NFPA 59
Standard for the Storage and Handling of Liquefied Petroleum Gases at Utility Gas Plants

1998 Edition

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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Standard for the

Storage and Handling of Liquefied Petroleum Gases at Utility Gas Plants

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This edition of NFPA 59, *Standard for the Storage and Handling of Liquefied Petroleum Gases at Utility Gas Plants*, was prepared by the Technical Committee on Liquefied Petroleum Gases at Utility Gas Plants and acted on by the National Fire Protection Association, Inc., at its Fall Meeting held November 17–19, 1997, in Kansas City, MO. It was issued by the Standards Council on January 15, 1998, with an effective date of February 6, 1998, and supersedes all previous editions.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

This document has been submitted to ANSI for approval.

Origin and Development of NFPA 59

NFPA 58, *Standard on Liquefied Petroleum Gases,* was used as a general guide until NFPA 59 was adopted in 1949. Subsequent editions were adopted in 1954, 1956, 1958, 1962, 1963, 1968, 1974, 1976, 1979, 1984, 1989, 1992, and 1995.

The cooperation of the American Gas Association was secured to facilitate the preparation of this standard. The result was the formation of a special committee under the sponsorship of the American Gas Association, which was made up of utility engineers, specialists in gas plant construction, and engineers of the liquefied petroleum gas industry. The standard was initially the result of the AGA Committee acting in an advisory capacity to the Sectional Committee on Utility Gas of the NFPA Committee on Gases.

With the formation of the Committee on Fuel Gases in 1966, NFPA 59 was assigned to that committee. The committee established the Subcommittee on Utility Gas Plants, which was assigned working responsibility for NFPA 59. In 1972, working responsibility for NFPA 59 was re-assigned to the Committee on Liquefied Petroleum Gases while maintaining the Subcommittee on Utility Gas Plants.

In 1992, NFPA 59 was assigned to the new Technical Committee on Liquefied Petroleum Gases at Utility Gas Plants. The committee maintains correlation with NFPA 58 by overlapping committee membership and concurrent or joint meetings. The new committee's initial membership was the former Subcommittee on Gas Plants.

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

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

Committee Scope: This Committee shall have primary responsibility for documents on the design, construction, location, installation, operation, and maintenance of refrigerated and nonrefrigerated liquefied petroleum gas storage systems and liquefied petroleum gas processing systems at utility gas plants to the point of introduction into the utility gas distribution system.

Contents

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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 Appendix A.

Information on referenced publications can be found in Chapter 11 and Appendix F.

All pressures used in this standard are gauge pressure unless otherwise indicated

Chapters and sections identified by a dagger (†) include text extracted from another NFPA document. The document and paragraph reference can be found in a note at the beginning of Chapter 3.

Foreword

Under moderate pressure, butane and propane liquefy, but, upon relief of the pressure, they are readily converted into the gaseous phase. Under moderately low temperature the gases liquefy. Generally, the gases are shipped and stored under pressure as liquids. The escape of liquid into the atmosphere normally results in instantaneous vaporization, with the volume of gases being between 200 and 300 times the volume of escaping liquid. When in the gaseous state, these gases are heavier than air and have a narrower range of flammability than natural or manufactured gas.

In the case of pure product at atmospheric pressure and below 31°F (–0.6°C), normal butane is a liquid. Propane is a liquid at atmospheric pressure at temperatures below –44°F (–42°C) and normally does not present a flammable liquid hazard, except when stored at or below its boiling point.

Commercially available butane and propane can have different liquefying points from those above because they normally contain various percentages of other hydrocarbon products.

Rapid vaporization takes place at temperatures above the boiling points [normal butane about 31°F (–0.6°C); propane about –44°F (–42°C)]. Normally these gases are stored as a liquid under pressure; however, in refrigerated storage, these gases are frequently stored at or below the boiling point at practically atmospheric pressure.

Chapter 1 General Provisions

1-1 General.

1-1.1 This standard outlines methods for the protection of persons and property by providing a standard of reference to serve as a guide to all persons concerned with the construction and operation of liquefied petroleum gas equipment at utility gas plants. *(See definition of Utility Gas Plant in Section 1-4.)*

1-1.2 The term *liquefied petroleum gases* (LP-Gases), as used in this standard, shall mean and include any material that has a vapor pressure that does not exceed that allowed for commercial propane, which is composed predominantly of any of the following hydrocarbons, or mixtures of them — propane, propylene, butanes (normal butane or isobutane), and butylenes.

1-1.3 Persons engaged in LP-Gas operating procedures and emergency procedures and in the handling of liquefied petroleum gases shall be trained in the properties and safe handling of these gases and in emergency procedures. This training shall be repeated at least annually.

1-1.4 Metric units in this standard are provided for the convenience of the user. Alternate usage of English and metric units shall not be used to lessen the requirements of the standard.

1-2 Scope.

1-2.1* This standard applies to utility gas plants for the design, construction, location, installation, operation, and maintenance of refrigerated and nonrefrigerated liquefied petroleum gas systems to the point where LP-Gas or a mixture of LP-Gas and air is introduced into the utility distribution system.

1-2.2 The provisions of this standard are not intended to prevent the use of any material, method of construction, or installation procedure that is not specifically prescribed by this standard, provided any such alternative is acceptable to the authority having jurisdiction. *(See definition of Authority Having Jurisdiction in Section 1-4.)* The authority having jurisdiction shall require that sufficient evidence be submitted to substantiate any claim made regarding the safety of such alternatives.

1-2.3 When operations that involve the liquid transfer of LP-Gas from the utility gas plant storage into cylinders or portable tanks (as defined by NFPA 58, *Liquefied Petroleum Gas Code*) are carried out in the utility gas plant, these operations shall conform to NFPA 58.

1-2.4 Installations that have an aggregate water capacity of 4000 gal (15.14 m^3) or less shall conform to NFPA 58, *Liquefied Petroleum Gas Code.*

1-3 Retroactivity.

1-3.1 The provisions of this document are considered necessary to provide a reasonable level of protection from loss of life and property from fire and explosion. They reflect situations and the state of the art at the time the standard was issued.

1-3.2 Unless otherwise noted, it is not intended that the provisions of this document be applied to facilities, equipment, structures, or installations that were existing or approved for construction or installation prior to the effective date of the document.

Exception: The provisions of this document can apply to facilities, equipment, structures, or installations that were existing or approved for construction or installation prior to the effective date of the document in those cases where it is determined by the authority having jurisdiction that the existing situation involves a distinct hazard to life or adjacent property.

1-4 Definitions.

Approved.* Acceptable to the authority having jurisdiction.

Barrel. A unit of volume. One barrel equals 42 U.S. gal (0.159 m^3).

Buried. Installations in which the top of the container (excluding the manway) is below the surrounding grade.

Buried, Partially (or Mounded). Installations in which the top of the container is above the surrounding grade and is covered with earth.

Containers. Vessels, such as tanks, cylinders, or drums, that are used for storing liquefied petroleum gases.

Containers, Field-Erected. Containers that are fabricated in whole or in part at or near their final location.

Containers, Shop-Fabricated. Containers that are completely fabricated within a plant under shop-controlled conditions.

Gas. Liquefied petroleum gases in either the liquid or gaseous state.

Gas-Air Mixer. A device or system of piping and controls that mixes LP-Gas vapor with air to produce a mixed gas of certain heating value but that is not within the flammable range. (Any gas-air mixer that is designed to produce a mixture that contains more than 85 percent air by volume is considered a combustion device and is not subject to the provisions of this standard.)

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.

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

psia. Pounds per square inch, absolute.

psig. Pounds per square inch, gauge.

Redundant Fail-Safe Product Control Measures (RFPCM). Specified product storage controls are more stringent than the basic requirements of this standard. (RFPCM would be used to alleviate the requirement for special protection and to be a factor in reducing distance requirements.)

Refrigerated LP-Gas. LP-gas that is maintained as liquid at temperatures at or below ambient temperature to reduce the storage pressure. This includes fully refrigerated LP-Gas for pressures near atmospheric pressure but not exceeding 15 psi (103 kPa) and semirefrigerated LP-Gas for pressures above 15 psi (103 kPa).

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 permit propagation of flame away from them.

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.

Where required in this standard, special protection consists of applied insulating coatings, mounding, burial, water spray fixed systems, or fixed monitor nozzles that meet the criteria specified in this standard *(see 10-5.4)* or by any means listed for this purpose. *(See definition of Listed.)*

Systems. An assembly of equipment that consists essentially of liquefied petroleum gas unloading equipment; a container or containers; major devices such as vaporizers, relief valves, excess-flow valves, and regulators; and interconnecting piping. In the case of refrigerated storage, it also includes compressors, condensers, and other related equipment and controls. Such systems include any unloading equipment, storage equipment, or interconnecting piping up to the outlet of the first stage regulator, vaporizer, or mixing device, whichever is the last unit before the liquefied petroleum gas enters other plant equipment or distribution lines.

Utility Gas Plant. A fuel gas distribution facility that is owned or operated by a utility, as designated by the appropriate governing jurisdiction.

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.

Vaporizer, Direct-Fired. 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.

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

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

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.

Vaporizer, Indirect (also known as Indirect-Fired). 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 that contains the liquid LP-Gas to be vaporized; the heating of the medium used being at a point remote from the vaporizer.

Vaporizer, Waterbath (also known as Immersion-Type). A vaporizer in which a vaporizing chamber, tubing, pipe coils, or other heat exchange surface that contains 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.

1-5* Odorizing Gases. All LP-Gases shall be odorized by the addition of a warning agent of such character that they are detectable by a distinct odor down to a concentration in air of not over one-fifth the lower limit of flammability.

Exception: Odorization shall not be required if harmful in the use or further processing of the liquefied petroleum gas or if odorization will serve no useful purpose as a warning agent in such use or further processing.

1-6 Acceptance of Equipment. In systems containers of over 2000-gal (7.6-m^3) water capacity, each container valve, excess-flow valve, gauging device, relief device directly connected on the liquefied petroleum gas container, and direct-fired vaporizer shall be approved. *(See definition of Approved in Section 1-4.)*

1-7 Damage from Vehicles. Where damage to liquefied petroleum gas systems from vehicular traffic is a possibility, precautions (such as warning signs or devices, or barricades) shall be taken against such damage. *(See 2-9.2.)*

1-8 Electrical Equipment and Lighting.

1-8.1 Electrical equipment and wiring shall be of the type specified by and shall be installed in accordance with NFPA 70, *National Electrical Code®*, for ordinary locations. *(See Table 1-8.1.)*

Exception: Fixed electrical equipment in classified areas shall comply with Section 1-9 of this standard.

1-8.2 Adequate lighting shall be provided to illuminate operating facilities such as walkways, essential control valves, and loading and unloading facilities in particular.

1-9 Fixed Electrical Equipment in Classified Areas.

1-9.1 Fixed electrical equipment and wiring installed within the classified areas specified in Table 1-8.1 shall comply with Table 1-8.1 and shall be installed in accordance with NFPA 70, *National Electrical Code*, for hazardous locations.

Table 1-8.1* Electrical Area Classification

Part	Location	Extent of Classified Area[1]	Equipment Shall Be Suitable for *NEC*, Class 1, Group D[4]
A	Nonrefrigerated container	Within 15 ft (4.6 m) in all directions from connections, except for connections otherwise covered in this table	Division 2
B	Refrigerated container	Within 15 ft (4.6 m) in all directions from connections, except for connections otherwise covered in this table	Division 2
		Area inside dike to a level of the top of the dike	Division 2
C	Tank vehicle and tank car unloading[2]	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 with the cylindrical volume between the horizontal equator of the sphere and grade *(See Figure 1-8.1.)*	Division 2
D	Gauge vent openings	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 valve discharge	Within direct path of discharge	Division 1
		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, except within path of discharge	Division 2
F	Pumps, compressors, gas-air mixers, meter areas, calorimeters other than open flame types, and vaporizers other than direct-fired		Division 1
	Indoors without ventilation	Entire room and any adjacent room not separated by a gastight partition[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 adequate ventilation[3]	Entire room and any adjacent room not separated by a gastight partition[1]	Division 2
	Outdoors, at or above grade	Within 15 ft (4.6 m) in all directions from equipment and within the cylindrical volume between the horizontal equator of the sphere and grade *(See Figure 1-8.1.)*	Division 2

Table 1-8.1* Electrical Area Classification ***(continued)***

Part	Location	Extent of Classified Area[1]	Equipment Shall Be Suitable for *NEC*, Class 1, Group D[4]
G	Pits or trenches containing equipment such as pumps, compressors, other than direct-fired vaporizers, and similar equipment (also pits or trenches located beneath classified areas)		Division 1
	Without mechanical ventilation[3]	Entire pit or trench	
		Entire room and any adjacent room not separated by a gastight partition where located indoors	Division 2
		Within 15 ft (4.6 m) in all directions from pit or trench where located outdoors	Division 2
	Without adequate mechanical ventilation[3]	Entire pit or trench	Division 2
		Entire room and any adjacent room not separated by a gastight partition where located indoors	Division 2
		Within 15 ft (4.6 m) in all directions from pit or trench where located outdoors	Division 2
H	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

[1]The classified area shall not extend beyond an unpierced wall, roof, or solid, vaportight partition.
[2]When determining the extent of a classified area, consideration shall be given to possible variations in the spotting of tank cars and tank vehicles at the unloading point and the effect that these variations of actual spotting point can have on the point of connection.
[3]Ventilation shall be considered adequate if provided in accordance with the provisions of this standard.
[4]See NFPA 70, *National Electrical Code*, for definitions of *Classes*, *Groups*, and *Divisions*.
Note: Direct-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.

