operator can use procedures or instructions provided by equipment vendors, procedures found in industrial codes, or procedures prepared by persons or organizations knowledgeable about the process and equipment as the basis for maintenance procedures.

Annex B Properties of LP-Gases

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 Approximate Properties of LP-Gases.

B.1.1 Source of Property Values.

B.1.1.1 The property values for the LP-Gases are based on average industry values and include values for LP-Gases coming from natural gas liquid plants as well as those coming from petroleum refineries. Thus, any particular commercial propane or butane might have properties varying slightly from the values shown. Similarly, any propane-butane mixture might have properties varying from those obtained by computation from these average values *(see B.1.2 for computation method used)*. Since these are average values, the interrelationships between them *(e.g., lb per gal, specific gravity)* will not cross-check perfectly in all cases.

B.1.1.2 Such variations are not sufficient to prevent the use of these average values for most engineering and design purposes. They stem from minor variations in composition. The commercial grades are not pure (CP — chemically pure) propane or butane, or mixtures of the two, but might also contain small and varying percentages of ethane, ethylene, propylene, isobutane, or butylene, which can cause slight variations in property values. There are limits to the accuracy of even the most advanced testing methods used to determine the percentages of these minor components in any LP-Gas.

B.1.2 Approximate Properties of Commercial LP-Gases. The principal properties of commercial propane and commercial butane are shown in Table B.1.2(a) and Table B.1.2(b). Reasonably accurate property values for propane-butane mixtures can be obtained by computation, applying the percentages by weight of each in the mixture to the values for the property it is desired to obtain. Slightly more accurate results for vapor pressure are obtained by using the percentages by volume. Very accurate results can be obtained using data and methods explained in petroleum and chemical engineering data books.

B.1.3 Specifications of LP-Gases. Specifications of LP-Gases covered by this code are listed in Gas Processors Association Standard 2140, *Liquefied Petroleum Gas Specifications for Test Methods*, or ASTM D 1835, *Standard Specification for Liquefied Petroleum (LP) Gases.*

Table B.1.2(a) (English) Approximate Properties of LP-Gases

	Commercial Propane	Commercial Butane
Vapor pressure in psi (absolute pressure) at		
70°F	145	32
100°F	218	52
105°F	233	56
130°F	315	84
Specific gravity of liquid at 60°F	0.504	0.582
Initial boiling point at 14.7 psia, °F	–44	15
Weight per gallon of liquid at 60°F, lb	4.20	4.81
Specific heat of liquid, Btu/lb at 60°F	0.630	0.549
Cubic feet of vapor per gallon at 60°F	36.38	31.26
Cubic feet of vapor per pound at 60°F	8.66	6.51
Specific gravity of vapor (air = 1) at 60°F	1.50	2.01
Ignition temperature in air, °F	920–1,120	900–1,000
Maximum flame temperature in air, °F	3,595	3,615
Limits of flammability in air, percent of vapor in air–gas mixture:		
Lower	2.15	1.55
Upper	9.60	8.60
Latent heat of vaporization at boiling point:		
Btu per pound	184	167
Btu per gallon	773	808
Total heating values after vaporization:		
Btu per cubic foot	2,488	3,280
Btu per pound	21,548	21,221
Btu per gallon	91,502	102,032

Table B.1.2(b) (Metric) Approximate Properties of LP-Gases

	Commercial Propane	Commercial Butane
Vapor pressure in kPa (absolute pressure) at		
20°C	1,000	220
40°C	1,570	360
45°C	1,760	385
55°C	2,170	580
Specific gravity	0.504	0.582
Initial boiling point at 1.00 atm pressure, °C	–42	–9
Weight per cubic meter of liquid at 15.56°C, kg	504	582
Specific heat of liquid, kilojoules per kilogram, at 15.56°C	1.464	1.276
Cubic meter of vapor per liter of liquid at 15.56°C	0.271	0.235
Cubic meter of vapor per kilogram of liquid at 15.56°C	0.539	0.410
Specific gravity of vapor (air = 1) at 15.56°C	1.50	2.01
Ignition temperature in air, °C	493–549	482–538
Maximum flame temperature in air, °C	1,980	2,008
Limits of flammability in air, % of vapor in air–gas mixture:		
Lower	2.15	1.55
Upper	9.60	8.60
Latent heat of vaporization at boiling point:		
Kilojoules per kilogram	428	388
Kilojoules per liter	216	226
Total heating value after vaporization:		
Kilojoules per cubic meter	92,430	121,280
Kilojoules per kilogram	49,920	49,140
Kilojoules per liter	25,140	28,100

Annex C Design, Construction, and Requalification of DOT (ICC) Cylinders

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

C.1 Scope.

C.1.1 Application.

C.1.1.1 This annex provides general information on cylinders referred to in this code. For complete information, consult the applicable specification *(see C.2.1)*. The water capacity of such cylinders is not permitted to be more than 1000 lb (454 kg).

C.1.1.2 This annex is not applicable to Department of Transportation (DOT) tank car portable tank container or cargo tank specifications. Portable and cargo tanks are basically ASME containers and are covered in Annex D.

C.1.1.3 Prior to April 1, 1967, these specifications were promulgated by the Interstate Commerce Commission (ICC). On this date, certain functions of the ICC, including the promulgation of specifications and regulations dealing with LP-Gas cylinders, were transferred to the Department of Transportation. Throughout this annex, both ICC and DOT are used, ICC applying to dates prior to April 1, 1967, and DOT to subsequent dates.

C.2 LP-Gas Cylinder Specifications.

C.2.1 Publishing of DOT Cylinder Specifications. DOT cylinder specifications are published under 49 CFR, "Hazardous Materials Regulations and Procedures," Part 178, "Specifications for Packaging, Subsection C," available from the U.S. Government Printing Office, Washington, DC. The information in this publication is also issued as a tariff at approximately 3-year intervals by the Bureau of Explosives, American Railroads Building, 1920 L Street, N.W., Washington, DC 20036.

