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NFPA 59 LP-Gases at Utility Gas Plants 1989 Edition

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National Fire Protection Association Batterymarch Park, Quincy, MA 02269

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

Statement on NFPA Procedures

This material has been developed under the published procedures of the National Fire Protection Association, which are designed to assure the appointment of technically competent Committees having balanced representation. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accepts any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

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NATIONAL FIRE PROTECTION ASSOCIATION

NFPA 59

Standard for the Storage and Handling of

Liquefied Petroleum Gases

at Utility Gas Plants

1989 Edition

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 and acted on by the National Fire Protection Association, Inc. at its Fall Meeting held November 14-17, 1988 in Nashville, Tennessee. It was issued by the Standards Council on January 13, 1989, with an effective date of February 6, 1989, and supersedes all previous editions.

The 1989 edition of this document has been approved by the American National Standards Institute.

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.

Origin and Development of NFPA 59

The *Standard on Liquefied Petroleum Gases* (NFPA 58) was used as a general guide until this standard was adopted in 1949. Subsequent editions were adopted in 1954, 1956, 1958, 1962, 1963, 1968, 1974, 1976, 1979, and 1984.

To facilitate the preparation of this standard, the cooperation of the American Gas Association was secured. This resulted in the formation of a special committee under the sponsorship of the American Gas Association, 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, this standard was assigned to that Committee. The Committee established a Subcommittee on Utility Gas Plants to have a working responsibility for NFPA 59. In 1972, responsibility for NFPA 59 was assigned to the Committee on Liquefied Petroleum Gases with the Subcommittee on Utility Gas Plants retained.

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Connor L. Adams, *Chairman*
City of Miami Bldg. Dept.

Theodore Lemoff, *Secretary*
National Fire Protection Association
(Nonvoting)

Marco Bosoni, Snamprogetti
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Phani Raj, Technology & Mgmt. Systems Inc.
Robert A. Reid, Petrolane Inc.
Rep. National Propane Gas Association
Henry W. Renfrew, Bureau of State Fire Marshal, Meriden, CT
Rep. FMANA
Bruce A. Schwartz, Washington Gas Light Co.
Rep. American Gas Association
Henry C. Scuoteguazza, Factory Mutual Research Corp.
Dennis S. Silverman, FL Dept. of Ins.
H. Emerson Thomas, Thomas Associates
Rep. National Propane Gas Association
J. Herbert Witte, Lincolnwood, IL
Rep. GVI

Alternates

William Biscontini, Walter Kidde
(Alternate to D. Maddock)
John A. Davenport, Industrial Risk Insurers
(Alternate to F. E. Rademacher)
Hal M. Faulconer, NPGA
(Alternate to J. Kukucka & H. Thomas)
E. E. Linder, Coast Gas Inc., NPGA
(Alternate to R. A. Reid)
William J. Montwieler, Industrial Truck Assn.
(Alternate to G. Maes)
Walter C. Retzsch, American Petroleum Institute
(Alternate to API Rep.)
Don J. Slee, Compressed Gas Assn. Inc.
(Alternate to CGA Rep.)

Nonvoting

Chappell D. Pierce, Office of Standards Development

Liquefied Petroleum Gases Utility Gas Plant Subcommittee

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Washington Gas Light Co.

Anthony C. Mirabella, *Secretary*
Connecticut Natural Gas Corp.

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James H. Stannard, Jr., Stannard & Company
H. Emerson Thomas, Thomas Associates

This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.

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.

Contents

NFPA 59

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

1989 Edition

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

Information on referenced documents may be found in Chapter 10 and Appendix E.

Chapter 1 General Provisions

1-1 Introduction.

1-1.1 The purpose of this standard is to outline methods for 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*).

1-1.2 The term "liquefied petroleum gases" as used in this standard shall mean and include any material having a vapor pressure not exceeding 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 In the interest of safety, it is important that persons engaged in handling liquefied petroleum gases understand the properties of these gases and that they be thoroughly trained in safe practices for the handling and distribution of these products.

1-1.4 Under moderate pressure the gases liquefy, but upon relief of the pressure are readily converted into the gaseous phase. Under moderately low temperature the gases liquefy. Advantage of this characteristic is taken by the industry. 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.

1-1.5 In the case of pure product at atmospheric pressure and below 31 °F (minus 0.6 °C), normal butane is a liquid. Propane is a liquid at atmospheric pressure at temperatures below minus 44 °F (minus 42.2 °C) and normally does not present a flammable liquid hazard except when stored at or below its boiling point.

1-1.6 Commercially available butane and propane may have different liquefying points from those in 1-1.5 because they normally contain various percentages of other hydrocarbon products.