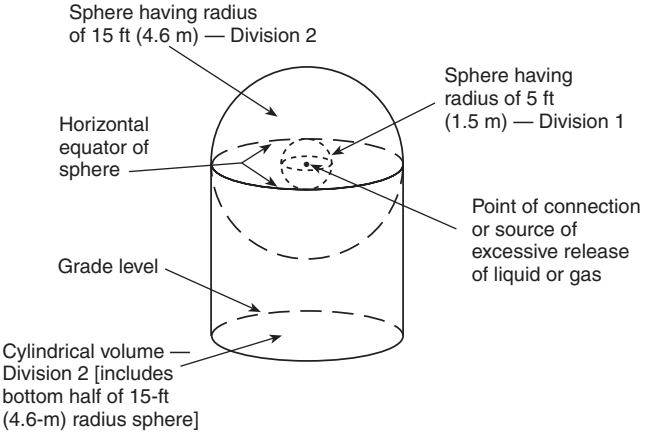

Figure 1-8.1 Extent of electrically classified area. ***(See Table 1-8.1.)***

1-9.2 Fixed electrical equipment on LP-Gas cargo vehicles shall comply with the provisions of Chapter 6 of NFPA 58, *Liquefied Petroleum Gas Code*.

1-10 Source of Ignition.

1-10.1 Smoking and nonprocess ignition sources within the protective enclosure *(see 10-9.2)* shall be prohibited.

Exception: Smoking and nonprocess ignition sources within the protective enclosure shall be permitted if in accordance with 1-10.1.1 through 1-10.1.3.

1-10.1.1 Smoking shall be permitted only in designated and properly signposted areas.

1-10.1.2 Welding, cutting, hotwork, use of portable electric tools and extension lights, and similar operations shall be conducted only at times and places specifically authorized. Welding and cutting shall be conducted in accordance with the provisions of NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes*. Portable electric tools and extension lights capable of igniting LP-Gas shall not be permitted within the classified areas specified in Table 1-8.1.

Exception: Portable electric tools and extension lights capable of igniting LP-Gas shall be permitted where the LP-Gas facilities have been freed of all liquid and vapor or where special precautions are observed under carefully controlled conditions.

1-10.1.3 Vehicles and other mobile equipment that constitute potential ignition sources shall be prohibited within diked areas or within 50 ft (15 m) of containers that contain LP-Gas, flammable liquids, or flammable refrigerants.

Exception: Vehicles and other mobile equipment that constitute potential ignition sources shall not be prohibited where specifically authorized and under constant supervision or where loading or unloading at facilities specifically designed for the purpose.

1-10.2* Electrical grounding and bonding shall be provided as required by NFPA 70, *National Electrical Code*.

1-10.3* If stray currents are present or if impressed currents are used on loading and unloading systems (such as for cathodic protection), protective measures shall be taken to prevent ignition.

1-10.4 Metallic storage containers for LP-Gas generally do not require lightning protection. Grounding systems shall be provided for LP-Gas storage containers in accordance with Chapter 3, Section 4-4, and 6-3.2 of NFPA 780, *Standard for the Installation of Lightning Protection Systems.*

Chapter 2 Nonrefrigerated Containers

2-1 Provision for Construction and Original Test of Nonrefrigerated Containers.

2-1.1 Shop-fabricated containers shall be designed, constructed, and tested in accordance with the ASME *Boiler and Pressure Vessel Code*, Section VIII, "Rules for Construction of Unfired Pressure Vessels," or in accordance with the rules of the authority under which the containers are installed, provided such rules conform to the rules of the ASME *Boiler and Pressure Vessel Code,* Section VIII.

Exception: UG-125 through UG-136 of the ASME Boiler and Pressure Vessel Code shall not apply.

2-1.2 The provisions of 2-1.1 shall not be construed as prohibiting the continued use or reinstallation of containers that are constructed and maintained in accordance with the ASME *Boiler and Pressure Vessel Code* in effect at the time of fabrication. *(See Section 1-3.)*

2-2 Design Pressure and Classification of Nonrefrigerated Containers.

2-2.1 Shop-fabricated containers for nonrefrigerated storage shall be in accordance with Table 2-2.1.

Table 2-2.1* Minimum Design Pressure for Shop-Fabricated Nonrefrigerated Containers

For Gases with Vapor Pressure in psi (kPa) at 100°F (37.8°C) Not to Exceed		Minimum Design Pressure in psi (kPa) (ASME *Boiler and Pressure Vessel Code*, Section VIII)	
80	(552)	100	(689)
100	(689)	125	(862)
125	(862)	156	(1076)
150	(1034)	187	(1289)
175	(1207)	219	(1510)
215	(1482)	250	(1724)

2-2.2 Field-erected nonrefrigerated containers shall be built in accordance with applicable provisions of the 1986 edition of the ASME *Boiler and Pressure Vessel Code.*

Exception: Construction using joint efficiencies in Table UW 12, Column C, Division 1, of the ASME Boiler and Pressure Vessel Code shall not be permitted.

2-2.3 Field-erected containers for nonrefrigerated storage shall be designed for a pressure of not less than 125 percent of the maximum vapor pressure of the product at 100°F (37.8°C) to be stored in the containers, but in no case shall the container be designed for a pressure of 25 psi (172 kPa) or less.

2-3 ASME Container Markings.

2-3.1 ASME containers shall be identified by the attachment of a nameplate. The marking specified shall be on a stainless steel metal nameplate attached to the container and located to remain visible after the container is installed. The nameplate shall be attached so as to minimize corrosion of the nameplate or its fastening means and so as not to contribute to corrosion of the container.

Exception: Where the container is buried, mounded, insulated, or otherwise covered so as to obscure the nameplate, the information contained on the nameplate shall be duplicated and installed on adjacent piping or on a structure in a clearly visible location.

2-3.2 The marking shall contain the following information:

(a) Name and address of container supplier or trade name of container

(b) Water capacity of container in pounds or U.S. gallons

(c) Design pressure in pounds per square inch (psi)

(d) The wording "This container shall not contain a product having a vapor pressure in excess of _____ psi at 100°F" *(See Table 2-2.1.)*

(e) Tare weight of container fitted for service for containers to be filled by weight

(f) Outside surface area in square feet

(g) Year of manufacture

(h) Shell thickness _____; head thickness _____.

(i) OL _____ OD _____ HD _____

(j) Manufacturer's serial number

(k) ASME *Boiler and Pressure Vessel Code* symbol

2-4 Location of Nonrefrigerated Containers.

2-4.1 Nonrefrigerated Aboveground Containers.

2-4.1.1 Containers shall be located outside of buildings.

2-4.1.2 Containers shall be located in accordance with Table 2-4.1.2 with respect to the distance between containers, the distance between containers and the nearest important building or group of buildings not associated with the LP-Gas plant, or a line of adjoining property that can be built upon.

2-4.1.3 Multiple aboveground containers (or groups of containers) 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 2-4.1.3.

Containers shall be oriented so that their longitudinal axes do not point toward other containers, aboveground liquefied natural gas tanks, and flammable liquid storage tanks on the same or adjoining property.

2-4.1.4 All aboveground LP-Gas containers shall be located 100 ft (30.5 m) or more from flammable liquids containers.

Table 2-4.1.2 Nonrefrigerated Container Installation Minimum Distances

Water Capacity of Each Container gal (m^3)	Minimum Distances	
	Between Containers ft (m)	From Container to Nearest Important Building or Group of Buildings Not Associated with the Utility Gas Plant, or a Line of Adjoining Property That Can Be Built Upon ft (m)
2001 to 30,000 (7.6 to 114)	5 (1.5 m)	50 (15)
30,001 to 70,000 (114 to 265)	1/4 of sum of diameters of adjacent containers	75 (23)
70,001 to 90,000 (265 to 341)	"	100 (30)
90,001 to 120,000 (341 to 454)	"	125 (38)
120,001 to 200,000 (454 to 757)	"	200 (61)
200,001 to 1,000,000 (747 to 3785)	"	300 (91)
1,000,001 or more (over 3785)	"	400 (122)

Note: The spacing of containers from buildings associated with utility gas plants shall be permitted to be reduced to 50 percent of the distances inTable 2-4.1.2, with a minimum separation of 50 ft (15 m).

Table 2-4.1.3 Fire Protection Requirements for Container Groups

Fire Protection Provided by	Maximum No. of Containers in One Group	Minimum Separation Between Groups ft (m)
Hose streams only *(See 10-1.1.)*	6	50 (15)
Fixed monitor nozzles per 10-5.4.5	6	25 (7.6)
Fixed water spray per 10-5.4.4	9	25 (7.6)
Insulation per 10-5.4.1	9	25 (7.6)

2-4.1.5 Nonrefrigerated LP-Gas containers shall not be located within dikes that enclose flammable liquid tanks and shall not be located within dikes that enclose refrigerated LP-Gas tanks.

2-4.1.6 Loose or piled combustible material and weeds and long, dry grass shall not be permitted within 25 ft (7.6 m) of any container.

2-4.2 Nonrefrigerated Underground Containers.

2-4.2.1 Underground containers shall include both buried and partially buried (or mounded) containers.

2-4.2.2 Containers shall be located outside of any buildings. Buildings or roadways shall not be constructed over any underground containers. Sides of adjacent containers shall be separated by not less than 3 ft (1 m).

2-4.2.3 Where containers are installed parallel with ends in line, any number of containers shall be permitted to be in one group. Where more than one row is installed, the adjacent ends of the tanks in each row shall be separated by not less than 10 ft (3 m).

2-4.2.4 Containers shall be located not less than 50 ft (15 m) from the nearest important building or group of buildings or line of adjacent property that can be built upon.

2-4.2.5 Containers shall be located not less than 50 ft (15 m) from buildings associated with the utility gas plant. They shall be located not less than 50 ft (15 m) from flammable liquids storage containers.

2-4.3 Nonrefrigerated containers shall not be stacked one above the other.

2-4.4 The ground within 25 ft (7.6 m) of any aboveground, nonrefrigerated container shall be kept clear of readily ignitible material such as weeds and long, dry grass.

2-4.5 Containers connected to a common manifold shall be installed so that their maximum liquid filling levels present substantially the same plane. This minimizes the possibility of overfilling lower level tanks.

2-5 Installation of Nonrefrigerated Storage Containers.

2-5.1 Nonrefrigerated Aboveground Containers.

2-5.1.1 Every container shall be supported to prevent the concentration of excessive loads on the supporting portion of the shell or heads.

2-5.1.2 Supports for containers shall be of solid masonry, concrete, or steel. Structural metal supports shall be permitted to be employed where they are protected against fire in an approved manner. Metal supports shall be protected against fire with a material that has a fire resistance rating of at least 2 hours. Steel skirts that have only one opening that is 18 in. (462 mm) or less in diameter shall be protected in accordance with the preceding, but fireproofing shall be required to be applied only to the outside of the skirt.

2-5.1.3 Horizontal containers shall be mounted on saddles so as to permit expansion and contraction, not only of the container, but also of the connected piping. Only two saddles shall be used.

2-5.1.4 Suitable means to prevent corrosion shall be provided on that portion of the container that is in contact with the foundations or saddles.

2-5.1.5 Containers shall be kept properly painted or otherwise protected from the elements.

2-5.1.6 Vertical containers shall be designed to be self-supporting without the use of guy wires and shall satisfy proper design criteria, taking into account wind, seismic forces (earthquake), and hydrostatic test loads.

2-5.1.7 Design pressure *(see Table 2-2.1)* shall be interpreted as the pressure at the top head with allowance made for increased pressure on the lower shell sections and bottom head due to the static pressure of the product.

2-5.1.8 Wind loading on containers of 10,000 gal (37.9 m^3) or larger 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.

2-5.1.9 Seismic loading on containers of 10,000 gal (37.9 m^3) or larger shall be based on the *Uniform Building Code (UBC).* In those areas identified as zones 3 and 4 on the seismic risk map of the United States (Figures 1, 2, and 3 of Chapter 16 of the *UBC*), a seismic analysis of the proposed installation shall be made that meets the approval of the authority having jurisdiction.

2-5.1.10* 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. The insulation system shall be inherently resistant to weathering and the action of hose streams. *(See Appendix D.)*

2-5.2 Nonrefrigerated Underground Containers.

2-5.2.1 Buried containers shall be placed so that the top of the container is not less than 6 in. (154 mm) below the grade of the surrounding area. Partially buried (or mounded) containers shall have not less than 12 in. (308 mm) of cover, sufficient to provide surface drainage without erosion or other deterioration.

2-5.2.2 The container manway shall not be covered with the backfill or mounding material. Under conditions where the container manway cover is below the ground level, a manway that provides sufficient access shall be installed. No other part of the container shall be exposed.

2-5.2.3 Containers shall be set on a firm foundation and surrounded with earth or sand that is firmly tamped in place. Foundations of firm earth shall be permitted to be used. Backfill shall be free of rocks or other abrasive materials. Provisions shall be made to take care of settling and rotation.

2-5.2.4* Containers shall be protected adequately against corrosion.

2-5.2.5 Bottom connections to the container shall be prohibited. All connections shall be in the container manway or at openings along the top length of the container.

Exception No. 1: Where tanks are mounded and the bottom of the tank is 30 in. (0.76 m) or more above the surrounding grade, bottom connections shall be permitted where access to connections is 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.

Exception No. 2: Bottom connections shall be permitted on mounded tanks where they extend beyond the mound. The connection shall be part of the ASME tank or shall be installed in compliance with the ASME Boiler and Pressure Vessel Code and shall be designed for the forces that can act on the connection.

2-5.2.6 If the area above a container is to be used for purposes permitted by this standard, consideration shall be given to depth of cover and loads that can be imposed.

2-5.3 Field welding, where necessary, shall be made only on saddle plates or brackets that were applied by the manufacturer of the container.

Exception: As provided by the code under which the container was fabricated.

2-5.4 Secure anchorage or adequate pier height shall be provided to protect against container flotation wherever sufficiently high water might occur.

2-5.5 Where flammable liquid storage tanks are in the same general area as LP-Gas containers, the flammable liquid storage tanks shall be diked, or diversion curbs or grading shall be used to prevent accidentally escaping flammable liquids from flowing into LP-Gas container areas.