C.2.2 DOT Specification Nomenclature.

C.2.2.1 The specification designation consists of a one-digit number, sometimes followed by one or more capital letters, then by a dash and a three-digit number. The one-digit number alone, or in combination with one or more capital letters, designates the specification number. The three-digit number following the dash shows the service pressure for which the cylinder is designed. Thus, "4B–240" indicates a cylinder built to Specification 4B for a 240-psig (1650-kPag) service pressure. *(See C.2.2.3.)*

C.2.2.2 The specification gives the details of cylinder construction, such as material used, method of fabrication, tests required, and inspection method, and prescribes the service pressure or range of service pressures for which that specification can be used.

C.2.2.3 The term *service pressure* is analogous to, and serves the same purpose as, the ASME design pressure. However, it is not identical, representing instead the highest pressure to which the cylinder will normally be subjected in transit or in use but not necessarily the maximum pressure to which it might be subjected under emergency conditions in transportation. The service pressure stipulated for the LP-Gases is based on the vapor pressures exerted by the product in the cylinder at two different temperatures, the higher pressure of the two becoming the service pressure, as follows:

(1) The pressure in the cylinder at 70°F (21°C) must be less than the service pressure for which the cylinder is marked.

(2) The pressure in the container at 130°F (54.4°C) must not exceed ¾ times the pressure for which the cylinder is marked.

Example: Commercial propane has a vapor pressure at 70°F (21°C) of 132 psig (910 kPag). However, its vapor pressure at 130°F (54.4°C) is 300 psig (2070 kPag), so service pressure [¾ times, which must not exceed 300 psig (2070 kPag)] is 300 divided by ¾, or 240 psig (1650 kPag). Thus, commercial propane requires at least a 240-psig (1650-kPag) service pressure cylinder.

C.2.3 DOT Cylinder Specifications Used for LP-Gas.

C.2.3.1 A number of different specifications were approved by DOT (and its predecessor ICC) for use with LP-Gases. Some of these are no longer published or used for new construction. However, cylinders built under these old specifications, if properly maintained and requalified, are still acceptable for LP-Gas transportation.

C.2.3.2 DOT specifications cover primarily safety in transportation. However, for the product to be used, it is necessary for it to come to rest at the point of use and serve as LP-Gas storage during the period of use. Cylinders adequate for transportation are also deemed to be adequate for use as provided in this code. As small-size ASME containers were not available at the time cargo tank vehicle delivery was started, ICC (now DOT) cylinders have been equipped for cargo tank vehicle deliveries and permanently installed.

C.2.3.3 The DOT cylinder specifications most widely used for the LP-Gases are shown in Table C.2.3.3. The differing materials of construction, the method of fabrication, and the date of the specification reflect the progress made in knowledge of the products to be contained and the improvement in metallurgy and methods of fabrication.

Table C.2.3.3 DOT Cylinder Specifications

Specification No. and Marking	Material of Construction	Method of Fabrication
26–150*	Steel	Welded and brazed
3B–300	Steel	Seamless
4–300	Steel	Welded
4B–300	Steel	2 piece welded and brazed
4B–240	Steel	2 piece welded and brazed
4BA–240	Alloy steel	2 piece welded and brazed
4E–240	Aluminum	Welded and brazed
4BW–240	Steel	3 piece welded

* The term *service pressure* had a different connotation at the time the specification was adopted.

C.3 Requalification, Retesting, and Repair of DOT Cylinders.

C.3.1 Application. This section outlines the requalification, retesting, and repair requirements for cylinders but should be used only as a guide. For official information, the applicable DOT regulations should be consulted.

C.3.2 Requalification (Including Retesting) of DOT Cylinders.

C.3.2.1 DOT rules prohibit cylinders from being refilled, continued in service, or transported unless they are properly qualified or requalified for LP-Gas service in accordance with DOT regulations.

C.3.2.2 DOT rules require a careful examination of every cylinder each time it is to be filled, and it must be rejected if there is evidence of exposure to fire, bad gouges or dents, seriously corroded areas, leaks, or other conditions indicating possible weaknesses that might render it unfit for service. The following disposition is to be made of rejected cylinders:

(1) Cylinders subjected to fire are required to be requalified, reconditioned, or repaired in accordance with C.3.3 or permanently removed from service except that DOT 4E (aluminum) cylinders must be permanently removed from service.
(2) Cylinders showing serious physical damage or leaks or showing a reduction in the marked tare weight of 5 percent or more are required to be retested in accordance with C.3.2.4(1) or C.3.2.4(2) and, if necessary, repaired in accordance with C.3.3.

C.3.2.3 All cylinders, including those apparently undamaged, are required to be periodically requalified for continued service. The first requalification for a new cylinder is required within 12 years after the date of manufacture. Subsequent requalifications are required within the periods specified under the requalification method used.

C.3.2.4 DOT regulations permit three alternative methods of requalification for most commonly used LP-Gas cylinders (see DOT regulations for permissible requalification methods for specific cylinder specifications). Two use hydrostatic testing, and the third uses a carefully made and duly recorded visual examination by a competent person. In the case of the two hydrostatic test methods, only test results are recorded, but a careful visual examination of each cylinder is also required. DOT regulations cite in detail the data to be recorded for the hydrostatic test methods, the observations to be made during the recorded visual examination method, and the marking of cylinders to indicate the requalification date and the method used. The three methods are outlined as follows:

(1) The water jacket–type hydrostatic test is permitted to be used to requalify cylinders for 12 years before the next requalification is due. A pressure of twice the marked service pressure is applied, using a water jacket (or the equivalent) so that the total expansion of the cylinder during the application of the test pressure can be observed and recorded for comparison with the permanent expansion of the cylinder after depressurization. The following disposition is made of cylinders tested in this manner:
   (a) Cylinders that pass the retest and the visual examination required with it *(see C.3.2.4)* are marked with the date and year of the test (6-90, indicating requalification by the water jacket test method in June 1990) and are permitted to be placed back in service.
   (b) Cylinders that leak, or for which the permanent expansion exceeds 10 percent of the total expansion (12 percent for Specification 4E aluminum cylinders), must be rejected. If rejected for leakage, cylinders are permitted to be repaired in accordance with C.3.3.
(2) Cylinders are requalified for 7 years before the next requalification is due. A pressure of twice the marked service pressure is applied, but no provision is made for measuring total and permanent expansion during the test outlined in C.3.2.4(1). The cylinder is carefully observed while under the test pressure for leaks, undue swelling, or bulging indicating weaknesses. The following disposition is made of cylinders tested in this matter:
   (a) Cylinders that pass the test and the visual examination required with it *(see C.3.2.4)* are marked with the date and year of the retest followed by an S (e.g., 8-91S, indicating requalification by the simple hydrostatic test method in August 1991) and are permitted to be placed back in service.
   (b) Cylinders that are developing leaks or showing undue swelling or bulging must be rejected. If rejected for leaks, cylinders are permitted to be repaired in accordance with C.3.3.
(3) The recorded visual examination is permitted to be used to requalify cylinders for 5 years before the next qualification is due provided the cylinder has been used exclusively for LP-Gas commercially free of corroding components. Inspection is to be made by a competent person, using as a guide the CGA *Standard for Visual Inspection of Steel Compressed Gas Cylinders* (CGA Pamphlet C-6) and recording the inspection results as required by DOT regulations. The following disposition is to be made of cylinders inspected in this manner:
   (a) Cylinders that pass the visual examination are marked with the date and year of the examination followed by an E (e.g., 7-90E, indicating requalification by the recorded visual examination method in July 1990) and are permitted to be placed back in service.
   (b) Cylinders that leak or show serious denting or gouging, or excessive corrosion must be either scrapped or repaired in accordance with C.3.3.

C.3.3 Repair of DOT Cylinders. Repair of DOT cylinders is required to be performed by a manufacturer of the type of cylinder to be repaired or by a repair facility authorized by DOT.

Repairs normally made are for fire damage, leaks, denting, and gouges and for broken or detached valve-protecting collars or foot rings.

Annex D Design of ASME and API-ASME Containers

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

D.1 General.

D.1.1 Application.

D.1.1.1 This annex provides general information on containers designed and constructed in accordance with ASME or API-ASME codes, usually referred to as ASME containers. For complete information on either ASME or API-ASME containers, the applicable code should be consulted. Construction of containers to the API-ASME *Code for Unfired Pressure Vessels for Petroleum Liquids and Gases* has not been authorized since July 1, 1961.

D.1.1.2 DOT (ICC) specification portable tank containers and cargo tanks are either ASME or API-ASME containers. In writing these specifications, which should be consulted for complete information, additions were made to these pressure vessel codes to cover the following:

(1) Protection of container valves and appurtenances against physical damage in transportation
(2) Hold-down devices for securing cargo containers to conventional vehicles
(3) Attachments to relatively large [6000 gal (22.7 m^3) or more water capacity] cargo containers in which the container serves as a stress member in lieu of a frame

D.1.2 Development of ASME and API-ASME Codes.

D.1.2.1 ASME-type containers of approximately 12,000 gal (45.4 m^3) water capacity or more were initially used for bulk storage in processing, distribution, and industrial plants. As the industry expanded and residential and commercial usage increased, the need for small ASME containers with capacities greater than the upper limit for cylinders grew. This ultimately resulted in the development of cargo containers for cargo tank vehicles and the wide use of ASME containers ranging in size from less than 25 gal (0.1 m^3) to 120,000 gal (454 m^3) water capacity.

D.1.2.2 The American Society of Mechanical Engineers (ASME) in 1911 set up the Boiler and Pressure Vessel Committee to formulate "standard rules for the construction of steam boilers and other pressure vessels." The ASME *Boiler and Pressure Vessel Code*, first published in 1925, has been revised regularly since that time. During this period there have been changes in the code as materials of construction improved and more was known about them and as fabrication methods changed and inspection procedures were refined.

D.1.2.3 One major change involved the so-called "factor of safety" (the ratio of the ultimate strength of the metal to the design stress used). Prior to 1946, a 5:1 safety factor was used. Fabrication changed from the riveting widely used when the code was first written (some forge welding was used) to fusion welding. This latter method was incorporated into the code as welding techniques were perfected and now predominates.

D.1.2.4 The safety factor change in the ASME Code was based on the technical progress made since 1925 and on experience with the use of the API-ASME code. This offshoot of the ASME Code, initiated in 1931, was formulated and published by the American Petroleum Institute (API) in cooperation with ASME. It justified the 4:1 safety factor on the basis of certain quality and inspection controls not at that time incorporated in the ASME code editions. In 1998, ASME reduced the safety factor or design margin from 4:1 to 3.5:1, noting improvements in metal manufacturing, welding techniques, X-ray quality, and pressure vessel manufacturer's quality systems.

D.1.2.5 ASME Code case interpretations and addenda are published between code editions and normally become part of the code in the new edition. Adherence to these is considered compliance with the code. *[See 5.2.1.1(A).]*

D.2 Design of Containers for LP-Gas.

D.2.1 ASME Container Design.

D.2.1.1 When ASME containers were first used to store LP-Gas, the properties of the CP grades of the principal constituents were available, but the average properties for the commercial grades of propane and butane were not. Also, there was no experience as to what temperatures and pressures to expect for product stored in areas with high atmospheric temperatures. A 200 psig (1378 kPag) design pressure was deemed appropriate for propane [the CP grade of which has a gauge vapor pressure of 176 psig (1210 kPag) at 100°F (37.8°C)] and 80 psig (550 kPag) for butane [CP grade has vapor pressure of 37 psig (255 kPag) at 100°F (37.8°C)]. These containers were built with a 5:1 safety factor *(see D.1.2.3)*.