1-1.7 Rapid vaporization takes place at temperatures above the boiling points (normal butane about 31 °F [minus 0.6 °C]; propane about minus 44 °F [minus 42.2 °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.

1-2 Application of Standard.

1-2.1 This standard applies to utility gas plants for the design, construction, location, installation, and operation of refrigerated and nonrefrigerated liquefied petroleum gas systems.

1-2.2 It is recognized that advancement in engineering and improvements in equipment may result in equipment fabrication methods and operating practices which differ from those specifically called for in this standard. Yet such deviations or improvements may provide desirable safety and compatible operation meeting the intent of this standard. Such deviations may be accepted when the authority having jurisdiction has made a special investigation of all factors and, based on sound experience and engineering judgment, concludes that the proposed deviations meet the intent of this standard.

1-2.3 Where existing plants, equipment, buildings, structures, and installations meet the applicable design, fabrication, or construction layout provisions of the edition of this standard in effect at the time of installation, they are permitted to be continued in use provided they do not constitute a distinct hazard to life or adjoining property.

1-2.4 When operations involving the liquid transfer of LP-Gas from the utility gas plant storage into cylinders or portable tanks (as defined by NFPA 58) are carried out in the utility gas plant, these operations shall conform to NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*.

1-2.5 Installations having an aggregate water capacity not exceeding 2,000 gal (7.6 m^3) shall conform to NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*.

1-3 Definitions.

Approved. Acceptable to the "authority having jurisdiction."

NOTE: 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 or 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 concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

Barrel. A unit of volume. One barrel equals 42 U.S. gal (0.159 kL) or 5.615 cu ft (0.159 cu m).

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, used for storing liquefied petroleum gases.

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

Containers, Shop Fabricated. Containers 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, which mixes LP-Gas vapor with air to produce a mixed gas of certain heating value but not within the flammable range. Any gas-air mixer which is designed to produce a mixture containing more than 85 percent air by volume shall be considered a combustion device 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 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 or materials included in a list published by an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which 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.

Psig and Psia. Pounds per sq in. gauge and pounds per sq in. absolute, respectively.

Sources of Ignition. Devices or equipment which, 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 which will 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.

When required in this standard, special protection consists of any of the following: applied insulating coatings, mounding, burial, water spray fixed systems or fixed monitor nozzles, meeting the criteria specified in this standard (*see 8-5.4*), or by any means listed (*see definition of Listed*) for this purpose.

Systems. An assembly of equipment consisting essentially of liquefied petroleum gas unloading equipment, container or containers, major devices such as vaporizers, relief valves, excess flow valves, regulators, and interconnecting piping. In the case of refrigerated storage, it would also include compressors, condensers, and other related equipment and controls. Such systems shall 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 owned or operated by a utility, as designated by the appropriate governing jurisdiction.

1-4 Odorizing Gases.

1-4.1* 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, provided, however, that odorization is not 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.

NOTE: The lower limits of flammability of the more commonly used liquefied petroleum gases are: Propane, approximately 2 percent; Butane, approximately 1½ percent. These figures represent volumetric percentages of gas in a gas-air mixture in each case.

1-5 Acceptance of Equipment.

1-5.1 In systems utilizing containers of over 2,000-gal (7.6-m³) 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 Section 1-3, Approved*).

1-6 Damage from Vehicles.

1-6.1 Where damage to liquefied petroleum gas systems from vehicular traffic is a possibility, precautions against such damage (such as warning signs or devices, or barricades) shall be taken (*see 2-9.2*).

1-7 Electrical Equipment and Lighting.

1-7.1 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 except that fixed electrical equipment in classified areas shall comply with Section 1-8.

1-7.2 Adequate lighting shall be provided to illuminate operating facilities, such as walkways and essential control valves, and particularly loading and unloading facilities.

Table 1

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	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.*)	Division 2
D	Gage 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 *Note:* Fixed electrical equipment should preferably not be installed.
		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.		
	Indoors without ventilation.	Entire room and any adjacent room not separated by a gastight partition.[1]	Division 1
		Within 15 ft (4.6 m) of the exterior side of any exterior wall or roof that is not vaportight or within 15 ft (4.6 m) of any exterior opening.	Division 2

Part	Location	Extent of Classified Area[1]	Equipment Shall Be Suitable for NEC, Class 1, Group D[4]
	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.)	Division 2
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.)		
	Without mechanical ventilation.	Entire pit or trench.	Division 1
		Entire room and any adjacent room not separated by a gastight partition when located indoors.	Division 2
		Within 15 ft (4.6 m) in all directions from pit or trench when located outdoors.	Division 2
	With adequate mechanical ventilation.[3]	Entire pit or trench.	Division 2
		Entire room and any adjacent room not separated by a gastight partition when located indoors.	Division 2
		Within 15 ft (4.6 m) in all directions from pit or trench when 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.	