2-6 Reinstallation of Nonrefrigerated Containers. Containers once installed underground or above ground that have been out of service for more than 1 year shall not be reinstalled above ground or underground unless they successfully withstand, without distortion, hydrostatic pressure retests at the pressure specified for the original hydrostatic test as required by the code under which they were constructed and they show no evidence of serious corrosion. Reinstallation of containers in all other respects shall be in accordance with all the provisions listed in this standard. *(See Section 2-5; see also Chapter 6 for relief valve requirements.)*

2-7 Gaskets. Gaskets used to retain LP-Gas in containers shall be resistant to the action of LP-Gas. They shall be of metal or other material confined in metal, including spiral-wound metal gaskets, that has a melting point over 1500°F (816°C) or shall be protected against fire exposure. When a flange is opened, the gasket shall be replaced.

2-8 Filling Densities.

2-8.1 The *filling density* is defined as the percent ratio of the weight of the gas in a container to the weight of water at 60°F (15.6°C) that the container will hold.

Exception: Nonrefrigerated containers, as provided in 2-8.3, shall be filled in accordance with Table 2-8.1.

2-8.2 The maximum liquid volume in percent of the total container capacity shall be permitted to be determined for nonrefrigerated liquefied petroleum gases at any liquid temperature by using the formula shown in Appendix B.

2-8.3 For individual underground nonrefrigerated installations, the authority having jurisdiction shall be permitted to authorize the use of increased filling densities where the maximum ground temperatures do not exceed 60°F (15.6°C). These filling densities shall be based on sound engineering practices for the operating conditions involved.

2-9 Loading and Unloading Facility Spacing.

2-9.1 Loading and unloading connections shall be at least 75 ft (23 m) from uncontrolled sources of ignition, process areas, control buildings, offices, shops, and other occupied or important plant structures. This shall not apply to structures or equipment directly associated with the transfer operation.

2-9.2 The filling pipe inlet terminal shall not be located inside a building. Such terminals shall be located at least 25 ft (7.6 m) from a container, shall be properly supported and protected from physical damage by vehicular movement, and shall be located at least 5 ft (1.5 m) behind any barriers provided for such protection.

Table 2-8.1 Maximum Permitted Filling Density

Specific Gravity at 60°F (15.6°C)	Aboveground Containers: 0 to 1200 U.S. Gal (1000 Imperial Gal, 4.5 m^3) Total Water Capacity (%)	Aboveground Containers: Over 1200 U.S. Gal (1000 Imperial Gal, 4.5 m^3) Total Water Capacity (%)	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

2-10 Supplemental Product Control.

2-10.1 Modification of Requirements. This section qualifies supplemental product control measures that modify certain distance and special protection requirements.

2-10.2 Redundant Fail-Safe Product Control Measures (RFPCM). Redundant fail-safe product control measures shall incorporate the provisions of 2-10.2.1 through 2-10.2.5.

2-10.2.1 All vapor and liquid withdraw openings on containers that are over 2000 gal (7.6 m^3) of water capacity, under RFPCM requirements, shall be equipped with an internal valve, an integral excess-flow valve, or excess-flow protection. The internal valves shall be designed to remain closed except during operating periods and shall be equipped with a means of remote closure. The internal valves shall also be equipped with automatic shutoff through thermal (fire) actuation. A positive manual shutoff valve shall be installed as close as practical to each internal valve.

2-10.2.2 All vapor and liquid inlet openings on containers over 2000 gal (7.6 m^3) of water capacity, under RFPCM requirements, shall be equipped in accordance with the provisions of 2-10.2.1 or shall be permitted to be equipped with a backflow check valve with a positive manual shutoff valve installed as close as practical to the backflow check valve.

2-10.2.3 At cargo tank and railroad tank car transfer points, protection shall be provided in accordance with 3-2.10.12 of NFPA 58, *Liquefied Petroleum Gas Code,* using approved emergency shutoff valves or backflow check valves, or a combination of the two.

2-10.2.4 Automatic system shutdown of all primary valves (internal valves and emergency shutoff valves) through thermal (fire) actuation shall be provided.

2-10.2.5 Remote shutdown capability, including power supply for transfer equipment and all primary valves (internal and emergency shutoff) shall be provided as follows:

(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) nor more than 100 ft (31 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. (51 mm) in height, on a background of contrasting color to the letters. The sign shall be visible from the point of transfer.

Chapter 3† Refrigerated Containers

NOTE: Chapter 3 is extracted from NFPA 58, *Liquefied Petroleum Gas Code.* Only editorial changes were made to make the text consistent with this standard.

3-1 Provisions for Construction, Design, and Testing of Refrigerated Containers.

3-1.1 Refrigerated LP-Gas containers shall be designed, constructed, and tested in accordance with the following codes.

3-1.1.1 Containers designed to operate at greater than 15 psi (103 kPa) shall be designed and constructed in accordance with the ASME *Boiler and Pressure Vessel Code,* Section VIII, except that construction using joint efficiencies in Table UW 12, Column C, Division 1, shall not be permitted. Materials shall be selected from those recognized by the American Society of Mathematical Engineers (ASME) that meet the requirements of ASME Section VIII, Appendix R, or Appendix Q of API 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks.*

3-1.1.2 Containers that operate at below 15 psi (103 kPa) shall be in accordance with API 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*, including Appendix R.

3-1.1.3 Where austenitic stainless steels or nonferrous materials are used, API 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*, Appendix Q, shall be used in the selection of materials.

3-1.2 The operator shall specify the maximum allowable working pressure, which includes a suitable margin above the operating pressure and the maximum allowable vacuum.

3-1.2.1 For ASME vessels, the positive margin for design pressure 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 620 vessels shall include the control range of the boil-off handling system, the effects of flash or vapor collapse during filling operations, the flash that can result from withdrawal pump recirculation, and the normal range of barometric pressure changes.

3-1.2.2 Allowance shall be made for the service temperature limits of the particular process and the products to be stored when determining material specifications and the design pressure. 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.

3-1.3 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*. Design wind speeds shall be based on a mean occurrence interval of 100 years.

3-1.4 The design seismic loading on refrigerated LP-Gas containers shall be based on forces recommended in the *ICBO Uniform Building Code (UBC)*. For those areas identified as zones 3 and 4 on the seismic risk map of the United States (Figures 1, 2, and 3 of Chapter 23 of the *UBC*), a seismic analysis of the proposed installation shall be made that meets the approval of the authority having jurisdiction.

3-1.5 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 B31.3, *Process Piping*. The container piping shall include all piping internal to the container, within the insulation spaces, and external piping attached or connected to the container up to the first circumferential external joint of the piping. Inert gas purge systems wholly within the insulation spaces shall be exempt from this provision.

Gaskets used to retain LP-Gas in containers shall be resistant to the action of LP-Gas. They shall be of metal or other material confined in metal, including spiral-wound metal gaskets, that has a melting point over 1500°F (816°C) or shall be protected against fire exposure. When a flange is opened, the gasket shall be replaced.

3-1.6 Refrigerated aboveground containers shall be installed on foundations that have been engineered with consideration for soil conditions and loadings.

3-1.6.1 Prior to the start of design and construction of the foundation, a subsurface investigation shall be conducted by a soils engineer. Foundations designed by an engineer who is experienced in foundations and soils and shall be constructed in accordance with recognized structural engineering practices.

NOTE: 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,* Appendix C, for further information.

3-1.6.2 For product storage at less than 30°F (–1.1°C), the foundation design and the container bottom insulation shall be such that damage from frost heave shall not occur. The bottom of the container shall be constructed of materials that are suitable for the temperatures to which they will be exposed. If the bottom of the refrigerated LP-Gas container is in contact with the soil, a heating system shall be provided to prevent the 32°F (0°C) isotherm from extending into the soil. Ambient or supplied heat shall be permitted to be used. The heating system shall be designed to permit both functional and performance monitoring. As a minimum, the undertank temperature shall be observed and logged on a weekly basis. Where there is a discontinuity in the foundation, such as bottom piping, careful attention and separate treatment shall be given to the heating system in that zone. 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. Provisions shall be incorporated to protect against the detrimental effects of moisture accumulation in the conduit, which could result in galvanic corrosion or other forms of deterioration within the conduit or heating element.

3-1.6.3 The refrigerated LP-Gas container foundation shall be periodically monitored for settlement during the life of the facility. The monitoring shall include construction, hydrostatic testing, commissioning, and operation. Any settlement in excess of that anticipated in the design shall be investigated, and corrective action shall be taken if appropriate.

3-1.6.4 The bottom of a refrigerated LP-Gas container, either the bottom of an outer tank or the bottom of the undertank insulation, shall be above the ground water table or otherwise protected from contact with ground water at all times and be protected from possible high flood waters. Secure anchorage or adequate pier height shall be provided to protect against container flotation wherever sufficiently high water might occur.

3-1.6.5 Where two or more containers are sited in a common dike, the container foundations shall be capable of withstanding contact with LP Gas or shall be protected against contact with an accumulation of -LP-Gas that might endanger structural integrity.

3-1.6.6 If the foundation of a refrigerated LP-Gas container is installed to provide adequate air circulation in lieu of a heating system, the bottom of the container shall be constructed of materials that are suitable for the temperatures to which they will be exposed. The material in contact with the bottom of the container shall be selected to minimize corrosion.

3-1.7 Marking on Refrigerated LP-Gas Containers. Each refrigerated LP-Gas container shall be identified by the attachment of a nameplate on the outer covering. The nameplate shall be in an accessible, visible place and marked with the following information:

(a) Manufacturer's name and date built
(b) Liquid volume of the container in U.S. gallons (U.S. standard) or barrels
(c) Maximum allowable working pressure in pounds per square inch
(d) Minimum temperature (in degrees Fahrenheit) for which the container was designed
(e) Density of the product to be stored in pounds per cubic foot, or specific gravity for which the container was designed
(f) Maximum level to which the container is permitted to be filled with the LP-Gas for which it was designed

3-2 Refrigerated LP-Gas Container Instruments and Controls.

3-2.1 Each refrigerated LP-Gas container shall be equipped with at least two independent liquid level gauging devices. These devices shall be installed so that they can be replaced without taking the container out of service.

3-2.2 The refrigerated LP-Gas container shall be provided with a high-liquid level alarm. The alarm shall be set so that the operator will have sufficient time to stop the flow without exceeding the maximum permissible filling height. The alarm shall be located so that it is audible to the personnel who control the filling. A high-liquid level flow cutoff device shall not be considered as a substitute for the alarm.

3-2.3 The refrigerated LP-Gas container shall be equipped with a high-liquid level flow cutoff device that is independent from all gauges.

Exception: Refrigerated LP-Gas containers of 70,000 gal (264.98 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.

3-2.4 Each refrigerated LP-Gas container shall be provided with temperature-indicating devices that assist in controlling cool-down rates when placing the container in service.

3-2.5 The internal pressure and vacuum of refrigerated LP-Gas containers shall be maintained within the limits established in the design specification. The design of pressure control means shall include the following failure modes.

(a) For pressure:
1. Loss of refrigeration
2. Operational upset, including failure of control devices
3. Vapor displacement and flash vaporization during filling, as a result of filling, and controlled mixing or pump recirculation of different compositions and temperatures
4. Drop in atmospheric pressure
5. Fire exposure
6. Flash vaporization resulting from pump recirculation

(b) For vacuum:
1. Withdrawal of liquid or vapor at the maximum rate
2. Rise in atmospheric pressure
3. Reduction in vapor pressure as a result of introduction of subcooled LP-gas

3-2.6 The minimum start-to-discharge of air from a pressure relief valve at 120 percent of the maximum permissible start-to-discharge pressure shall be computed using the following formula:

$$Q_a = \frac{633,000\ FA^{0.82}}{LC}\sqrt{\frac{ZT}{M}}$$

where:

Q_a = Minimum required flow capacity of air, in cubic feet per minute, at 60°F and 14.7 psia.

F = A composite environmental factor, as tabulated in Table 3-2.6A. To receive credit for reduced heat input, the insulation shall resist dislodgment by fire hose streams, shall be noncombustible, and shall not decompose at temperatures up to 1500°F (816°C). If insulation does not comply with these criteria, the environmental factor, F, for a bare container shall be used.

A = Total exposed wetted surface, in square feet. For a vertical container, the wetted area shall be equal to the total surface area of the shell up to a height of 30 ft (9.1 m) above grade.

L = Latent heat of product at the flow rating pressure, in Btu per pound. (The latent heat of pure propane at atmospheric pressure is 183.5 Btu/lb and of isobutane is 157.8 Btu/lb.)

C = Constant for gas or vapor related to specific heats.

$k = C_p/C_v$ at 60°F (16°C) and 14.696 psia (an absolute pressure of 101.325 kPa). (The ratio of specific heat, k, is 1.13 and C=330 for pure propane and k=1.10 and C=316 for butane.)

Table 3-2.6A Environmental Factors

Insulation	Factor F
Bare container	1.0
Insulated containers with the following typical conductance values, k, in Btu per hour per square foot per degrees Fahrenheit, based on 1600°F temperature difference:	
k = 4.0	0.3
k = 2.0	0.15
k = 1.0	0.075

Table 3-2.6B Chart for Gas Constant, *C*

k	*C*	*k*	*C*	*k*	*C*
1.00	315	1.26	343	1.52	366
1.02	318	1.28	345	1.54	368
1.04	320	1.30	347	1.56	369
1.06	322	1.32	349	1.58	371
1.08	324	1.34	351	1.60	372
1.10	327	1.36	352	1.62	374
1.12	329	1.38	354	1.64	376
1.14	331	1.40	356	1.66	377
1.16	333	1.42	358	1.68	379
1.18	335	1.44	359	1.70	380
1.20	337	1.46	361	2.00	400
1.22	339	1.48	363	2.20	412
1.24	341	1.50	364		

Z = Compressibility factor at flowing conditions
T = Absolute temperature at flowing conditions
M = Molecular weight of gas

3-3 Refrigerated LP-Gas Container Impoundment.