D.2.1.2 Pressure vessel codes, following boiler pressure relief valve practice, require that the pressure relief valve start-to-leak setting be the design pressure of the container. In specifying pressure relief valve capacity, however, they stipulate that this relieving capacity be adequate to prevent the internal pressure from rising above 120 percent of the design pressure under fire exposure conditions.

D.2.1.3 Containers built in accordance with D.2.1.1 were entirely adequate for the commercial grades of the LP-Gases [the vapor pressure of propane at 100°F (37.8°C) is 220 psig (1515 kPag); the gauge vapor pressure of commercial butane at 100°F (37.8°C) is 37 psig (255 kPag)]. However, because they were equipped with pressure relief valves set to start-to-leak at the design pressure of the container, these relief valves occasionally opened on an unusually warm day. Since any unnecessary release of a flammable gas is potentially dangerous, and considering recommendations of fire prevention and insurance groups as well as to the favorable experience with API-ASME containers *(see D.2.2.1)*, relief valve settings above the design pressure [up to 250 psig (1720 kPag) for propane and 100 psig (690 kPag) for butane] were widely used.

D.2.1.4 In determining safe filling limits for compressed liquefied gases, DOT (ICC) uses the criterion that the container not become liquid full at the highest temperature the liquid is expected to reach due to the normal atmospheric conditions to which the container can be exposed. For containers of more than 1200 gal (4.5 m^3) water capacity, the liquid temperature selected is 115°F (46°C). The vapor pressure of the gas to be contained at 115°F (46°C) is specified by DOT as the minimum design pressure for the container. The gauge vapor pressure of CP propane at 115°F (46.1°C) is 211 psig (1450 kPag) and of commercial propane 255 psig (1756 kPag). The gauge vapor pressure of both normal butane and commercial butane at 115°F (46.1°C) is 51 psig (350 kPag).

D.2.1.5 The ASME *Boiler and Pressure Vessel Code* editions generally applicable to LP-Gas containers, and the design pressures, safety factors, and exceptions to these editions for LP-Gas use, are shown in Table D.2.1.5. They reflect the use of the information in D.2.1.1 through D.2.1.4.

D.2.2 API-ASME Container Design.

D.2.2.1 The API-ASME code was first published in 1931. Based on petroleum industry experience using certain material quality and inspection controls not at that time incorporated in the ASME code, the 4:1 safety factor was first used. Many LP-Gas containers were built under this code with design pressures of 125 psig (860 kPag) [100 psig (690 kPag) until December 31, 1947] for butane and 250 psig (1725 kPag) for propane. Containers constructed in accordance with the API-ASME code were not required to comply with Section 1 or to the Annex to Section 1. Paragraphs W-601 through W-606 of the 1943 and earlier editions were not applicable to LP-Gas containers.

D.2.2.2 The ASME Code, by changing from the 5:1 to the 4:1 safety factor through consideration of the factors described in D.2.1.1 through D.2.1.4, became nearly identical in effect to the API-ASME code by the 1950s. Thus, the API-ASME code was phased out, and construction was not authorized after July 1, 1961.

D.2.3 Design Criteria for LP-Gas Containers. To prevent confusion in earlier editions of this code, the nomenclature container type was used to designate the pressure rating of the container to be used for various types of LP-Gases. With the adoption of the 4:1 safety factor in the ASME Code and the phasing out of the API-ASME code, the need for container type ceased to exist.

D.2.4 DOT (ICC) Specifications Utilizing ASME or API-ASME Containers.

D.2.4.1 DOT (ICC) specifications for portable tank containers and cargo tanks require ASME or API-ASME construction for the container proper *(see D.1.1.2)*. Several such specifications were written by the ICC prior to 1967, and DOT has continued this practice.

D.2.4.2 ICC specifications written prior to 1946, and to some extent through 1952, used ASME containers with a 200 psig (1380 kPag) design pressure for propane and 80 psig (550 kPag) for butane [100 psi (690 kPa) after 1947] with a 5:1 safety factor. During this period and until 1961, ICC specifications also permitted API-ASME containers with a 250 psig (1720 kPag) design pressure for propane and 100 psig (690 kPag) for butane [125 psig (862 kPag) after 1947].

D.2.4.3 To prevent any unnecessary release of flammable vapor during transportation *(see D.2.1.3)*, the use of safety relief valve settings 25 percent above the design pressure was common for ASME 5:1 safety factor containers. To eliminate confusion, and in line with the good experience with API-ASME containers, the ICC permitted the rerating of these particular ASME containers used under its specifications to 125 percent of the originally marked design pressure.

D.2.4.4 DOT (ICC) specifications applicable to portable tank containers and cargo tanks currently in use are listed in Table D.2.4.4. New construction is not permitted under the older specifications. However, use of these older containers is permitted to continue provided they have been maintained in accordance with DOT (ICC) regulations.

Table D.2.1.5 Container Pressure and Safety Factors/Design Margin for Various Editions of the ASME Code

Year ASME Code Edition Published	Design Pressure				Safety Factor/Design Margin
	Butane		Propane		
	psig	MPag	psig	MPag	
1931 through 1946[a]	100[a]	0.7	200	1.4	5:1
1949, paragraph U-68 and U-69[b]	100	0.7	200	1.4	5:1
1949, paragraph U-200 and U-201[c]	125	0.9	250	1.7	4:1
1952 through 1998	125	0.9	250	1.7	4:1
1998 to current					3.5:1

[a] Until December 31, 1947, containers designed for 80 psig (550 kPag) under prior (5:1 safety factor) codes were authorized for butane. Since that time, either 100 psig (690 kPag) (under prior codes) or 125 psig (860 kPag) (under present codes) is required.

[b] Containers constructed in accordance with the 1949 edition and prior editions of the ASME Code were not required to be in compliance with paragraphs U-2 to U-10 inclusive or with paragraph U-19. Construction in accordance with paragraph U-70 of these editions was not authorized.