Notes:

[1] The classified area shall not extend beyond an unpierced wall, roof or solid vaportight partition.

[2] When determining extent of 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 may have on the point of connection.

[3] Ventilation is considered adequate when provided in accordance with the provisions of this standard.

[4] See Article 500 — "Hazardous Locations," NFPA 70 (ANSI), for definitions of Classes, Groups and Divisions.

1-8 Fixed Electrical Equipment in Classified Areas.

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

1-8.2 Fixed electrical equipment on LP-Gas cargo vehicles shall comply with the provisions of Chapter 6 of NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*.

1-9 Source of Ignition.

1-9.1 Smoking and nonprocess ignition sources within the protective enclosure (*see 8-9.2*) shall be prohibited except in accordance with 1-9.2 through 1-9.4.

1-9.2 Smoking shall be permitted only in designated and properly signposted areas.

1-9.3 Welding, cutting, hot work, 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, *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 classified areas specified in Table 1 unless the LP-Gas facilities have been freed of all liquid and vapor or special precautions observed under carefully controlled conditions.

1-9.4 Vehicles and other mobile equipment which constitute potential ignition sources shall be prohibited within diked areas or within 50 ft (15 m) of containers containing LP-Gas, flammable liquids, or flammable refrigerants except when specifically authorized and under constant supervision or when loading or unloading at facilities specifically for the purpose.

1-9.5 Electrical grounding and bonding shall be provided as required by NFPA 70, *National Electrical Code*.

Exception: 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 (top or bottom) outlets where both halves of metallic couplings are in contact.

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

1-9.6 If stray currents may be present or if impressed currents are used on loading and unloading systems (such as for cathodic protection), protective measures to prevent ignition shall be taken in accordance with API RP 2003, *Protection Against Ignitions Arising Out of Static, Lightning and Stray Currents*.

1-9.7 Although metallic storage containers and tanks do not require lightning protection, ground rods shall be provided for tanks supported on nonconductive foundations for personnel and foundation protection. (*See NFPA 78, Lightning Protection Code, and API RP 2003, Protection Against Ignitions Arising Out of Static, Lightning and Stray Currents, for additional information on lightning protection.*)

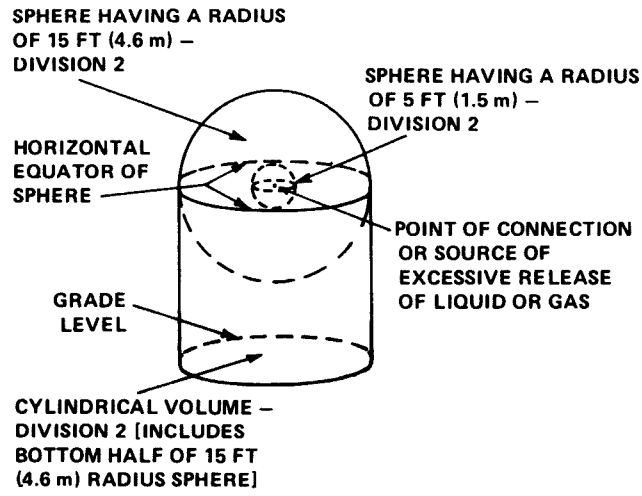


Figure 1
(See Table 1)

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 *Rules for Construction of Unfired Pressure Vessels, Section VIII, ASME Boiler and Pressure Vessel Code*, or in accordance with the rules of the authority under which the containers are installed provided such rules substantially conform to the rules of the *ASME (Section VIII) Code*, except that UG-125 through UG-136 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 constructed and maintained in accordance with the *ASME Code* in effect at the time of fabrication. (*See 1-2.3.*)

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.

Table 2

For gases with vapor pressure in psig at 100°F (37.8°C) not to exceed	Minimum design pressure in psig *ASME Code Section VIII*, 1986 Edition (Notes 1, 3)
80	100 (Note 2)
100	125
125	156
150	187
175	219
215	250

NOTE 1: See Appendix C of NFPA 58 for information on earlier ASME or API-ASME Codes.

NOTE 2: New containers for 100 psig design pressure (or equivalent under earlier codes) not authorized after December 31, 1947.

NOTE 3: Because of low soil temperature usually encountered,

and the insulating effect of the earth, the average vapor pressure of products stored in underground containers will be materially lower than when stored aboveground. This reduction in actual operating pressure therefore provides a substantial corrosion allowance for these containers when installed underground.

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*, except that construction using joint efficiencies in Table UW 12, Column C, Division 1 is not permitted.