3-3.1 Each refrigerated LP-Gas container shall be located within an impoundment that complies with this section, in order to minimize the possibility that the accidental release of liquid LP-Gas from the container would endanger adjoining property or lives, process equipment, or structures, or that an accidental release could reach waterways or enclosed drainage systems.

3-3.2 Enclosed drainage channels for LP-Gas shall be prohibited.

Exception: Container downcomers used to conduct spilled LP-Gas away from materials subject to failure upon exposure to liquid LP-Gas shall be permitted to be enclosed.

3-3.3 Impoundment for refrigerated LP-Gas and flammable refrigerant containers shall have a minimum volumetric holding capacity, including any useful holding capacity of the area, and with 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.

3-3.4 More than one container shall be permitted to be installed in a single impoundment, under the following conditions:

(a) Where an outer shell is used to contain loose insulation:
   1. Containers shall be elevated above grade so that liquid will not reach the outside container wall in the event of a liquid spill; or
   2. If liquid can reach the outside container wall, the material that can be wetted by spilled liquid shall be suitable for use at –44°F (–42°C).

(b) Container foundations are constructed of concrete that is properly designed for fire exposure.

3-3.5 An impoundment structure shall be of compacted earth, concrete, metal, or other suitable material. Such structures shall be permitted to be constructed independently of the container, mounted integrally to the container, or constructed against the container. These structures, and any penetrations thereof, shall be designed to withstand the full hydrostatic head of impounded LP-Gas or flammable refrigerant, the effect of rapid cooling to the temperature of the liquid to be confined, any anticipated fire exposure, and natural forces such as earthquake, wind, or rain.

3-3.6 Where topography can provide suitable containment, dike walls, where required, shall be required to be only as high as the containment capacity requires.

3-3.7 Provision shall be made to clear rain or other water from the impoundment area. Automatically controlled sump pumps shall be permitted if equipped with an automatic cutoff device that prevents their operation when exposed to LP-Gas temperatures. Piping, valves, and fittings whose failure could permit liquid to escape from the impounding area shall be suitable for continuous exposure to LP-Gas temperature. If gravity drainage is employed for water removal, provision shall be made to prevent the escape of LP-Gas by way of the drainage system. Gravity drainage that uses piping penetrations through or below impoundment dikes shall not be permitted.

3-4 Inspection of Refrigerated LP-Gas Containers and Systems.

3-4.1 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 standard and other applicable referenced codes and standards. Such inspections or tests shall ensure that the design, material specifications, fabrication methods, and quality comply with the requirements of this standard and other applicable referenced codes and standards.

3-4.2 The inspections or tests required shall be the responsibility of the operator. The operator shall be permitted to delegate any part of those inspections or tests to the operator's employees or a third-party engineering, scientific, recognized insurance, or inspection organization. Each inspector shall be qualified in accordance with the code or standard that is applicable to the test or inspection being performed.

3-4.3 After acceptance tests are completed, there shall be no field welding on the LP-Gas containers. Retesting by a method appropriate to the repair or modification shall be required only where the repair or modification is of such a nature that a retest actually tests the element affected and is necessary to demonstrate the adequacy of the repair or modification.

Exception: Welding shall be permitted on saddle plates or brackets that are provided for the purpose or as otherwise permitted by the code under which the container was fabricated.

3-5 Locating Aboveground Refrigerated LP-Gas Containers.

3-5.1 Spacing of refrigerated propane containers from important buildings, storage containers for flammable or combustible liquids, and lines of adjoining property that can be built upon shall be in accordance with Table 3-5.1.

3-5.2 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.

3-5.3 Nonrefrigerated LP-Gas containers or flammable liquid tanks shall not be located within dikes or impoundments enclosing refrigerated LP-Gas containers.

Table 3-5.1 Minimum Distances

Water Capacity per Container gal (m^3)	Aboveground Containers ft (m)
Up to 70,000 (265)	75 (23)
70,001 to 90,000 (265 to 341)	100 (30)
90,001 to 120,000 (341 to 454)	125 (38)
120,001 to 200,000 (454 to 757)	200 (61)
200,001 to 1,000,000 (757 to 3785)	300 (91)
Over 1,000,000 (3785)	400 (122)

Note: Minimum distances for mounded or underground containers of 2001 gal to 30,000 gal (7.6 m^3 to 114 m^3) water capacity incorporating RFPCM provisions shall be permitted to be reduced to 10 ft (3 m). Distances for all underground and mounded containers shall be measured from the relief valve and filling connection, except that no part of an underground 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 container, 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.

3-5.4 Refrigerated LP-Gas containers shall not be installed one above the other.

3-5.5 The minimum distance between aboveground refrigerated LP-Gas containers shall be one-half the diameter of the larger container.

3-5.6 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 ignitible materials such as weeds and long, dry grass.

Chapter 4 Piping, Valves, and Equipment

4-1 General.

4-1.1 Piping, valves, and equipment shall be suitable for their intended use at the temperatures of the application and shall be designed for not less than the maximum pressure and for the minimum temperature to which they can be subjected.

4-1.1.1 The design and fabrication of piping systems shall be in accordance with ASME B31.3, *Process Piping*, except as modified by the provisions of this chapter and any applicable federal pipeline regulations. Special consideration shall be given to the behavior of the piping material upon possible fire exposure.

4-1.1.2 Pressure-containing metal parts of equipment for application temperatures of –20°F (–29°C) or above shall be fabricated of materials suitable for LP-Gas service and shall be resistant to the action of LP-Gas under service conditions. They shall be of steel; ductile (nodular) iron (ASTM A 395, *Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*, or ASTM A 536, *Specifications for Ductile Iron Castings*, Grade 60-40-18 or 65-45-12); malleable iron (ASTM A 47, *Standard Specification for Ferritic Malleable Iron Castings*); higher strength gray iron (ASTM A 48, *Specification for Gray Iron Castings*, Class 40B); brass; or the equivalent. Cast iron shall not be used for strainers or flow indicators.

4-1.1.3 Piping that can contain liquid LP-Gas and that can be isolated by valving and that requires hydrostatic relief valves, as specified under Section 6-6, shall have as a minimum a design pressure of 350 psi (2400 kPa), or the maximum discharge pressure of any pump or other source feeding that piping system, whichever is greater. Such piping shall be subjected to a pressure test, in accordance with 4-1.1.1, of no less than 150 percent of the design pressure.

4-1.2 Piping connections to the container for sizes over 2 in. nominal pipe diameter shall be made by welding or with welded flanges.

Exception: Piping connections for excess-flow valves.

4-1.3 The use of cast-iron valves, pipe, and fittings shall be prohibited in piping that carries LP-Gas. This shall not prohibit the use of container valves or fittings made of malleable or ductile iron if used within the limitations set forth in 323.4.2 of ASME B31.3, *Process Piping*.

4-1.4 Emergency shutoff valves shall be approved and shall incorporate all of the following means of closing *(see 4-3.5)*:

(a) Automatic shutoff through thermal (fire) actuation [Where fusible elements are used, they shall have a melting point not exceeding 250°F (121°C).]

(b) Manual shutoff from two or more remote locations

(c) Manual shutoff at the installed location

4-1.5 Gaskets used to retain LP-Gas in flanged connections in piping shall be resistant to the action of LP-Gas. They shall be of metal or other suitable material that is confined in metal that has a melting point over 1500°F (816°C) or shall be protected against fire exposure. When a flange is opened, the gasket shall be replaced.

4-1.6 All piping, tubing, fittings, and valves shall be leak tested after assembly and proved to be free of leaks at not less than normal operating pressures. Tests shall not be made with a flame.

4-1.7* Provision shall be made for expansion, contraction, jarring, vibration, and settling.

4-1.8* Piping outside buildings shall be permitted to be buried, above ground, or be buried and above ground, but shall be well-supported and protected against physical damage and corrosion. Underground and submerged piping shall be protected and maintained to minimize corrosion.

4-1.9 Equipment selection for application temperatures below –20°F (–29°C) shall be based on sound engineering practices for the individual design and operating conditions involved. Special consideration shall be given to the behavior of material upon possible fire exposure.

4-2 Container Valves and Accessories.

4-2.1 All shutoff valves and accessory equipment (liquid or gas) shall be suitable for use with LP-Gas and designed for not less than the maximum extreme pressure and temperature to which they can be subjected. Valves for use with nonrefrigerated containers that can be subjected to container pressure shall have a rated working pressure of at least 250 psi (1.7 MPa). Cast-iron valves, piping, and fittings shall be prohibited on LP-Gas containers and their connections. This shall not prohibit the use of container valves or fittings that are made of malleable or nodular iron.

4-2.2 All connections to containers shall have shutoff valves located as close to the container as practical. The valves shall be readily accessible for operation and maintenance under normal and emergency conditions, either by location or by means of permanently installed special provisions. Valves installed in unobstructed locations that are not more than 6 ft (1.8 m) above ground level shall be considered accessible. Special provisions shall include stairs, ladders, platforms, remote operators, extension handles, and so on.

Exception: Safety relief connections, liquid level gauging devices, and plugged openings shall not be considered to be special provisions.

4-2.3 Excess-flow valves, where required by this standard, shall close automatically at those rated flows of vapor or liquid as specified by the manufacturer. The connections or lines, including valves, fittings, etc., downstream of an excess-flow valve shall have a greater capacity than the rated flow of the excess-flow valve.

4-2.4 All liquid and vapor connections on containers shall be equipped with one of the following:

(a) A back-pressure check valve

(b) An excess-flow valve and an emergency shutoff valve as specified in 4-1.4

(c) A quick-acting internal valve incorporating the means of closing as specified in 4-1.4

Exception: Safety relief valves, liquid level gauging devices, and openings not larger than No. 54 drill size as covered in 4-2.5 and 4-4.4.

4-2.5 Openings from a container or through fittings attached directly on the container to which pressure gauge connection is made shall not be required to be equipped with an excess-flow valve if such openings are not larger than No. 54 drill size.

4-2.6 Excess-flow and back-pressure check valves, where required by this standard, shall be located inside of the container or at a point outside where the line enters the container. In the latter case, installation shall be made in such a manner that any undue stress beyond the excess-flow or back-pressure check valve will not cause breakage between the container and such valve.

4-2.7 Excess-flow valves shall be designed with a bypass, not to exceed a No. 60 drill size opening, to allow equalization of pressures.

4-2.8 All inlet and outlet connections on any container shall be labeled or color coded to designate whether they are connected to a vapor or liquid space. Labels shall be permitted to be on valves.

Exception: Labels shall not be required to be on safety valves, liquid level gauging devices, and pressure gauges.

4-2.9 Each storage container shall be provided with a suitable pressure gauge.

4-3 Filler and Discharge Pipes, Manifolds.

4-3.1 Piping connections between container and manifold shall be designed to provide adequate allowances for contraction, expansion, vibration, and settlement. Compression-type couplings shall not be considered suitable for this purpose.

4-3.2 Liquid manifold connections shall be located at nonadjacent ends of parallel rows of containers.

4-3.3 The use of nonmetallic hose shall be prohibited for interconnecting stationary containers.

4-3.4 In the design of the liquid piping system, shutoff or block valves shall be installed to limit the volume of liquid that could be discharged in the vicinity of containers or important structures in the event of a liquid line failure. Automatically or remotely controlled valves, or both, of the fail-safe type shall be used. The mechanism for such valves shall be provided with a secondary control equipped with a fusible release [not over 250°F (121°C) melting point] that will cause the valve to close automatically in case of fire. Such valves also shall be capable of being operated manually at the installed location. A remote closing control shall be located so as to be accessible during a fire or other emergency. On aboveground piping systems, such valves shall be arranged to limit the quantity that could be discharged within 300 ft (91.4 m) of a container, important building, or line of adjoining property that can be built upon to a maximum of 500 gal (1.89 m^3) of liquid.

4-3.5 In addition to the valving specified in 4-3.4, suitable safeguards shall be provided to prevent the uncontrolled discharge of LP-Gas in the event of failure in the flexible connecting hose or swivel-type piping, located as close as practical to the points where connections are made between the flexible and fixed parts of the piping system, as follows:

4-3.5.1 The connection or connecting piping into which the liquid or vapor is being transferred shall be equipped with one of the following:

(a) A backflow check valve

(b) An emergency shutoff valve that complies with 4-1.4

4-3.5.2 The connection, or connecting piping, from which the liquid or vapor is being drawn shall be equipped with an emergency shutoff valve that complies with 4-1.4.

4-3.5.3 Where used in conjunction with hose or swivel-type piping, the valve specified in 4-3.4 shall be as follows:

(a) The valve shall be supplemented with a thermal sensor mounted along the entire length of the hose or swivel piping. This requirement shall be considered to be met by the use of hydraulically or pneumatically operated valves with plastic tubing attached along the entire length of the hose or swivel-type piping such that the melting of the plastic tubing will cause the valve to close, or approved alternate equipment that provides equal protection.

(b) *Installed in the plant piping so that any break resulting from a pull will occur on the hose or swivel-type piping side of the connection. This provision shall apply to backflow check valves installed in accordance with 4-3.5.1.

4-3.6 Where the liquid line manifold connecting containers in a group has a volumetric capacity of more than 100 gal (0.4 m^3), such container manifolds shall be located not less than 100 ft (31 m) from the nearest adjacent property, owned by others, that can be built upon. The manifold piping shall terminate at the first line valve, which is used to isolate the manifolded containers from any other part of the liquid line system.

4-4 Liquid Level Gauging Device.