[c] Higher design pressure [312.5 psig (2.2 MPag)] is required for small ASME containers used for vehicular installations because they can be exposed to higher temperatures and consequently develop higher internal pressure.

Table D.2.4.4 DOT Pressure Specification for Cargo Tanks

Specification Number	ASME Construction			API-ASME Construction		
	MAWP (psig)		Safety Factor/Design Margin	Design Pressure (psig)		Safety Factor
	Propane	Butane		Propane	Butane	
ICC-50[a]	200[b]	100[b]	5:1	250	125	4:1
ICC-51[a]	250	125	4:1	250	125	4:1
MC-320[c,d]	200[b]	100[b]	5:1	250	125	4:1
MC-330[c]	250	125	4:1	250	125	4:1
MC-331[c]	250	125	4:1	250	125	4:1

For SI units, 100 psi = 0.69 MPa; 125 psi = 0.86 MPa; 200 psi = 1.40 MPa; 250 psi = 1.72 MPa.

[a] Portable tank container.

[b] Permitted to be rerated to 125 percent of original ASME design pressure.

[c] Cargo tank.

[d] Requires DOT exemption.

D.3 Underground ASME or API-ASME Containers.

D.3.1 Use of Containers Underground.

D.3.1.1 ASME or API-ASME containers are used for underground or partially underground installation in accordance with 6.6.6.1 or 6.6.6.2. The temperature of the soil is normally low so that the average liquid temperature and vapor pressure of product stored in underground containers will be lower than in aboveground containers.

D.3.1.2 Containers listed to be used interchangeably for installation either above ground or under ground must comply as to pressure relief valve rated relieving capacity and filling limit with aboveground provisions when installed above ground *(see 5.7.2.5)*. When installed under ground, the pressure relief valve rated relieving capacity and filling limit can be in accordance with underground provisions *[see 5.7.2.7]*, provided all other underground installation provisions are met. Partially underground containers are considered as aboveground insofar as filling limit and pressure relief valve rated relieving capacity are concerned.

Annex E Pressure Relief Devices

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

E.1 Pressure Relief Devices for DOT Cylinders.

E.1.1 Source of Provisions for Relief Devices. The requirements for relief devices on DOT cylinders are established by the DOT. Complete technical information regarding these requirements will be found in the CGA Publication S-1.1, *Pressure-Relief Device Standards*, Part 1 — "Cylinders for Compressed Gases."

E.2 Pressure Relief Devices for ASME Containers.

E.2.1 Source of Provisions for Pressure Relief Devices. Capacity requirements for pressure relief devices are in accordance with the applicable provisions of CGA Publication S-1.2, *Pressure-Relief Device Standards*, Part 2 — "Cargo and Portable Tanks for Compressed Gases;" or with CGA Publication S-1.3, *Pressure Relief-Device Standards*, Part 3 — "Compressed Gas Storage Containers."

E.2.2 Spring-Loaded Pressure Relief Valves for Aboveground and Cargo Containers. The minimum rate of discharge for spring-loaded pressure relief valves is based on the outside surface of the containers on which the valves are installed. Paragraph 5.2.8.3(6) provides that new containers be marked with the surface area in square feet. The surface area of containers not so marked (or not legibly marked) can be computed by use of the applicable formula.

(1) The following formula is used for cylindrical container with hemispherical heads:

$$\text{Surface area} = \text{overall length} \times \text{outside diameter} \times 3.1416$$

(2) The following formula is used for cylindrical container with other than hemispherical heads:

$$\text{Surface area} = (\text{overall length} + 0.3\ \text{outside diameter}) \times \text{outside diameter} \times 3.1416$$

NOTE: This formula is not precise but will give results with limits of practical accuracy in sizing relief valves.

(3) The following formula is used for spherical containers:

$$\text{Surface area} = \text{outside diameter squared} \times 3.1416$$

(4) The following formula is used for flow rate for all containers.

$$\text{Flow rate CFM Air} = 53.632 \times A^{0.82}$$

where:
A = total outside surface area of container in square feet obtained from E.2.2(1), E.2.2(2), or E.2.2(3).

E.2.3 Pressure Relief Valve Testing.

E.2.3.1 Frequent testing of pressure relief valves on LP-Gas containers is not considered necessary for the following reasons:

(1) The LP-Gases are so-called "sweet gases," having no corrosive or other deleterious effect on the metal of the containers or relief valves.
(2) The relief valves are constructed of corrosion-resistant materials and are installed so as to be protected against the weather. The variations of temperature and pressure due to atmospheric conditions are not sufficient to cause any permanent set in the valve springs.
(3) The required odorization of the LP-Gases makes escape almost instantly evident.
(4) Experience over the years with the storage of LP-Gases has shown a good safety record on the functioning of pressure relief valves.

E.2.3.2 Since no mechanical device can be expected to remain in operative condition indefinitely, it is suggested that the pressure relief valves on containers of more than 2000 gal (7.6 m^3) water capacity be tested at approximately 10-year intervals.

Annex F Liquid Volume Tables, Computations, and Graphs

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

F.1 Scope.

F.1.1 Application. This annex explains the basis for Table 7.4.2.2, includes the LP-Gas liquid volume temperature correction table, Table F.3.3, and describes its use. It also explains the methods of making liquid volume computations to determine the maximum permissible LP-Gas content of containers in accordance with Table 7.4.2.3(a), Table 7.4.2.3(b), and Table 7.4.2.3(c).

F.2 Basis for Determination of LP-Gas Container Capacity. The basis for determination of the maximum permitted filling limits shown in Table 7.4.2.2 is the maximum safe quantity that will assure that the container will not become liquid full when the liquid is at the highest anticipated temperature.

F.2.1 For portable containers built to DOT specifications and other aboveground containers with water capacities of 1200 gal (4.5 m^3) or less, this temperature is assumed to be 130°F (54°C).