2-2.3 Field-erected containers for nonrefrigerated storage shall be designed for a pressure not less than 125 percent of the maximum vapor pressure of the product at 100 °F (38 °C) to be stored in the containers, but in no case shall the container be designed for a pressure of 25 psig or less.

2-3 Markings on Nonrefrigerated Containers.

2-3.1 Each container for nonrefrigerated storage shall be marked as specified in the following:

(a) With a marking identifying compliance with and other markings required by the rules of the code under which the container is constructed; or with the stamp and other markings required by the National Board of Boiler & Pressure Vessel Inspectors.

Underground: Container and an accessible nameplate.

Aboveground: Container.

(b) With notation as to whether system is designed for underground or aboveground installation.

Underground: Container and an accessible nameplate.

Aboveground: Container.

(c) With the water capacity of the container in gal, US Standard.

Underground: Container and an accessible nameplate.

Aboveground: Container.

(d) With the pressure in lb per sq in. for which the container is designed.

Underground: Container and an accessible nameplate.

Aboveground: Container.

(e) With the wording "This container shall not contain a product having a vapor pressure in excess of ____ lb per sq in. gauge at 100 °F." (*See 2-1.2 and 2-2.3.*)

Underground and aboveground: A nameplate or tag on filler connection.

(f) With the outside surface area in sq ft.

Underground: Container and an accessible nameplate.

Aboveground: Container.

(g) With marking indicating the maximum level to which the container may be filled with liquid at temperatures between 20 °F (6.7 °C) and 130 °F (54 °C) except on containers provided with fixed maximum level indicators. Markings shall be in increments of 20 Fahrenheit degrees.

Aboveground and underground: System nameplate or on liquid level gauging device.

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 3 with respect to the distance between containers and 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 which may be built upon.

Table 3

Water capacity of each container in gal	Minimum Distances	
	Between containers in ft	From container to nearest important building or groups of buildings not associated with the LP-Gas plant, or a line of adjoining property which may be built upon.
2,001 to 30,000	5	50
30,001 to 70,000	¼ of sum of diameters of adjacent containers	75
70,001 to 90,000	"	100
90,001 to 120,000	"	125
120,001 to 200,000	"	200
200,001 to 1,000,000	"	300
1,000,001 or more	"	400

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.

Table 2-4.1.3

Fire Protection Provided B	Maximum No. of Containers in One Group	Min. Separation Between Groups—Feet
Hose Streams Only. See 8-5.3(1)	6	50 (15 m)
Fixed Monitor Nozzles per 8-5.3.2(2)	6	25 (7.6 m)
Fixed Water Spray per 8-5.3.1(2)	9	25 (7.6 m)
Insulation per 2-5.2.6	9	25 (7.6 m)

(a) 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 A container or containers with an aggregate water capacity in excess of 120,000 gal (454.8 m^3) shall be located 100 ft (31 m) or more from buildings associated with the LP-Gas plant which are occupied for generation, compression, or purification of manufactured gas or from natural gas compressor buildings or from outdoor installations essential to the maintenance of operation in such buildings.

Such a container or containers shall be 100 ft (31 m) or more from aboveground storage of flammable liquids and from any building of such construction or occupancy which constitutes a material hazard of exposure to the containers in the event of fire or explosion in said buildings.

2-4.1.5 If any capacity container or containers associated with the LP-Gas plant are located closer than 100 ft (31 m) or the distances in Table 3, whichever is less, to buildings occupied for generation, compression, or purification of manufactured gas or from natural gas compressor buildings, then such buildings shall be protected by walls adjacent to such storage containers or by other appropriate means against the entry of escaped liquefied petroleum gas, or of drainage from the storage container area and its loading points — all in such a manner as may be required and approved by the authority having jurisdiction.

2-4.1.6 Nonrefrigerated liquefied petroleum gas containers shall not be located within dikes enclosing flammable liquid tanks and shall not be located within dikes enclosing refrigerated liquefied petroleum gas tanks.

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 When containers are installed parallel with ends in line, any number of containers are permitted to be in one group. When 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 (15.4 m) from the nearest important building or group of buildings or line of adjacent property which may be built upon.

2-4.2.5 Containers shall be located not less than 50 ft (15.4 m) from buildings occupied for generation, compressions or purification of gas, or from outdoor installations essential to the maintenance of operation in such buildings. They shall be located not less than 50 ft (15.4 m) from aboveground storage of flammable liquids and from any buildings of such construction or occupancy which constitutes a severe exposure to any aboveground appurtenances of the underground installation in the event of fire or explosion in said buildings. If the underground installations by necessity are located closer than 50 ft (15.4 m) to any such buildings or installations, then the latter shall be protected against the entry of escaping liquefied petroleum gas in such a manner as may be required and approved by the authority having jurisdiction.