4-4.1 Each nonrefrigerated storage system shall be equipped with a liquid level gauging device of approved design, such as a pressure differential type, a float gauge, a rotary gauge, slip tube, or a magnetic or fixed tube device. If the liquid level gauging device is a float type or a pressure differential type and the container is a nonrefrigerated type, the container also shall be provided with an auxiliary gauging device, such as a fixed dip tube, slip tube, rotary gauge, or similar device.

Unlisted gauge glasses of the columnar type shall not be permitted.

4-4.2 Refrigerated containers shall be equipped with a liquid level gauging device of approved design. An auxiliary gauging device shall not be required for refrigerated containers. However, in lieu of an auxiliary gauge, refrigerated containers, if subject to overfilling, shall be equipped with an automatic device to interrupt filling of the tank when the maximum filling level is reached.

4-4.3 All gauging devices shall be arranged so that the maximum liquid level to which the container can be filled for butane, for a 50-50 mixture of butane and propane, and for propane is readily determinable.

4-4.4 Gauging devices that require bleeding of the product to the atmosphere, such as the rotary tube, fixed tube, and slip tube, shall be designed so that the bleed valve maximum opening is not larger than a No. 54 drill size, unless provided with an excess-flow valve.

4-4.5 Gauging devices for containers shall have a maximum allowable working pressure at least equal to that of the containers to which they are attached.

4-4.6* Where used, the length of a fixed tube device shall be designed to indicate the maximum level to which the container can be filled for the product contained. The length or location of the fixed tube that indicates this level shall be based on the volume of the product at 40°F (4.4°C) at its max-

imum permitted filling density for aboveground containers and at 50°F (10°C) for buried containers.

4-5 Hose Specifications for Nonrefrigerated LP-Gas.

4-5.1 Hose shall be fabricated of materials that are resistant to the action of LP-Gas and shall be approved.

4-5.2 Hose, hose connections, and flexible connections shall comply with 4-5.2.1 and 4-5.2.2.

4-5.2.1 Hose shall be designed for a minimum bursting pressure of 1750 psi (12.1 MPa) [350 psi (2.41 MPa) working pressure] and shall be marked with "LP-Gas" or "LPG," with the working pressure in psi marked at not greater than 10-ft (3-m) intervals.

4-5.2.2 Hose assemblies, after the application of connections, shall have a design capability of withstanding a pressure of not less than 700 psi (4.8 MPa). If a test is made, such assemblies shall not be leak tested at pressures higher than the working pressure [350 psi (2.41 MPa) minimum] of the hose.

4-6 Drips, Pits, and Drains.

4-6.1 Where vaporized gas can condense, suitable means shall be provided for revaporization or disposal of the condensate.

4-6.2 If pits are used, they shall be fitted with continuous automatic flammable vapor detecting devices equipped with an alarm. No drains or blow-off lines shall be directed into or in proximity to sewer systems used for other purposes.

4-7 Pumps and Compressors.

4-7.1 Each pump and compressor shall be suitable for the LP-Gas service intended. Each pump and compressor shall be marked with its maximum working pressure.

4-7.2 Refrigerated storage systems shall be provided with sufficient capacity to maintain all containers at a pressure not in excess of the operating pressure under summer weather conditions and shall be provided with additional capacity for filling or standby service. Unless facilities are provided for safely disposing of vented vapors while the refrigeration system is inoperative, at least two compressors shall be installed where compressors and condensers are used. Compressor capacity provided for standby service shall be capable of handling the volume of vapors necessary to be evolved to maintain operating pressure. Auxiliary equipment, such as fans, circulating water pumps, and instrument air compressors, shall be provided with spare or standby facilities sufficient to ensure that prolonged failure of refrigeration can be prevented.

4-7.3 Adequate means shall be available for operating equipment in the event of failure of normal facilities.

4-8 Protection of Container Accessories.

4-8.1 Valves and regulating, gauging, and other container accessory equipment shall be protected against tampering and physical damage. If locks are used, they shall be of the frangible shank type.

4-8.2 All connections on underground containers shall be located within a substantial dome, housing, or manhole and shall be protected by a substantial, round cover. *(See 6-4.2.)*

Chapter 5 Vaporizers, Heat Exchangers, and Gas-Air Mixers

5-1 General.

5-1.1 Liquefied petroleum gas storage containers shall not be directly heated with open flames.

5-1.2 Heating or cooling coils shall not be installed inside of a storage container.

5-1.3 Vaporizer houses shall not have drains to sewers or sump pits.

5-1.4 Building or structural enclosures in which vaporizers or gas-air mixers are installed shall be of lightweight noncombustible construction with non-load-bearing walls. If rooms that contain such equipment are located within or attached to buildings in which LP-Gases are not handled (control rooms, shops, boiler rooms, and so on), the common walls shall be limited to no more than two in number, shall be designed to withstand a static pressure of at least 100 psf (4.8 kPa), shall have no doors or other communicating openings, and shall have a fire resistance rating of at least 1 hour. Such buildings or structural enclosures shall be ventilated to minimize the possibility of hazardous accumulations of flammable vapors by a gravity system composed of a combination of wall openings near the floor line and roof ventilators. The ventilation rate shall be at least 1 ft^3/min of air per square foot [(0.0052 m^3/sec) of air per square meter] of floor area.

5-2 Vaporizers, Heat Exchangers, and Gas-Air Mixers.

5-2.1 Vaporizers shall be of the indirect type (utilizing steam, hot water, or other heating medium) or direct fired. This subsection shall not apply to engine fuel vaporizers or to integral vaporizer-burners such as those used with weed burners or tar kettles.

5-2.2 Indirect vaporizers and heat exchangers shall comply with the following:

(a) Indirect vaporizers with an inside diameter of more than 6 in. (152 mm) shall be constructed in accordance with the applicable provisions of the ASME *Boiler and Pressure Vessel Code* for a design pressure of not less than 250 psi (1.7 MPa) and shall be permanently and legibly marked with the following:

1. The markings required by the ASME code
2. The outside surface area in square feet
3. The area of the heat exchange surface in square feet
4. The maximum vaporizing capacity in gallons per hour
5. The rated heat input in British thermal units (Btu) per hour
6. The name or symbol of the manufacturer

(b) Indirect vaporizers shall be provided with a suitable automatic means to prevent liquid from passing through the vaporizer to the vapor discharge piping. This means shall be permitted to be integral with the vaporizer or otherwise provided in the external piping. *(See 5-3.2.6.)*

(c) Indirect vaporizers, including atmospheric-type vaporizers that use heat from the surrounding air or the ground, shall be equipped, at or near the discharge, with a spring-loaded pressure relief valve that provides a relieving capacity in accordance with 5-2.5. Fusible plug devices shall not be used.

5-2.3 Direct-fired vaporizers shall comply with the following:

(a) Design and construction of direct-fired vaporizers shall be in accordance with the applicable requirements of the ASME *Boiler and Pressure Vessel Code* for the working conditions to which the vaporizer will be subjected. The vaporizer shall be permanently and legibly marked with the following information:

1. The markings required by the ASME code
2. The outside surface area in square feet
3. The area of the heat exchange surface in square feet
4. The maximum vaporizing capacity in gallons per hour
5. The rated heat input in British thermal units (Btu) per hour
6. The name or symbol of the manufacturer

(b) Direct-fired vaporizers shall be equipped, at or near the discharge, with a spring-loaded pressure relief valve that provides a relieving capacity in accordance with 5-2.5. 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.

(c) Direct-fired vaporizers shall be provided with suitable automatic means to prevent liquid from passing from the vaporizer to its vapor discharge piping.

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

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

(f) 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 shown in the first column of Table 5-2.3(f) corresponding with the design pressure of the container [or its ASME *Boiler and Pressure Vessel Code* equivalent — *see Table 5-2.3(f)*].

Table 5-2.3(f)* ASME *Boiler and Pressure Vessel Code* Minimum Design Pressure

For Gases with Vapor Pressure in psi (MPa) at 100°F (37.8°C) Not to Exceed	Minimum Design Pressure in psi (MPa) from ASME Code, Section VIII, Division 1, 1986 Edition
80 (0.6)	100 (0.7)
100 (0.7)	125 (0.9)
125 (0.9)	156 (1.1)
150 (1.0)	187 (1.3)
175 (1.2)	219 (1.5)
215 (1.5)	250 (1.7)

5-2.4 Waterbath vaporizers shall comply with the following:

(a) The vaporizing chamber, tubing, pipe coils, or other heat exchange surface containing the LP-Gas to be vaporized, hereinafter referred to as the "heat exchanger," shall be constructed in accordance with the applicable provisions of the ASME *Boiler and Pressure Vessel Code* for a minimum design pressure of 250 psi (1.7 MPa) and shall be permanently and legibly marked with:

1. The markings required by the ASME code
2. The outside surface area in square feet
3. The area of the heat exchange surface in square feet
4. The maximum vaporizing capacity in gallons per hour
5. The rated heat input in British thermal units (Btu) per hour
6. The name or symbol of the manufacturer

(b) Heat exchangers for water bath vaporizers shall be provided with an automatic control to prevent liquid from entering the distribution piping system.

(c) Heat exchangers for waterbath vaporizers shall be equipped at or near the discharge with a spring-loaded pressure relief valve that provides a relieving capacity in accordance with 5-2.5. Fusible plug devices shall not be used.

(d) Waterbath sections of waterbath vaporizers shall be designed to eliminate a pressure buildup above the design pressure.

(e) The immersion heater, which provides heat to the waterbath, shall be installed so as not to contact the heat exchanger. The immersion heater shall be permitted to be electric or gas-fired.

(f) A control to limit the temperature of the waterbath shall be provided.

(g) 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.

(h) 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 programming to provide for prepurge prior to ignition, proof of pilot before main burner valve opens, and full shutdown of main gas and pilot upon flame failure.

(i) A means shall be provided to shut off the source of heat in the event the level of the heat transfer medium falls below the top of the heat exchanger.

5-2.5 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 be determined as follows:

(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 permitted to be used in conjunction with Table E-1.

5-2.6* LP-Gas-air mixers shall comply with the following.

5-2.6.1 LP-Gas-air mixers shall be designed for the air, vapor, and mixture pressures to which they can be subjected. Piping shall comply with 4-1.1.

5-2.6.2 LP-Gas-air mixers that are to be used to supplement (peak-shave) a natural gas supply shall be designed to produce a mixture of natural gas, air, and LP-Gas vapor that is safely interchangeable with the natural gas. If necessary, redundant controls or interlocks shall be provided to prevent the introduction of either undiluted air or vapor into the gas distribution lines in quantities that would create interchangeability problems.

5-2.6.3 A positive valving arrangement, such as a double-block-and-bleed (check valves shall not be considered to be sufficient for this purpose), shall be installed close to the mixer to prevent backflow of gas into the air supply lines or of air into the LP-Gas system when the plant is not in operation. LP-Gas-air mixer control valves in the LP-Gas and air supply lines that are arranged to fail closed when actuated by safety interlock or other trip devices shall be considered as acceptable shutdown devices but not as isolation devices as specified in this paragraph.

5-2.6.4 Where it is possible for condensation to take place between the vaporizer and LP-Gas-air mixer, a separator or other means shall be provided to prevent LP-Gas liquid from entering the LP-Gas-air mixer.

5-2.6.5 LP-Gas-air mixers that use the kinetic energy of the LP-Gas vapor to entrain air from the atmosphere shall require only a shutoff that will minimize the leakage of either gas or LP-Gas vapors to the atmosphere when the mixer is not operating. Such mixers also shall be provided with sufficient pressure regulation and associated interlocks to prevent significant departure from the design ratio of LP-Gas-air mixture.

Exception: Mixers receiving air from a blower, compressor, or any source of air other than directly from the atmosphere shall comply with 5-2.6.3.

5-3 Vaporizer Installation.

5-3.1 Application. This section applies to the installation of vaporizing devices covered in Section 5-2.

5-3.2 Installation of Indirect-Fired Vaporizers.

5-3.2.1 Indirect-fired vaporizers shall comply with 5-2.2 and shall be installed as follows.

5-3.2.2 Indirect vaporizers shall be permitted to be installed outdoors, in buildings used exclusively for gas manufacturing or distribution, or in separate structures constructed in accordance with 5-1.4. Any such buildings shall be well ventilated near the floor line and roof.

5-3.2.3 Indirect vaporizers shall also be permitted to be installed in structures attached to, or rooms within, buildings not used for gas manufacturing or distribution, provided such attached structures or rooms comply with Section 7-3 of NFPA 58, *Liquefied Petroleum Gas Code*, and that there are no openings of any sort from the vaporizer room into the building or structure of which it is a part.

5-3.2.4 The housing for the vaporizer covered by 5-3.2.2 or 5-3.2.3 shall not have any unprotected drains to sewers or sump pits. Pressure relief valves on vaporizers within buildings shall be piped to a point outside the building and shall discharge vertically upward.

5-3.2.5 The device that supplies the heat necessary for producing steam, hot water, or other heating medium shall be permitted to be installed outdoors, in a separate building, or in a structure attached to, or in rooms within, another gas manufacturing or distributing building (but not buildings used for other purposes), provided the following:

(a) The housing provided shall comply with 5-1.4 and shall be well ventilated near the floor line and roof.

(b) The heat supplying device, if outdoors, or the housing in which it is installed, shall be located at least 75 ft (23 m) from other LP-Gas facilities and operations. If the heat supplying device is gas-fired and is packaged with the vaporizer, or installed within 15 ft (5 m) of the vaporizer, it shall be subject to the provisions of 5-3.3 covering installation of direct gas-fired vaporizers.

5-3.2.6 The heating medium piping into and from the vaporizer shall be provided with a suitable means for preventing the flow of gas into a heating system that is supplying heat to areas other than the LP-Gas facility in the event of a tube rupture in the vaporizer. If the device supplying the heat to the vaporizer is for that purpose only, the device, or the piping to and from the device, shall contain a relief valve, vented to the outside, to relieve excessive pressure in the event of a tube rupture in the vaporizer.