F.2.2 For other aboveground uninsulated containers with water capacities in excess of 1200 gal (4.5 m^3), including those built to DOT portable or cargo tank specifications, this temperature is assumed to be 115°F (46°C).

F.2.3 For all containers installed under ground, this temperature is assumed to be 105°F (41°C).

F.3 Liquid Volume Correction Table. Table F.3.3 shows the correction of observed volume to standard temperature condition (60°F and equilibrium pressure).

F.3.1 The volume of a given quantity of LP-Gas liquid in a container is directly related to its temperature, expanding as temperature increases and contracting as temperature decreases. Standard conditions, often used for weights and measures purposes and, in some cases, to comply with safety regulations, specify correction of the observed volume to what it would be at 60°F (16°C).

F.3.2 To correct the observed volume to 60°F (16°C), the specific gravity of LP-Gas at 60°F (16°C) in relation to water at 60°F (16°C) (usually referred to as "60°/60°F") and its average temperature must be known. The specific gravity normally appears on the shipping papers. The average liquid temperature can be obtained as follows:

(1) Insert a thermometer in a thermometer well in the container into which the liquid has been transferred, and read the temperature after the completion of the transfer *[see F.3.2(3) for proper use of a thermometer].*
(2) If the container is not equipped with a well but is essentially empty of liquid prior to loading, the temperature of the liquid in the container from which liquid is being withdrawn can be used. Otherwise, a thermometer can be inserted in a thermometer well or other temperature-sensing device installed in the loading line at a point close to the container being loaded. Read temperatures at intervals during transfer and averaging. *[See F.3.2(3).]*
(3) A suitable liquid should be used in thermometer wells to obtain an efficient heat transfer from the LP-Gas liquid in the container to the thermometer bulb. The liquid used should be noncorrosive and should not freeze at the temperatures to which it will be subjected. Water should not be used.

F.3.3 The volume observed or measured is corrected to 60°F (16°C) by use of Table F.3.3. The column headings, across the top of the tabulation, list the range of specific gravities for the LP-Gases. Specific gravities are shown from 0.500 to 0.590 by 0.010 increments, except that special columns are inserted for chemically pure propane, isobutane, and normal butane. To obtain a correction factor, follow down the column for the specific gravity of the particular LP-Gas to the factor corresponding with the liquid temperature. Interpolation between the specific gravities and temperatures shown can be used if necessary.

Table F.3.3 Liquid Volume Correction Factors

	Specific Gravities at 60°F/60°F												
Observed Temperature, Degrees Fahrenheit	**0.500**	**Propane 0.5079**	**0.510**	**0.520**	**0.530**	**0.540**	**0.550**	**0.560**	**iso-Butane 0.5631**	**0.570**	**0.580**	**n-Butane 0.5844**	**0.590**
	Volume Correction Factors												
–50	1.160	1.155	1.153	1.146	1.140	1.133	1.127	1.122	1.120	1.116	1.111	1.108	1.106
–45	1.153	1.148	1.146	1.140	1.134	1.128	1.122	1.117	1.115	1.111	1.106	1.103	1.101
–40	1.147	1.142	1.140	1.134	1.128	1.122	1.117	1.111	1.110	1.106	1.101	1.099	1.097
–35	1.140	1.135	1.134	1.128	1.122	1.116	1.112	1.106	1.105	1.101	1.096	1.094	1.092
–30	1.134	1.129	1.128	1.122	1.116	1.111	1.106	1.101	1.100	1.096	1.092	1.090	1.088
–25	1.127	1.122	1.121	1.115	1.110	1.105	1.100	1.095	1.094	1.091	1.087	1.085	1.083
–20	1.120	1.115	1.114	1.109	1.104	1.099	1.095	1.090	1.089	1.086	1.082	1.080	1.079
–15	1.112	1.109	1.107	1.102	1.097	1.093	1.089	1.084	1.083	1.080	1.077	1.075	1.074
–10	1.105	1.102	1.100	1.095	1.091	1.087	1.083	1.079	1.078	1.075	1.072	1.071	1.069
–5	1.098	1.094	1.094	1.089	1.085	1.081	1.077	1.074	1.073	1.070	1.067	1.066	1.065
0	1.092	1.088	1.088	1.084	1.080	1.076	1.073	1.069	1.068	1.066	1.063	1.062	1.061
2	1.089	1.086	1.085	1.081	1.077	1.074	1.070	1.067	1.066	1.064	1.061	1.060	1.059
4	1.086	1.083	1.082	1.079	1.075	1.071	1.068	1.065	1.064	1.062	1.059	1.058	1.057
6	1.084	1.080	1.080	1.076	1.072	1.069	1.065	1.062	1.061	1.059	1.057	1.055	1.054
8	1.081	1.078	1.077	1.074	1.070	1.066	1.063	1.060	1.059	1.057	1.055	1.053	1.052
10	1.078	1.075	1.074	1.071	1.067	1.064	1.061	1.058	1.057	1.055	1.053	1.051	1.050
12	1.075	1.072	1.071	1.068	1.064	1.061	1.059	1.056	1.055	1.053	1.051	1.049	1.048
14	1.072	1.070	1.069	1.066	1.062	1.059	1.056	1.053	1.053	1.051	1.049	1.047	1.046
16	1.070	1.067	1.066	1.063	1.060	1.056	1.054	1.051	1.050	1.048	1.046	1.045	1.044
18	1.067	1.065	1.064	1.061	1.057	1.054	1.051	1.049	1.048	1.046	1.044	1.043	1.042
20	1.064	1.062	1.061	1.058	1.054	1.051	1.049	1.046	1.046	1.044	1.042	1.041	1.040
22	1.061	1.059	1.058	1.055	1.052	1.049	1.046	1.044	1.044	1.042	1.040	1.039	1.038
24	1.058	1.056	1.055	1.052	1.049	1.046	1.044	1.042	1.042	1.040	1.038	1.037	1.036
26	1.055	1.053	1.052	1.049	1.047	1.044	1.042	1.039	1.039	1.037	1.036	1.036	1.034
28	1.052	1.050	1.049	1.047	1.044	1.041	1.039	1.037	1.037	1.035	1.034	1.034	1.032
30	1.049	1.047	1.046	1.044	1.041	1.039	1.037	1.035	1.035	1.033	1.032	1.032	1.030
32	1.046	1.044	1.043	1.041	1.038	1.036	1.035	1.033	1.033	1.031	1.030	1.030	1.028