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

2-4.4 The ground within 25 ft (7.7 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 are permitted to be employed when they are protected against fire in an approved manner. Metal supports shall be protected against fire with a material having a fire resistance rating of at least two hours. Steel skirts having only one opening 18 in. (462 mm) or less in diameter shall be protected in accordance with the preceding, but fireproofing need only be applied to the outside of the skirt.

2-5.1.3 Horizontal containers shall be mounted on saddles in such a manner 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 in contact with the foundations or saddles.

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

2-5.2 In addition to the applicable provisions for horizontal ASME storage containers, vertical ASME storage containers over 2,000-gal (7.6-m^3) water capacity shall comply with 2-5.2.1 through 2-5.2.5.

2-5.2.1 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 (earthquake) forces, and hydrostatic test loads.

2-5.2.2 Design pressure (*see Table 2*) shall be interpreted as the pressure at the top head with allowance made for increased pressure on lower shell sections and bottom head due to the static pressure of the product.

2-5.2.3 Wind loading on containers shall be based on wind pressures on the projected area at various height zones aboveground as recommended in *Building Code Requirements for Minimum Design Loads in Buildings and Other Structures*, ANSI A58.1. Wind speeds shall be based on a Mean Occurrence Interval of 100 years.

2-5.2.4 Seismic loading on containers shall be based on forces recommended in 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 23 of the *UBC*, a seismic analysis of the proposed installation shall be made which meets the approval of the authority having jurisdiction.

2-5.2.5 Containers shall be fabricated with lifting lugs or some other suitable means to facilitate erection in the field.

2-5.3 Nonrefrigerated Underground Containers.

2-5.3.1 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.

2-5.3.2 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 providing sufficient access shall be installed. No other part of the container shall be exposed.

2-5.3.3 Containers shall be set upon a firm foundation (firm earth is permitted to be used) and surrounded with earth or sand firmly tamped in place. Backfill shall be free of rocks or other abrasive materials. Provision shall be made to take care of settling and rotation.

2-5.3.4 Containers shall be adequately protected against corrosion.

2-5.3.5 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.

2-5.3.6 If the area above a container is to be used for purposes not prohibited by this standard, consideration shall be given to depth of cover and loads that may be imposed.

2-5.4 Field welding where necessary shall be made only on saddle plates or brackets which were applied by manufacturer of container, except as provided by the code under which the container was fabricated.

2-5.5 Secure anchorage or adequate pier height shall be provided to protect against container flotation wherever sufficiently high water might occur.

2-5.6 When flammable liquid storage tanks are in the same general area as liquefied petroleum gas containers, the flammable liquid storage tanks shall be diked or diversion curbs or grading used to prevent accidentally escaping flammable liquids from flowing into liquefied petroleum gas container areas.

2-6 Reinstallation of Nonrefrigerated Containers.

2-6.1 Containers once installed underground or aboveground which have been out of service for more than one year shall not be reinstalled aboveground 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 constructed and 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.

2-7.1 Gaskets used to retain LP-Gas in containers shall be resistant to the action of LP-Gas. They shall be of metal or other suitable material confined in metal, including spiral wound metal gaskets, having a melting point over 1,500 °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. Except as noted in 2-8.3, nonrefrigerated containers shall be filled in accordance with Table 4.

Table 4

Maximum Permitted Filling Density

	Aboveground Containers		Underground Containers
Specific Gravity at 60°F (15.6°C)	0 to 1,200 U.S. Gal (1,000 Imp. gal, 4,550 L) Total Water Cap.	Over 1,200 U.S. Gal (1,000 Imp. gal, 4,550 L) Total Water Cap.	All Capacities
.496 – .503	41%	44%	45%
.504 – .510	42	45	46
.511 – .519	43	46	47
.520 – .527	44	47	48
.528 – .536	45	48	49
.537 – .544	46	49	50
.545 – .552	47	50	51
.553 – .560	48	51	52
.561 – .568	49	52	53
.569 – .576	50	53	54
.577 – .584	51	54	55
.585 – .592	52	55	56
.593 – .600	53	56	57

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

2-8.3 For individual underground nonrefrigerated installations, the authority having jurisdiction is 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 upon 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 (23.1 m) from uncontrolled sources of ignition, process areas, control buildings, offices, shops, and other occupied or important plant structures. This does 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 (7.7 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.

Chapter 3 Refrigerated Containers

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

3-1.1 Refrigerated containers shall be built in accordance

with applicable provisions of one of the following codes as appropriate for conditions of maximum allowable working pressure, design temperature, and hydrostatic testing:

3-1.1.1 For pressures of 15 psig or more, use the 1986 edition of the *ASME Boiler and Pressure Vessel Code, Section VIII*, except that construction using joint efficiencies in Table UW 12, Column C, Division 1 is not permitted. Material shall be selected from those recognized by ASME which meet the requirements of Appendix R of ANSI/API 620.