5-3.2.7 Gas-fired heating systems that supply heat for vaporization purposes shall be equipped with automatic safety devices to shut off gas to the main burners if the pilot light should fail.

5-3.2.8 Vaporizers shall be permitted to be an integral part of a fuel storage container, directly connected to either the liquid or vapor space, or to both. A limit control shall be provided to prevent the heater from raising the product pressure above the design pressure of the vaporizer equipment, or the pressure within the storage container above the pressure shown in the first column of Table 5-2.3(f) corresponding with the design pressure of the container [or its 1980 code equivalent — *see Table 5-2.3(f)*].

5-3.3 Installation of Direct Gas-Fired Vaporizers. Direct gas-fired vaporizers shall comply with 5-2.3 and shall be installed as follows.

5-3.3.1 Direct gas-fired vaporizers shall be permitted to be installed outdoors or in separate structures constructed in accordance with 5-1.4. Any such buildings shall be well ventilated near the floor line and roof.

5-3.3.2 Direct gas-fired vaporizers also shall be permitted to be installed in structures attached to, or in rooms within, a gas manufacturing or distributing structure (but not buildings used for other purposes), provided the following:

(a) The housing provided shall comply with 5-1.4 and shall be well ventilated near the floor line and roof.

(b) The wall separating it from all other compartments or rooms containing LP-Gas vaporizers, pumps, and central gas mixing devices shall have no openings.

5-3.3.3 The housing for the vaporizer covered in 5-3.3.1 and 5-3.3.2 shall not have unprotected drains or sump pits. Pressure relief valves on vaporizers within buildings shall be piped to a point outside the building and shall discharge vertically upward.

5-3.3.4 Direct gas-fired vaporizers shall be permitted to be connected to the liquid space or to both the liquid and the vapor space of the container, but in any case there shall be a manually operated shutoff valve in each connection at the container to permit shutting off completely all flow of vapor or liquid.

5-3.3.5 Direct gas-fired vaporizers of any capacity shall be located in accordance with Table 5-3.3.5.

5-3.4 Installation of Waterbath Vaporizers. Waterbath vaporizers shall comply with 5-2.4 and shall be installed as follows:

(a) If a waterbath vaporizer is electrically heated and all electrical equipment is suitable for Class 1, Group D, locations, the unit shall be treated as indirect fired and shall be installed in accordance with 5-3.2.

(b) All others shall be treated as direct-fired vaporizers and shall be installed in accordance with 5-3.3.

Table 5-3.3.5 Separation of Vaporizers from Exposures

Exposure	Minimum Distance Required ft (m)
Container	50 (15)
Container shutoff valves	50 (15)
Point of transfer	50 (15)
Nearest important building or group of buildings or line of adjoining property that can be built upon [except buildings in which vaporizer is installed *(see Section 5-3)*]	50 (15)
Building or room housing gas-air mixer	10 (3)
Cabinet housing gas-air mixer outdoors	0 (0)

5-3.5 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 5-3.2.

5-3.6 Installation of Gas-Air Mixers.

5-3.6.1 Gas-air mixing equipment shall comply with 5-2.6 and shall be installed as follows:

(a) Where used without the vaporizer(s), the mixer(s) shall be permitted to be installed outdoors or in buildings that comply with 5-1.4.

(b) Where used with the indirect heated vaporizer(s), the mixer(s) shall be permitted to be installed outdoors, or in the same compartment or room with the vaporizer(s), in a building(s) that complies with 5-1.4, or shall be permitted to be installed remotely from the vaporizer(s) and shall be located in accordance with 5-3.2.

(c) Where used with the direct-fired vaporizer(s), the mixer(s) shall be installed as follows:

1. Listed or approved in a common cabinet with the vaporizer(s) outdoors in accordance with 5-3.3.5
2. Outdoors on a common skid with the vaporizer(s) in accordance with 5-3.3
3. Installed adjacent to the vaporizer(s) to which it is connected in accordance with 5-3.3
4. In a building complying with 5-1.4 with no direct-fired vaporizer in the same room

5-3.6.2 Listed vaporizer-mixers in a common cabinet having a direct-fired-type vaporizer shall be installed outdoors in accordance with the distance provisions in 5-3.3. Listed vaporizer-mixers not in a common cabinet having an indirect-fired-type vaporizer shall be permitted to be installed in a building or structure that complies with 5-1.4, provided there is no source of ignition in such building or structure.

Chapter 6 Relief Devices

6-1 General.

6-1.1* Relief devices on containers shall be arranged so that the possibility of tampering will be minimized; if the pressure setting or adjustment is external, the relief devices shall be provided with an approved means for sealing the adjustment.

6-1.2 Each container relief device shall be plainly and permanently marked with the pressure in psi at which the device is set to start to discharge, with the actual rate of discharge in cubic feet per minute of air at 60°F (16°C) and 14.7 psia (an absolute pressure of 0.101 MPa), and with the manufacturer's name and catalog number. For example, a safety relief valve marked "250-15,000 AIR" indicates that it is set to start to discharge at 250 psi (1.7 MPa) and that its rate of discharge is 15,000 ft^3 (424.5 m^3) per minute of air.

6-1.3 Connections to which relief devices are attached, such as couplings, flanges, nozzles, and discharge lines for venting, shall have internal dimensions that will not restrict the net relief area.

6-1.4 The size of the relief device outlet connection shall not be smaller in diameter than the nominal size of the relief device outlet connection and shall not appreciably restrict flow through the relief device.

6-1.5 All container relief devices shall be located on the containers and shall be connected with the vapor space of the container.

6-1.6 No shutoff valve shall be installed between the relief device and the container, equipment, or piping to which the relief device is connected.

Exception: A shutoff valve shall be permitted to be used where the arrangement of this valve is such that full required capacity flow through the relief device is always afforded.*

6-1.7 Any outlet piping shall be directed horizontally or upward so as not to cause flame impingement or endanger personnel. It shall have at least the area of the valve outlet and shall be arranged so as not to restrict the flow unduly.

Return bends and restrictive pipe fittings shall not be permitted in relief device discharge vents.

6-1.8 Discharge lines from two or more relief devices located on the same unit or similar lines from two or more different units shall be permitted to be run into a common discharge header, provided the header is designed with a flow capacity that is sufficient to limit the maximum back pressure to (1) not exceeding 10 percent of the lowest start-to-discharge pressure setting for conventional relief valves, and (2) not exceeding 50 percent of the lowest start-to-discharge pressure setting for balanced valves. Header design shall assume that all valves connected to the header are discharging at the same time.

Exception: Discharge lines located on storage containers shall not be combined.

Relief valve piping shall be designed so that liquid that can be trapped will not create dangerous back pressure when the relief valve operates.

6-1.9 All discharge vents from the safety relief valves or common discharge headers shall be installed in such a manner as to allow the following:

(a) They shall lead to the open air.

(b) They shall be protected against mechanical damage.

(c) They shall exclude or remove moisture and condensate. This shall be permitted to be done by the use of loose-fitting rain caps and drains. Drains shall be installed so as to prevent possible flame impingement on the containers, piping, equipment, and structures.

6-1.9.1 All discharge vents from the safety relief valves or common discharge headers shall be installed in such a manner as to discharge in an area that:

(a) Prevents possible flame impingement on containers, piping, equipment, and structures
(b) Prevents possible vapor entry into enclosed spaces
(c) Is located above the heads of personnel who can be on the container or adjacent containers, stairs, platforms, or ground
(d) Is located above the possible water level, if discharging from underground containers where there is a possibility of flooding

6-1.9.2 All discharge vents from the safety relief valves or common discharge headers shall be installed in such a manner as to prevent malfunction due to freezing or icing.

6-2 Testing Relief Devices. Relief devices shall be tested for proper operation at intervals not exceeding 5 years.

6-3 Aboveground Containers.

6-3.1 The discharge from the relief devices shall be vented away from the container and shall be unobstructed to the open air in a manner to prevent any impingement of escaping gas upon the container, adjacent containers, piping, and other equipment. The vents shall be fitted with loose-fitting rain caps. Suitable provision shall be made to prevent any liquid or condensate that can accumulate inside the relief device or its vent from rendering the relief device inoperative. If a bottom drain is used, a means shall be provided to protect the container, adjacent containers, and piping of equipment against impingement of flame resulting from ignition of product escaping from the drain. The vent piping shall extend upward at least 7 ft (2.2 m) above the top of the container.

6-3.2 Relief devices on containers shall be constructed to discharge at not less than the rates shown in Appendix E before the pressure is in excess of 120 percent of the maximum (not including the 10 percent referred to in the asterisked note of Table 6-3.2) permitted start-to-discharge pressure setting of the devices.

Table 6-3.2 Relief Valve Setting Pressure

Containers	Minimum (%)	Maximum (%)
All ASME codes prior to the 1949 edition, and the 1949 edition, paragraphs U-68 and U-69	110%	125%*
ASME *Boiler and Pressure Vessel Code*, 1949 edition, paragraphs U-200 and U-201, and all ASME codes later than 1949	88%	100%*
ANSI/API 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks*		100%*

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

6-3.3 For refrigerated storage, consideration shall be given to making proper provisions for vacuum conditions.

6-4 Underground Containers.

6-4.1 Relief devices shall meet all the conditions outlined for aboveground containers, except the rate of discharge for relief devices installed thereon shall be permitted to be reduced to a minimum of 30 percent of the specified rate of discharge shown in Appendix E. The discharge pipe from safety relief devices shall extend directly, vertically upward at least 7 ft (2.2 m) above the ground. If liquid product is placed in containers while they are not buried, these containers shall be considered to be aboveground containers.

6-4.2 Where there is a probability of the manhole or housing becoming flooded, the discharge from regulator vent lines shall be above such water level. All manholes or housings shall be provided with ventilated louvers or their equivalent.

6-5 Vaporizers.

6-5.1 Each vaporizer shall be provided with a relief device that provides an effective rate of discharge in accordance with 5-2.5.

6-5.2 Relief valves on direct-fired vaporizers shall be located so that they shall not be subjected to normal operating temperatures in excess of 140°F (60°C). *(See Section 6-1 for other requirements on relief devices.)*

6-6 Hydrostatic Relief Valves. A hydrostatic relief valve shall be installed between each pair of shutoff valves on liquefied petroleum gas liquid piping so as to relieve the pressure that could develop from the trapped liquid to a safe atmosphere or other portion of the system that can safely accept it. Hydrostatic relief valves shall have pressure settings not less than 400 psi (2.76 MPa) or more than 500 psi (3.45 MPa) unless installed in systems designed to operate above 350 psi (2.41 MPa). Hydrostatic relief valves for use in systems designed to operate above 350 psi (2.41 MPa) shall have settings not less than 110 percent or more than 125 percent of the system design pressure.

Chapter 7 Handling

7-1 Transfer of Liquids within a Utility Plant.

7-1.1 Pumps and compressors used for transferring LP-Gas shall be suitable for the product handled.

7-1.2 The transfer of LP-Gases by pressure differential using fuel gas or inert gas at a pressure higher than the pressure of the LP-Gas in the container being filled shall be permitted in accordance with the following:

(a) Two backflow check valves and a manually operated shutoff valve shall be installed in the fuel gas or inert gas line or system in series to prevent LP-Gas from flowing back into the fuel gas or inert gas line or system.
(b) Any fuel gas or inert gas used to obtain a pressure differential to move liquid LP-Gas shall be noncorrosive and dried to avoid stoppage by freezing.
(c) Before any fuel gas or inert gas is placed in a tank car for unloading LP-Gas by pressure differential, permission shall be obtained and documented from the vendor of the LP-Gas to introduce such vapors into the tank car or a tank truck.

7-1.3 Transfer operations shall be conducted by employees familiar with the properties of the material and instructed in transfer and emergency procedures. At least one competent person shall remain in attendance during the entire period of transfer from the time connections are made until the transfer is completed, shutoff valves are closed, and lines are disconnected.

7-1.4 Written procedures shall be available to cover all transfer operations, and they shall cover emergency as well as normal operating procedures. Written procedures shall be

reviewed and updated at least annually and shall be available to all personnel engaged in transfer operations.

7-1.5 The maximum vapor pressure of nonrefrigerated product at 100°F (37.8°C) that can be transferred into a container shall be in accordance with 2-2.1 or 2-2.2 and 2-2.3.

7-1.6 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 of liquid, and depressured before disconnecting. Bleeds or vents shall discharge to a safe area.

7-1.7 Caution shall be exercised to ensure that only those gases for which the system is designed, examined, and listed are employed in its operation, particularly with regard to pressures.

7-1.8 Transfer of refrigerated product shall be made only into systems that are designed to accept refrigerated product.

7-2 Tank Car Loading and Unloading Point.

7-2.1 The track of tank car siding shall be relatively level.

7-2.2* A "tank car connected" sign, as covered by DOT (U.S. Department of Transportation) rules, shall be installed at the active end or ends of the siding while the tank car is connected for unloading.

7-2.3 While cars are on side-track for unloading, the wheels at both ends shall be blocked on the rail.

7-3 Tank Truck Loading and Unloading.

7-3.1 The area of tank truck transfer shall be relatively level.

7-3.2 A tank truck loading and unloading area shall be of sufficient size to accommodate the vehicles without excessive movement or turning. Tank trucks or transports that unload into storage containers shall be at least 25 ft (7.6 m) from the container and positioned so that the shutoff valves on both the truck and the container are readily accessible.

7-3.3 While trucks are loading or unloading, the wheels shall be blocked.

Chapter 8 Operations

8-1 Operating Procedures Manuals.

8-1.1 Each facility shall prepare and maintain written operating procedures manuals that cover facility start-up, operation, and shutdown.

8-1.2 Operating procedures manuals 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, and human senses. Where human senses are relied on, a schedule of tours of the facility shall be included in the operating procedures.

8-1.3* Operating procedures shall include procedures for purging and inerting equipment.

8-1.4 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.

8-1.5 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.

8-2 Personnel Safety.