Table F.3.3 *Continued*

Observed Temperature, Degrees Fahrenheit	Specific Gravities at 60°F/60°F												
	0.500	Propane 0.5079	0.510	0.520	0.530	0.540	0.550	0.560	iso-Butane 0.5631	0.570	0.580	n-Butane 0.5844	0.590
	Volume Correction Factors												
34	1.043	1.041	1.040	1.038	1.036	1.034	1.032	1.031	1.030	1.029	1.028	1.028	1.026
36	1.039	1.038	1.037	1.035	1.033	1.031	1.030	1.028	1.028	1.027	1.025	1.025	1.024
38	1.036	1.035	1.034	1.032	1.031	1.029	1.027	1.026	1.025	1.025	1.023	1.023	1.022
40	1.033	1.032	1.031	1.029	1.028	1.026	1.025	1.024	1.023	1.023	1.021	1.021	1.020
42	1.030	1.029	1.028	1.027	1.025	1.024	1.023	1.022	1.021	1.021	1.019	1.019	1.018
44	1.027	1.026	1.025	1.023	1.022	1.021	1.020	1.019	1.019	1.018	1.017	1.017	1.016
46	1.023	1.022	1.022	1.021	1.020	1.018	1.018	1.017	1.016	1.016	1.015	1.015	1.014
48	1.020	1.019	1.019	1.018	1.017	1.016	1.015	1.014	1.014	1.013	1.013	1.013	1.012
50	1.017	1.016	1.016	1.015	1.014	1.013	1.013	1.012	1.012	1.011	1.011	1.011	1.010
52	1.014	1.013	1.012	1.012	1.011	1.010	1.010	1.009	1.009	1.009	1.009	1.009	1.008
54	1.010	1.010	1.009	1.009	1.008	1.008	1.007	1.007	1.007	1.007	1.006	1.006	1.006
56	1.007	1.007	1.006	1.006	1.005	1.005	1.005	1.005	1.005	1.005	1.004	1.004	1.004
58	1.003	1.003	1.003	1.003	1.003	1.003	1.002	1.002	1.002	1.002	1.002	1.002	1.002
60	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
62	0.997	0.997	0.997	0.997	0.997	0.997	0.997	0.998	0.998	0.998	0.998	0.998	0.998
64	0.993	0.993	0.994	0.994	0.994	0.994	0.995	0.995	0.995	0.995	0.996	0.996	0.996
66	0.990	0.990	0.990	0.990	0.991	0.992	0.992	0.993	0.993	0.993	0.993	0.993	0.993
68	0.986	0.986	0.987	0.987	0.988	0.989	0.990	0.990	0.990	0.990	0.991	0.991	0.991
70	0.983	0.983	0.984	0.984	0.985	0.986	0.987	0.988	0.988	0.988	0.989	0.989	0.989
72	0.979	0.980	0.981	0.981	0.982	0.983	0.984	0.985	0.986	0.986	0.987	0.987	0.987
74	0.976	0.976	0.977	0.978	0.980	0.980	0.982	0.983	0.983	0.984	0.985	0.985	0.985
76	0.972	0.973	0.974	0.975	0.977	0.978	0.979	0.980	0.981	0.981	0.982	0.982	0.983
78	0.969	0.970	0.970	0.972	0.974	0.975	0.977	0.978	0.978	0.979	0.980	0.980	0.981
80	0.965	0.967	0.967	0.969	0.971	0.972	0.974	0.975	0.976	0.977	0.978	0.978	0.979
82	0.961	0.963	0.963	0.966	0.968	0.969	0.971	0.972	0.973	0.974	0.976	0.976	0.977
84	0.957	0.959	0.960	0.962	0.965	0.966	0.968	0.970	0.971	0.972	0.974	0.974	0.975
86	0.954	0.956	0.956	0.959	0.961	0.964	0.966	0.967	0.968	0.969	0.971	0.971	0.972
88	0.950	0.952	0.953	0.955	0.958	0.961	0.963	0.965	0.966	0.967	0.969	0.969	0.970
90	0.946	0.949	0.949	0.952	0.955	0.958	0.960	0.962	0.963	0.964	0.967	0.967	0.968
92	0.942	0.945	0.946	0.949	0.952	0.955	0.957	0.959	0.960	0.962	0.964	0.965	0.966
94	0.938	0.941	0.942	0.946	0.949	0.952	0.954	0.957	0.958	0.959	0.962	0.962	0.964
96	0.935	0.938	0.939	0.942	0.946	0.949	0.952	0.954	0.955	0.957	0.959	0.960	0.961
98	0.931	0.934	0.935	0.939	0.943	0.946	0.949	0.952	0.953	0.954	0.957	0.957	0.959
100	0.927	0.930	0.932	0.936	0.940	0.943	0.946	0.949	0.950	0.952	0.954	0.955	0.957
105	0.917	0.920	0.923	0.927	0.931	0.935	0.939	0.943	0.943	0.946	0.949	0.949	0.951
110	0.907	0.911	0.913	0.918	0.923	0.927	0.932	0.936	0.937	0.939	0.943	0.944	0.946
115	0.897	0.902	0.904	0.909	0.915	0.920	0.925	0.930	0.930	0.933	0.937	0.938	0.940
120	0.887	0.892	0.894	0.900	0.907	0.912	0.918	0.923	0.924	0.927	0.931	0.932	0.934
125	0.876	0.881	0.884	0.890	0.898	0.903	0.909	0.916	0.916	0.920	0.925	0.927	0.928
130	0.865	0.871	0.873	0.880	0.888	0.895	0.901	0.908	0.909	0.913	0.918	0.921	0.923
135	0.854	0.861	0.863	0.871	0.879	0.887	0.894	0.901	0.902	0.907	0.912	0.914	0.916
140	0.842	0.850	0.852	0.861	0.870	0.879	0.886	0.893	0.895	0.900	0.905	0.907	0.910

F.4 Use of Liquid Volume Correction Factors, Table F.3.3.