3-1.1.2 For pressures below 15 psig, use ANSI/API 620, Recommended Rules for the Design and Construction of Large, Welded, Low-Pressure Storage Tanks, including Appendix R.

3-1.1.3 Wind loading on containers shall be based on wind pressures on the projected area at various height zones aboveground as recommended in ANSI A58.1, *Building Code Requirements for Minimum Design Loads in Buildings and Other Structures*. Wind speeds shall be based on a Mean Occurrence Interval of 100 years.

3-1.1.4 Seismic loading on containers shall be based on forces recommended in 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 23 of the *UBC*, a seismic analysis of the proposed installation shall be made which meets the approval of the authority having jurisdiction.

3-1.2 Field-erected containers for refrigerated storage shall be designed as an integral part of the storage system including tank insulation, compressors, condensers, controls, and piping. Proper 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. Welded construction shall be used.

3-1.3 When austenitic steels or nonferrous materials are used, ANSI/API 620, Appendix Q shall be used as a guide in the selection of materials for use at the design temperature.

3-2 Marking on Refrigerated Containers.

3-2.1 Each refrigerated container shall be identified by the attachment of a nameplate on the outer covering in an accessible place marked as specified in the following:

(a) Manufacturer's name and date built.

(b) With liquid volume of the container in gal (US Standard) or barrels.

(c) With the maximum allowable working pressure in lbs per sq in.

(d) With the minimum temperature in degrees Fahrenheit for which the container was designed.

(e) The maximum allowable water level to which the container may be filled for test purposes.

(f) With the density of the product to be stored in lbs per cu ft for which the container was designed.

(g) With the maximum level to which the container is permitted to be filled with the liquefied petroleum gas for which it was designed.

3-3 Location of Refrigerated Containers.

3-3.1 Refrigerated Aboveground Containers.

3-3.1.1 Containers shall be located outside of buildings.

3-3.1.2 Containers shall be located in accordance with Table 5.

Table 5

Water capacity of each container (gal)	Minimum Distances	
	Between containers (ft)	*From container to nearest important building, or group of buildings, not associated with the LP-Gas plant, or a line of adjoining property which may be built upon (ft)*
125,001-200,000	¼ of sum of diameters of adjacent containers	200
200,001-1,000,000		300
Over 1,000,000		400

3-3.1.3 A container or containers with an aggregate water capacity in excess of 120,000 gal (454.8 m^3) shall be located 100 ft (31 m) or more from buildings associated with the LP-Gas plant which are occupied for generation, compression, or purification of manufactured gas, or from natural gas compressor buildings or from outdoor installations essential to the maintenance of operation in such buildings. Such a container or containers shall be 100 ft (31 m) or more from aboveground storage of flammable liquids and from any buildings of such construction or occupancy which constitute a material hazard of exposure to the containers in the event of fire or explosion in said buildings. If the container or containers are located closer to any such buildings or installations, then the latter shall be protected by walls adjacent to such storage containers or by other appropriate means against the entry of escaped liquefied petroleum gas, or of drainage from the storage container area and its loading points — all in such a manner as may be required and approved by the authority having jurisdiction.

3-3.1.4 Refrigerated liquefied petroleum gas containers shall not be located within dikes enclosing flammable liquid tanks or within dikes enclosing nonrefrigerated liquefied petroleum gas containers.

3-3.2 Refrigerated containers shall not be installed one above the other.

3-3.3 The ground within 25 ft (7.7 m) of any aboveground refrigerated container and all ground within a diked area shall be kept clear of readily ignitible material such as weeds and long dry grass.

3-4 Installation of Refrigerated Containers.

3-4.1 Refrigerated aboveground containers shall be installed on the ground or on foundations or supports of concrete, masonry piling, or steel. Foundations and supports

shall be protected to have a fire-resistance rating of not less than two hours.

3-4.2 For product storage at less than 30 °F (minus 1.1 °C), the foundation design or the container bottom insulation shall be such that damage from frost heave will be prevented. Ambient or supplied heat is permitted to be utilized.

3-4.3 Any exposed insulation shall be fire resistant and shall resist dislodgment by fire hose streams. When an outer shell is used to retain loose insulation, the shell shall be constructed of steel or concrete.

3-4.3.1 If natural gas is used to purge any insulation space, it shall be vented to a safe location.

3-4.4 Aboveground LP-Gas containers shall be inside a diked area except where spillage of hydrocarbon can be contained in a designated area within the plant site by topography.