8-2.1* Employees assigned and trained to perform emergency actions shall be assigned personal protective equipment for use when responding to emergencies that have progressed beyond the incipient stage. Employees assigned personal protective equipment shall be trained in its proper use.

8-2.2 Each utility gas plant shall have first-aid materials on hand in sufficient quantity to handle a reasonably anticipated emergency.

8-3 Transfer Procedures.

8-3.1 The procedures required in Section 8-1 shall include all aspects of LP-Gas transfer, including the following:

(a) Verification of connections to ensure proper delivery of LP-Gas
(b) Verification of gas tightness of connections
(c) Inspection of hoses and fittings
(d) Valve sequencing
(e) Disconnection procedures
(f) Purging procedures, if used

8-3.2 All LP-Gas transfers shall be attended by plant personnel in accordance with 7-1.3.

8-3.3 Provisions shall be implemented to prevent moving of tank vehicles during transfer.

8-4 Operating Records.

8-4.1 Each facility shall maintain a record of all operating log sheets and recorded data. These records shall be made available to the authority having jurisdiction upon reasonable request.

8-4.2 Operating log sheets required under 8-4.1 shall be retained for at least 5 years.

Chapter 9 Maintenance

9-1 Maintenance Manuals.

9-1.1 Maintenance manuals for all equipment at the facility shall be kept at the facility and shall be available to maintenance personnel.

Exception: 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.

9-1.2 Maintenance manuals shall include:

(a) Drawings, procedures, and parts lists provided by the manufacturer or installer
(b) Routine and preventative maintenance procedures and schedules
(c) Routine inspections to be performed
(d) Corrosion inspection and control procedures, where applicable

9-2 Maintenance of Fire Protection Equipment. Maintenance activities on fire control 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.

9-3 Auxiliary Power Sources. Each auxiliary power source shall be tested at least monthly to verify its operational capability.

9-4 Purging Prior to Maintenance. All equipment that contains flammable or hazardous materials shall be purged in accordance with 8-1.3 prior to beginning maintenance procedures.

9-5 Maintenance Records.

9-5.1 Each facility shall maintain a record of all maintenance log sheets of process equipment. These records shall be made available to the authority having jurisdiction upon reasonable request.

Exception: Maintenance records for normally unattended facilities shall be permitted to be stored at another location.

9-5.2 Records that are required under 9-5.1 shall be retained for the life of the equipment, while in use, and for 3 years thereafter.

Chapter 10 Fire Protection, Safety, and Security

10-1 General.

10-1.1* Fire protection shall be provided for all utility gas plants. The extent of such protection shall be determined by an evaluation based on the type (refrigerated or nonrefrigerated), quantity, and size of storage containers; an analysis of local conditions; hazards within the facility; and exposure to and from other property. The evaluation shall consider the following, as a minimum:

(a) The time of response and effectiveness of local emergency response agencies
(b) The type, quantity, and location of equipment necessary for the detection and control of potential nonprocess and electrical fires
(c) The methods necessary for protection of the equipment and structures from the effects of fire exposure
(d) Fire protection water systems
(e) Fire extinguishing and other fire control equipment
(f) Automatic shutdown equipment, including the types and location of sensors to initiate manual or automatic operation
(g) The availability and duties of individual plant personnel and the availability of external response personnel during an emergency
(h) *The protective equipment and special training needed by the individual plant personnel for their respective emergency duties
(i) The need for a permanently mounted combustible gas detection system or a permanently mounted fire detection system

10-1.2 The wide range in size, design, and location of facilities covered by this standard precludes the inclusion of detailed fire protection provisions completely applicable to all facilities.

10-1.3 A detailed emergency procedures manual shall be prepared to cover the potential emergency conditions that can develop whether or not a fire has occurred. Such procedures shall include, but not necessarily be limited to, the following:

(a) Shutdown or isolation of various portions of the equipment and other applicable steps to ensure that the escape of gas or liquid is promptly cut off or reduced as much as possible
(b) Use of fire protection facilities
(c) Notification of public authorities
(d) First aid
(e) Duties of personnel

The emergency procedures manual shall be kept readily available in the operating control room or at a constantly attended location if the plant site is not continually manned. It shall be reviewed and updated annually and as required by changes in equipment or procedures.

10-1.4 All personnel shall be trained in their respective duties contained in the emergency procedures manual. Those personnel responsible for the use of fire protection or other plant emergency equipment shall be trained annually in the use of that equipment.

10-1.5 The planning of effective fire control measures shall be coordinated with the authority having jurisdiction and local emergency handling agencies, such as fire and police departments, who are expected to respond to such emergencies.

10-1.6 Gas fires normally shall not be extinguished until the source of the burning gas has been shut off.

10-2 Ignition Source Control. Control of ignition sources shall comply with Section 1-10.

10-3 Fire and Leak Detection.

10-3.1 Those areas, including enclosed buildings, that have a potential for flammable gas concentrations and fire shall be monitored as determined by the evaluation required in 10-1.1.

10-3.2 Continuously monitored flammable gas detection systems shall alarm at the plant site and at a constantly attended location if the plant site is not continuously manned. Flammable gas detection systems shall alarm at not more than 25 percent of the lower flammable limit of the gas or vapor being monitored.

10-3.3 Fire detectors shall alarm at the plant site and at a constantly attended location if the plant site is not continually manned.

10-3.4 Detection systems, where used, shall be designed, installed, and maintained in accordance with NFPA 72, *National Fire Alarm Code®*, and NFPA 1221, *Standard for the Installation, Maintenance, and Use of Public Fire Service Communication Systems.*

10-4 Container Protection. Nonrefrigerated storage containers shall be considered adequately protected against fire exposure if they are buried or mounded in accordance with 2-5.2 or if they are insulated. *(See Appendix D.)*

10-5 Fire Protection Water Systems.

10-5.1 A water supply and a system for distributing and applying water shall be provided for protection of exposures; cooling containers, equipment, and piping; and controlling unignited leaks and spills unless an evaluation in accordance with 10-1.1 indicates that the use of water is unnecessary or impractical.

10-5.2 The design of fire water supply and distribution systems, if provided, shall provide for the simultaneous supply of those fixed fire protection systems, including monitor nozzles, at their design flow and pressure, involved in the maximum single incident expected in the plant. An additional supply of 1000 gal/min (63 L/sec) shall be available for hand hose streams for a period of not less than 2 hours. Manually actuated monitors shall be permitted to be used to augment hand hose streams.

10-5.3 Nonrefrigerated storage containers that are not adequately protected per Section 10-4 shall be analyzed based on the availability of water supply, the probable effectiveness of the plant fire brigades, and the time of response and probable effectiveness of the fire department. The first consideration in such an analysis shall consist of the use of water applied by the fire brigade or fire department for effective control of hazardous leakage or fire exposing storage tanks, cargo vehicles, or railroad tank cars that can be present. If the analysis indicates that additional water protection is needed, the protection shall comply with 10-5.4.

10-5.4 Special Protection.

10-5.4.1* 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. The insulation system shall be inherently resistant to weathering and the action of hose streams.

10-5.4.2 If mounding is used, the provisions of 3-2.4.7 of NFPA 58, *Liquefied Petroleum Gas Code*, shall constitute adequate protection.

10-5.4.3 If burial is used, the provisions of 2-5.2 shall constitute adequate protection.

10-5.4.4 If water spray fixed systems are used, they shall comply with NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*. Such systems shall be automatically actuated by fire-responsive devices and also shall have a capability for manual actuation.

10-5.4.5 If monitor nozzles are used, they shall be located and arranged so that container surfaces likely to be exposed to fire will be wetted. Such systems shall otherwise comply with NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, and shall be automatically actuated by fire-responsive devices and also shall have a capability for manual actuation.

10-5.5 Fire protection water systems, where used, shall be designed, installed, and maintained in accordance with the following NFPA standards, as applicable, considering the fire control problems in facilities covered by this standard.

(a) NFPA 13, *Standard for the Installation of Sprinkler Systems*

(b) NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*

(c) NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*

(d) NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*

(e) NFPA 22, *Standard for Water Tanks for Private Fire Protection*

(f) NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*

(g) NFPA 1961, *Standard for Fire Hose*

(h) NFPA 1962, *Standard for the Care, Use, and Service Testing of Fire Hose Including Couplings and Nozzles*

(i) NFPA 1963, *Standard for Fire Hose Connections*

10-6 Fire Extinguishing and Other Fire Control Equipment.

10-6.1 Portable or wheeled fire extinguishers that are suitable for gas fires, preferably of the dry chemical type, shall be available at strategic locations, as determined in accordance with 10-1.1, within the facility. The minimum size portable dry chemical extinguisher shall be 18 lb (8.2 kg) with a B:C rating. These extinguishers shall be provided and maintained in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*.

10-6.2 Fixed fire extinguishing and other fire control systems can be appropriate for the protection of specific hazards as determined in accordance with 10-1.1. If provided, such systems shall be designed, installed, and maintained in accordance with the following NFPA standards, as applicable:

(a) NFPA 11, *Standard for Low-Expansion Foam*

(b) NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems*

(c) NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*

(d) NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*

(e) NFPA 16, *Standard for the Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*

(f) NFPA 17, *Standard for Dry Chemical Extinguishing Systems*

10-7 Maintenance of Fire Protection Equipment. Facility operators shall prepare and implement a maintenance program for all plant fire protection equipment.

10-8 Personnel Safety.

10-8.1 Personnel shall be advised of the danger of frostbite, which can result upon contact with LP-Gas liquid or cold refrigerants. Suitable protective clothing and equipment shall be available.

10-8.2 Those employees who will be involved in emergency activities, as determined in accordance with 10-1.1, shall be equipped with the necessary clothing and equipment. Protective clothing shall comply with NFPA 1971, *Standard on Protective Ensemble for Structural Fire Fighting*, and shall have an impermeable outer shell. Those employees requiring such protective clothing also shall be equipped with helmets, face shields, gloves, and boots that are suitable for the intended exposure.

10-8.3 Self-contained breathing apparatus shall be provided for those employees who are required to enter an atmosphere that could be injurious to health during an emergency. Such apparatus shall comply with NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for the Fire Service*, and shall be maintained in accordance with the manufacturer's instructions.

10-8.4 A portable flammable gas detector shall be readily available.

10-9 Security.

10-9.1 The facility operator shall provide a security system with controlled access, which shall be designed to minimize entry by unauthorized persons.

10-9.2 A protective enclosure including a peripheral fence, building wall, or natural barrier shall be provided enclosing major facility components, such as the following:

(a) LP-Gas storage containers

(b) Flammable refrigerant storage tanks

(c) Flammable liquid storage tanks

(d) Other hazardous materials storage areas

(e) Outdoor process equipment areas

(f) Buildings that house process or control equipment

(g) Onshore loading and unloading facilities

The location and arrangement of protective structures shall minimize pocketing of escaping gas, interference with the application of cooling water by fire departments, redirection of flames against containers, and impeding egress of personnel in an emergency.

Exception: As an alternative to fencing the operating area, suitable 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.

10-9.3 The provisions of 10-9.2 shall be permitted to be met by either one continuous enclosure or several independent enclosures. At least two exit gates or doors shall be provided for rapid escape of personnel in the event of an emergency.

10-9.4 Provisions shall be made for the ready access to the facility by emergency personnel or services.

10-9.5 Illumination shall be provided as necessary in the vicinity of protective enclosures and in other areas to promote security of the facility.

Chapter 11 Referenced Publications

11-1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix F.

11-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers,* 1998 edition.

NFPA 11, *Standard for Low-Expansion Foam,* 1998 edition.

NFPA 11A, *Standard for Medium- and High-Expansion Foam Systems,* 1994 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems,* 1998 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems,* 1997 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 1996 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 1996 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 1996 edition.

NFPA 16, *Standard for the Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems,* 1995 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems,* 1998 edition.

NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps,* 1996 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection,* 1996 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances,* 1995 edition.

NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes,* 1994 edition.

NFPA 58, *Liquefied Petroleum Gas Code,* 1998 edition.

NFPA 70, *National Electrical Code®,* 1996 edition.

NFPA 72, *National Fire Alarm Code®,* 1996 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems,* 1997 edition.

NFPA 1221, *Standard for the Installation, Maintenance, and Use of Public Fire Service Communication Systems,* 1994 edition.

NFPA 1961, *Standard for Fire Hose,* 1997 edition.

NFPA 1962, *Standard for the Care, Use, and Service Testing of Fire Hose Including Couplings and Nozzles,* 1998 edition.

NFPA 1963, *Standard for Fire Hose Connections,* 1993 edition.

NFPA 1971, *Standard on Protective Ensemble for Structural Fire Fighting,* 1997 edition.

NFPA 1981, *Standard on Open-Circuit Self-Contained Breathing Apparatus for the Fire Service,* 1997 edition.

11-1.2 Other Publications.

11-1.2.1 API Publication. American Petroleum Institute, 2101 L Street NW, Washington, DC 20037.

API 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks,* 1990 edition.

11-1.2.2 ASCE Publication. American Society of Civil Engineers, 345 East 47th Street, New York, NY 10017.

ASCE 7, *Minimum Design Loads for Buildings and Other Structures,* 1993 edition.

11-1.2.3 ASME Publications. American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

ASME *Boiler and Pressure Vessel Code,* 1949, 1980, and 1986 editions.

ASME *Boiler and Pressure Vessel Code,* "Rules for the Construction of Unfired Pressured Vessels," Section VIII, 1992 edition.

ASME B31.3, *Process Piping,* 1996 edition.

11-1.2.4 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,* 1990 edition.

ASTM A 48, *Specification for Gray Iron Castings,* 1992 edition.

ASTM A 395, *Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures,* 1988 edition.

ASTM A 536, *Specifications for Ductile Iron Castings,* 1984 edition.

11-1.2.5 ICBO Publication. International Conference of Building Officials, 5360 Workman Mill Road, Whither, CA 90601.