F.4.1 To correct the observed volume in gallons for any LP-Gas (the specific gravity and temperature of which is known) to gallons at 60°F (16°C), Table F.3.3 is used as follows:

(1) Obtain the correction factor for the specific gravity and temperature as described in F.3.3.
(2) Multiply the gallons observed by this correction factor to obtain the gallons at 60°F (16°C).

Example: A container has in it 4055 gal of LP-Gas with a specific gravity of 0.560 at a liquid temperature of 75°F. The correction factors in the 0.560 column are 0.980 at 76°F and 0.983 at 74°F, or, interpolating, 0.9815 for 75°F. The volume of liquid at 60°F is 4055 × 0.9815, or 3980 gal.

F.4.2 To determine the volume in gallons of a particular LP-Gas at temperature *t* to correspond with a given number of gallons at 60°F (16°C), Table F.3.3 is used as follows:

(1) Obtain the correction factor for the LP-Gas, using the column for its specific gravity and reading the factor for temperature *t*.
(2) Divide the number of gallons at 60°F (16°C) by this correction factor to obtain the volume at temperature *t*.

Example: It is desired to pump 800 gal (3.03 m^3) at 60°F (15.5°C) into a container. The LP-Gas has a specific gravity of 0.510, and the liquid temperature is 44°F. The correction factor in the 0.510 column for 44°F is 1.025. Volume to be pumped at 44°F is 800/1.025 = 780 gal (2.95 m^3).

F.5 Maximum Liquid Volume Computations.

F.5.1 Maximum Liquid LP-Gas Content of a Container at Any Given Temperature.

F.5.1.1 The maximum liquid LP-Gas content of any container depends on the size of the container, whether it is installed above ground or under ground, the maximum permitted filling limit, and the temperature of the liquid *[see Table 7.4.2.3(a), Table 7.4.2.3(b), and Table 7.4.2.3(c)]*.

F.5.1.2 The maximum volume fraction V_t (in percent of container capacity) of an LP-Gas at temperature *t*, having a specific gravity *G* and a filling limit and weight percent filling limit of *L*, is computed by use of the following formula:

$$V_t = \frac{L}{G} \div F$$

or

$$V_t = \frac{L}{G \times F}$$

where:
V_t = percent of container capacity that can be filled with liquid
L = maximum permitted filling limit by weight *(see Table 7.4.2.2)*
G = specific gravity of particular LP-Gas
F = correction factor to correct volume at temperature *t* to 60°F (16°C)

Example: The maximum liquid content, in percent of container capacity, for an aboveground 30,000 gal (114 m^3) water capacity container of LP-Gas having a specific gravity of 0.508 and at a liquid temperature of 80°F (27°C) is computed as follows:

From Table 7.4.2.2, L = 0.45, and from Table F.3.3, F = 0.967. Thus,

$$V_{80} = \frac{0.45}{0.508 \times 0.967}$$
$$= 0.915\ (91\%) \text{ or } 27{,}300 \text{ gal } \left(103\ m^3\right)$$

F.5.2 Alternate Method of Filling Containers.

F.5.2.1 Containers equipped with fixed maximum level gauges or with variable liquid level gauges when temperature determinations are not practical can be filled with either gauge provided that the fixed maximum liquid level is installed or the variable gauge is set to indicate the volume equal to the maximum permitted filling limit as provided in 7.4.3.2(A). The level is computed on the basis of the liquid temperature being 40°F (4.4°C) for aboveground containers or 50°F (10°C) for underground containers.

F.5.2.2 The percentage of container capacity that can be filled with liquid is computed by use of the formula shown in F.5.1.2, substituting the appropriate values as follows:

$$V_t = \frac{L}{G \times F}$$

where:
t = the liquid temperature [assumed to be 40°F (4.4°C) for aboveground containers or 50°F (10°C) for underground containers]
L = the loading limit obtained from Table 7.4.2.2 for the following:

(1) The specific gravity of the LP-Gas to be contained
(2) The method of installation, aboveground or underground, and if aboveground, then:
  (a) For containers of 1200 gal (4.5 m^3) water capacity or less
  (b) For containers of more than 1200 gal (4.5 m^3) water capacity

G = the specific gravity of the LP-Gas to be contained
F = the correction factor [obtained from Table F.3.3, using G and 40°F (4°C) for aboveground containers or 50°F (10°C) for underground containers]

Example: The maximum volume of LP-Gas with a specific gravity of 0.508 that can be in a 1000 gal (3.8 m^3) water capacity aboveground container that is filled by use of a fixed maximum liquid level gauge is computed as follows:

t = 40°F (4.4°C) for an aboveground container.
L = 0.508 specific gravity, and an aboveground container of less than 1200-gal (4.5-m^3) water capacity, from Table 7.4.2.2, is 42 percent.
G = 0.508.
F = 0.508 specific gravity at 40°F (4.4°C) from Table F.3.3 is 1.033.

Thus,

$$V_{40} = \frac{0.42}{0.508 \times 1.033}$$
$$= 0.800\ (80\%) \text{ or } 800 \text{ gal } \left(3\ m^3\right)$$

F.5.2.3 Percentage values, such as in the example in F.5.2.2, are rounded off to the next lower full percentage point, or to 80 percent in this example.