3-4.4.1 The usable volume of the diked area or topographical enclosure shall be at least 100 percent of the capacity of the largest container enclosed.

3-4.4.2 More than one container is permitted to be installed in a single diked area or topographical enclosure provided:

(a) The volume of the enclosure complies with 3-4.4.1.

(b) When 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 minus 44 °F (minus 42 °C).

(c) Container foundations are constructed of concrete properly designed for fire exposure.

3-4.4.3 Dikes shall be constructed of earth, concrete, solid masonry, or other suitable material designed to prevent the escape of liquid and to withstand a full hydraulic head. The dikes shall be constructed to withstand thermal shock.

3-4.4.4 The walls of the dikes shall be not less than 5 ft (1.5 m) in height. Where topography can provide suitable containment, dike walls, where required, need only be as high as the containment capacity requires.

3-4.4.5 Provision shall be made to drain rainwater from the diked area and drains shall be equipped with a positive closure which shall be closed except when manually opened for draining. The valve and other parts of the drain system that may be subject to LP-Gas temperature shall be of suitable material to withstand low temperatures. Such drains shall not permit drainage of tank contents to enter natural water courses, public sewers, or public drains. When pumps control drainage from the diked area, they shall be manually controlled and provided with an open sight discharge.

3-4.5 After acceptance tests are completed, there shall be no field welding on the LP-Gas containers except upon saddle plates or brackets provided therefor or as otherwise provided for by the code under which the container was fabricated.

3-4.6 Secure anchorage or adequate pier height shall be provided to protect against container flotation wherever sufficiently high water might occur.

3-4.7 When flammable liquid storage tanks are in the same general area as liquefied petroleum gas containers, the flammable liquid storage tanks shall be diked or diversion curbs or grading used to prevent accidentally escaping flammable liquids from flowing into liquefied petroleum gas container areas.

3-5 Reinstallation of Refrigerated Containers.

3-5.1 Containers once installed, which have been out of service for more than one year, shall not be put back in service 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 constructed and 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 3-4. See also Chapter 6 for relief valve requirements.*)

3-6 Gaskets.

3-6.1 Gaskets used to retain LP-Gas in containers shall be resistant to the action of LP-Gas. They shall be of metal or other suitable material confined in metal, including spiral wound metal gaskets, having a melting point over 1,500 °F (816 °C) or shall be protected against fire exposure. When a flange is opened, the gasket shall be replaced.

3-7 Filling Densities.

3-7.1 The filling limits for refrigerated storage containers shall be based upon sound engineering practice for the individual design and operating conditions involved. Since negligible expansion of the liquid can take place within the possible range of operating pressure and temperature of a refrigerated container, the maximum liquid volume in percent of the total container capacity is greater for a refrigerated container than normally employed for a nonrefrigerated container.

3-8 Loading and Unloading Facility Spacing.

3-8.1 Loading and unloading connections shall be at least 75 ft (23.1 m) from uncontrolled sources of ignition, process areas, control buildings, offices, shops, and other occupied or important plant structures. This does not apply to structures or equipment directly associated with the transfer operation.

3-8.2 The filling pipe inlet terminal shall not be located inside a building or diked area. Such terminals shall be located at least 25 ft (7.7 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.

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 may be subjected.

4-1.1.1 The design and fabrication of piping systems shall be in accordance with ANSI/ASME B31.3, *Chemical Plant and Petroleum Refinery 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 resistant to the action of LP-Gas under service conditions. They shall be of steel, ductile (nodular) iron (ASTM A395-80 or A 536-80 Grade 60-40-18 or 65-45-12), malleable iron (ASTM A47-77), higher strength gray iron (ASTM A48-76, Class 40B), brass, or the equivalent. Cast iron shall not be used for strainers or flow indicators.

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 with the possible exception of piping connections for excess flow valves.

4-1.3 The use of cast-iron valves, pipe, and fittings shall be prohibited in piping carrying LP-Gas. This does not prohibit the use of container valves or fittings made of malleable or ductile iron if used within the limitations set forth in paragraph 323.4.2 of ANSI B31.3.

4-1.4 Emergency shut-off valves shall be approved and incorporate all of the following means of closing (*See 4-3.6*):

(a) Automatic shut-off through thermal (fire) actuation. When fusible elements are used, they shall have a melting point not exceeding 250 °F (121 °C).

(b) Manual shut-off from two or more remote locations.

(c) Manual shut-off 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 confined in metal having 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 the valves shall be leak tested after assembly and proved free from leaks at not less than normal operating pressures. Test shall not be made with a flame.

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

NOTE: It must be recognized that the temperature of liquid propane will drop to about −40 °F (−40 °C) when released to the atmosphere.