Uniform Building Code (UBC), 1994 edition.

Appendix A Explanatory Material

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

A-1-2.1 Those portions of LP-Gas systems downstream of the point where LP-Gas or a mixture of LP-Gas and air is introduced into the utility distribution system are covered in the United States by Department of Transportation, CFR 49, Part 192.

See Figure A-1-2.1.

A-1-4 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-1-4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A-1-5 It is recognized that no odorant will be completely effective as a warning agent in all circumstances.

It is recommended that odorants be qualified as to compliance with Section 1-5 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/10,000 gal (0.0119 kg/m^3) of liquid LP-Gas has been recognized as an effective odorant. Other odorants and quantities that meet the provisions of Section 1-5 can be used. Research on odorants has shown that thiophane (tetrahydrothiopene) in a ratio of at least 6.4 lb/10,000 gal (0.0767 kg/m^3) of liquid LP-Gas can satisfy the requirements of Section 1-5. The lower limits of flammability of the more commonly used liquefied petroleum gases are approximately 2 percent for propane and approximately $1^1/_2$ percent for butane. These figures represent volumetric percentages of gas in a gas-air mixture in each case. (Odorant research includes *A New Look at Odorization Levels for Propane Gas,* B BERC/RI-77-1, United States Energy Research and Development Administration, Technical Information Center, September 1977.)

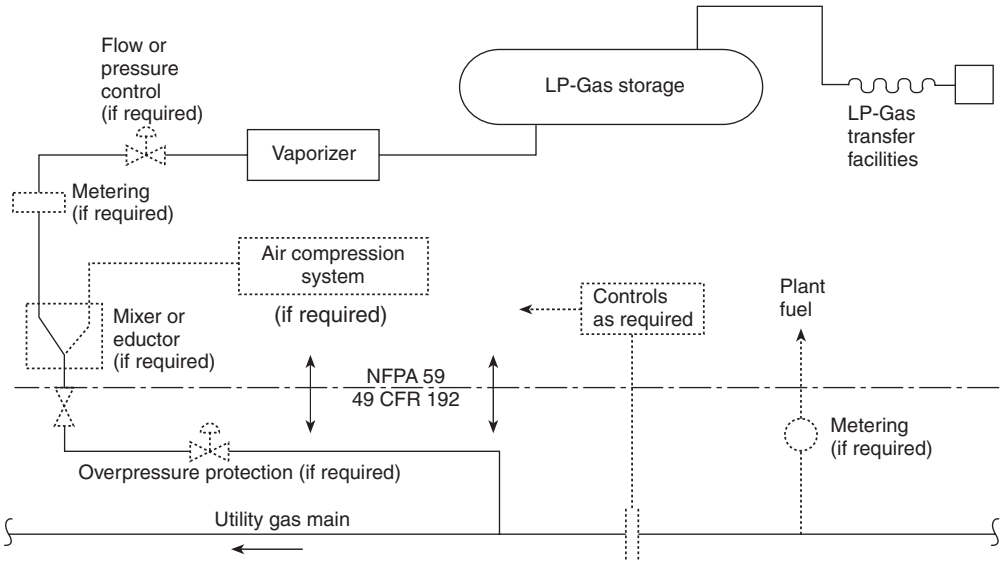

Figure A-1-2.1 Typical installation of an LP-Gas air base or peaking facility, LP-Gas vapor base load, or enrichment facility.

A-1-8.1 Table. Fixed electrical equipment preferably should not be installed within the direct path of discharge of relief valves.

A-1-10.2 Static grounding or bonding protection is not required when tank cars, tank vehicles, or marine equipment are loaded or unloaded by conductive or nonconductive hose, flexible metallic tubing, or pipe connections through or from tight outlets (top or bottom) where both halves of metallic couplings are in contact.

For additional information on grounding and bonding to reduce the hazards due to static electricity, see NFPA 77, *Recommended Practice on Static Electricity.*

A-1-10.3 For additional information, see API RP 2003, *Protection Against Ignitions Arising Out of Static, Lightning and Stray Currents.*

A-2-2.1 Table See Appendix D of NFPA 58, *Liquefied Petroleum Gas Code,* for information on earlier ASME or API/ASME codes.

New containers for 100-psi (689-kPa) design pressure (or equivalent under earlier codes) were not authorized after December 31, 1947.

A-2-5.1.10 For LP-Gas fixed storage facilities of 60,000-gal (227-m^3) water capacity or less, a competent fire safety analysis *(see 10-1.1)* could indicate that applied insulating coatings are quite often the most practical solution for special protection.

A-2-5.2.4 For information on corrosion protection, see NACE RP-01-69, *Control of External Corrosion of Underground or Submerged Metallic Piping Systems.*

A-4-1.7 It should be recognized that the temperature of liquid propane will drop to about –40°F (–40°C) when released to the atmosphere.

A-4-1.8 For information on corrosion protection, see NACE RP-01-69, *Control of External Corrosion of Underground or Submerged Metallic Piping Systems.*

A-4-3.5.3(b) This can be accomplished by use of concrete bulkheads or equivalent anchorage or by the use of a weakness or shear fittings or other means.

A-4-4.6 Refer to Appendix B for information on calculating the filling point for which the tube should be designed.

A-5-2.3(f) Table See NFPA 58, *Liquefied Petroleum Gas Code,* Appendix D, for information on earlier ASME or API-ASME codes.

New containers for 100 psi (0.7 MPa) design pressure (or equivalent under earlier codes) were not authorized after December 31, 1947.

A-5-2.6 For information on interchangeability of LP-Gas-air mixtures with natural gas, see the AGA publications *Interchangeability — What it Means,* AGA Catalog No. XL0884, and *Interchangeability of Other Fuel Gases with Natural Gas,* Research Bulletin, AGA Catalog No. X50284.

A-6-1.1 Experience has indicated that a vertical and unimpeded vent of high-velocity hydrocarbon gases will entrain sufficient air within a very short distance so that the resultant plume will be diluted below the lower flammable limit. This behavior is documented in API 521, *Guide for Pressure-Relieving and Depressuring Systems.* This document was based, in part, on a study that was commissioned by API, "The Effect of Velocity, Temperature, and Gas Molecular Weight on Flammability Limits in Wind-Blown Jets of Hydrocarbon Gases," by Battelle Memorial Institute, April 1, 1970.

These reports clearly indicate that a vertical and unimpeded jet will be diluted below its lower flammable limit within 50 pipe diameters of the issuing jet and that the effects of "wind-tilt" can be safely neglected if a 50-ft (15-m) horizontal clearance is provided between the jet and a source of ignition. A *high-velocity jet* is defined as a jet having an exit velocity in excess of 100 ft/sec (30.5 m/sec), which is slightly more than an order of magnitude less than the acoustic velocity that can be anticipated at the throat of an operating relief valve. API 521 also indicates that a partially open relief valve will produce a velocity sufficient to achieve the necessary dilution.

Once such a mixture has been diluted below its flammable limit, there are no known natural forces (including gravitational forces) that will cause the reconcentration of the LP-Gases so as to create a flammable cloud. The application of water, either as a fog or heavy stream, will not hasten and can actually inhibit the dilution of the jet stream. It is recommended that this information be included in any emergency procedure manual and that the responding emergency services be made aware of this information.

A-6-1.6 Exception This exception is made to cover such arrangements as a three-way valve installed under two relief devices, each of which has the required rate of discharge. The installation allows either of the relief valves to be closed but does not allow both to be closed at the same time. In another arrangement, two separate relief valves are permitted to be installed with individual shutoff valves if the shutoff valve stems are mechanically interconnected in a manner that allows full required flow from one relief valve at all times.

A-7-2.2 The U.S. Department of Transportation (DOT) was formerly the ICC (Interstate Commerce Commission). Published in the *Federal Code of Regulations,* Title 49, Parts 171–190. In Canada, the regulations of the Canadian Transport Commission for Canada apply.

A-8-1.3 For information on purging and inerting equipment, see NFPA 327, *Standard Procedures for Cleaning or Safeguarding Small Tanks and Containers Without Entry,* and AGA *Purging Principles and Practice.*

A-8-2.1 For more information on personnel safety, see AGA *Introduction to LPG Safety for Propane Air Plant Operators,* AGA catalog number XO9608.

A-10-1.1 The first consideration in such an analysis should consist of the use of water applied by hose streams by the fire brigade or fire department for the effective control of hazardous leakage or fire exposing storage tanks, cargo vehicles, or railroad tank cars that can be present.

Experience has indicated that hose stream application of water in adequate quantities as soon as possible after the initiation of flame contact is an effective way to prevent container failure from fire exposure. The majority of large containers exposed to sufficient fire to result in container failure have failed in from 10 to 30 minutes after the start of the fire when water was not applied. Water in the form of a spray also can be used to control unignited gas leakage.

A-10-1.1(h) In heavily populated or congested areas where serious mutual exposures between container(s) and adjacent properties prevail, it is recommended that greater distances or special protection in accordance with good fire protection engineering practices be provided. Special protection can

consist of mounding or burying containers or providing fixed water spray or monitor nozzle protection.

A-10-5.4.1 It is recommended that insulation systems be evaluated on the basis of experience or listings by an approved testing laboratory. *(See also Appendix D.)*

Appendix B Method of Calculating Maximum Liquid Volume That Can Be Placed in a Container at any Liquid Temperature

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

The quantity of gas that can be placed in a container depends on the temperature of the liquid in the container and the maximum permitted filling density, in addition to the size of the container.

The filling density depends on the size of the container, whether it is installed above ground or underground, and the specific gravity at 60°F (15.6°C) of the LP-Gas placed in the container. Filling density values for these conditions are given in Table 2-8.1. Since the temperature of the liquid in the container is seldom exactly 60°F (15.6°C), it is necessary to measure the actual liquid temperature and then obtain a correction factor from the attached table and insert this in the following formula. The average liquid temperature can be obtained by one of two ways. One procedure is to measure the liquid temperature in the container after the container is almost filled to its permissible liquid content. This is secured by inserting a thermometer into a thermometer well installed in the container so as to be in the liquid. The other procedure can be used only if the container is essentially empty prior to filling. In this case, the liquid temperature is measured by a thermometer placed in a thermometer well or other device installed in the filling line at a place near the container. The temperature should be read at intervals and averaged.

Knowing the filling density, the liquid specific gravity at 60°F (15.6°C) of the product to be placed in the container, the correction factor for the temperature of the liquid in the container, and the container capacity, the maximum quantity that can be placed in a container is determined as follows:

$$V = \frac{D}{G \times F}$$

where:

V = maximum liquid volume (in percent of total container capacity) that should be placed in a container when the liquid temperature is T

D = filling density from 2-8.1 (in percent)

G = specific gravity of LP-Gas at 60°F (15.6°C) to be placed in container

F = correction factor from Table B-1 for correcting liquid volume from 60°F (15.6°C) to volume at temperature, T. The correction factor is determined by finding the specific gravity at 60°F (15.6°C), G, in the column at the top of the table and coming down this column until the actual liquid temperature, T, is found. The correction factor corresponding to this specific gravity and the temperature is then read. Interpolation is permitted.

T = temperature of liquid LP-Gas in container (in degrees Fahrenheit)

After obtaining V from the above formula, the actual maximum gallons, Q_T, of LP-Gas that can be placed in a container is obtained by multiplying the water capacity of the container by

$$\frac{V}{100}$$

where: Q_T = actual gallons at liquid temperature, T.

Example: Assume an aboveground container with 10,000-gal (37.8-m^3) water capacity.

Propane with a specific gravity of 0.508 at 60°F (15.6°C) is to be placed in container.

The filling density from 2-8.1 for an aboveground container that has a capacity greater than 1200 gal (4.5 m^3) in which a product that has a specific gravity of 0.508 at 60°F (15.6°C) is to be placed is 45 percent.

To determine the maximum quantity that can be placed in the container when the liquid temperature is 60°F (15.6°C), use the following formula:

$$Q_{60}F = \frac{45 \times 10{,}000}{0.508 \times 100} = 8860 \text{ gal } (33.5 \text{ m}^3)$$

When the liquid temperature is 82°F (27.8°C), find the correction factor in Table B-1 for specific gravity of 0.508 at 60°F (15.6°C) and a liquid temperature of 82°F (27.8°C), which is 0.963.

$$Q_{82}F = \frac{45 \times 10{,}000}{0.508 \times 0.963 \times 100} = 9200 \text{ gal } (34.8 \text{ m}^3)$$

Appendix C Method of Calculating Maximum Volume of Liquefied Petroleum Gas That Can be Placed in a Container for Which Length of Fixed Dip Tube Is Set

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

C-1 It is impossible to set out in a table the length of a fixed dip tube for various capacity containers because of the varying container diameters and lengths and because the container can be installed in either a vertical or horizontal position. Knowing the maximum permitted filling volume in gallons, however, the length of the fixed tube can be determined by the use of a strapping table obtained from the container manufacturer. The length of the fixed tube should be such that, when its lower end touches the surface of the liquid in the container, the contents of the container will be the maximum permitted volume.

C-2 The following formula is used for determining the maximum volume of LP-Gas for which a fixed length of dip tube should be set.

$$\frac{\text{Water capacity of container (gal)* } \times \text{Filling density**}}{\text{Specific gravity of LP-G* } \times \text{Volume}} = \text{Maximum Volume of LP-Gas gal}$$

Correction factor† $\times 100$

*Measured at 60°F (15.6°C) **From Table 2-8.1

†For aboveground containers, the liquid temperature is assumed to be 40°F (4.4°C); for underground containers, the liquid temperature is assumed to be 50°F (10°C). To correct the liquid volumes at these temperatures to 60°F (15.6°C), the factors in 4-4.6 should be used.

Table B-1 Liquid Volume Correction Factors

Specific Gravities at 60°F/60°F													
Observed Temperature	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
(°F)	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
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