4-1.8 Piping outside buildings is permitted to be buried, aboveground, or both, but shall be well supported and protected against physical damage and corrosion. Underground and submerged piping shall be protected and maintained in accordance with the principles of the National Association of Corrosion Engineers Standard RP-01-69, *Control of External Corrosion of Underground or Submerged Metallic Piping Systems*.

4-1.9 Equipment selection for application temperatures below −20 °F (−29 °C) shall be based upon 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 liquefied petroleum gas and designed for not less than the maximum extreme pressure and temperature to which they may be subjected. Valves for use with nonrefrigerated containers which may be subjected to container pressure shall have a rated working pressure of at least 250 psig. Cast-iron valves, piping, and fittings shall be prohibited on liquefied petroleum gas containers and their connections. This does not prohibit the use of container valves or fittings made of malleable or nodular iron.

4-2.2 All connections to containers, except safety relief connections, liquid level gauging devices, and plugged openings, shall have shutoff valves located as close to the container as practicable. The valves shall be readily accessible for operation and maintenance under normal and emergency conditions, either because of location or by means of permanently installed special provisions. Valves installed in an unobstructed location not more than 6 ft (1.85 m) above ground level shall be considered accessible. Special provisions include, but are not limited to, stairs, ladders, platforms, remote operators, or extension handles.

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 line 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 a back pressure check valve or an emergency shut-off valve as specified in 4-1.4.

Exception: Openings not larger than a 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 need not 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 con-

tainer; 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 except safety valves, liquid level gauging devices, and pressure gauges on any container shall be labeled or color coded to designate whether they are connected to vapor or liquid space. Labels are permitted to be on valves.

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 Where practical, liquid manifold connections shall be located at nonadjacent ends of parallel rows of containers.

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

4-3.4 The pipe inlet terminal shall be labeled to designate its purpose.

4-3.5 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) which will cause the valve to close automatically in case of fire. Such valves shall also be capable of being manually operated at the installed location. A remote closing control shall be located so as to be accessible during a fire or other emergency. Such valves within 300 ft (93 m) of a container or important structure shall be arranged to limit the quantity that could be discharged to a maximum of 300 cu ft (8.5 m^3) of liquid. In no case shall there be more than 150 ft (46 m) between valves on the same line within 300 ft (93 m) of a container or important structure.

4-3.6 In addition to the valving specified in 4-3.5, 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:

4-3.6.1 The connection or connecting piping into which the liquid or vapor is being transferred shall be equipped with:

(a) A backflow check valve, or

(b) An emergency shut-off valve complying with 4-1.4.

4-3.6.2 The connection, or connecting piping, from which the liquid or vapor is being drawn shall be equipped with an emergency shut-off valve complying with 4-1.4.

4-3.6.3 When used in conjunction with hose or swivel type piping, the valve specified in 4-3.5 shall be:

(a) 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 piping such that the melting of the plastic tubing will cause the valve to close, or approved alternate equipment providing equal protection, and

(b) Installed in the plant piping so that any break resulting from a pull will occur on the hose or swivel piping side of the connection. This provision shall apply to backflow check valves installed in accordance with 4-3.6.1.

NOTE: This may be accomplished by use of concrete bulkheads or equivalent anchorage or by the use of a weakness or shear fittings.

4-3.7 When 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 which may be built upon. The manifold piping terminates at the first line valve which may be 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, 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 shall also be provided with an auxiliary gauging device, such as a fixed dip tube, slip tube, rotary gauge, or similar device.

4-4.1.1 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 is not 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 may 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 so designed 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 When used, the length of a fixed tube device shall be designed to indicate the maximum level to which the container may be filled for the product contained. The length or location of the fixed tube to indicate this level shall be based on the volume of the product at 40 °F (4.4 °C) at its maximum permitted filling density for aboveground containers and at 50 °F (10 °C) for buried containers. Refer to Appendix B for calculating filling point for which tube shall be designed.

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 1,750 psig (12.1 MPa) (350 psi [2.41 MPa] working pressure) and shall be marked with "LP-Gas" or "LPG" and with the working pressure in psig 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 psig (4.8 MPa). If a test is made, such assemblies shall not be leak tested at pressures higher than the working pressure [350 psig (2.41 MPa) minimum] of the hose.

4-6 Drips, Pits, and Drains.

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

4-6.2 Avoid the use of pits containing LP-Gas equipment. If pits are used they shall be fitted with continuous automatic flammable vapor detecting devices equipped with an alarm. No drains or blowoff 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 liquefied petroleum 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 to safely dispose of vented vapors while the refrigeration system is inoperative, at least two (2) 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 insure that prolonged failure of refrigeration may be prevented.

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

4-8 Protection of Container Accessories.

4-8.1 Valves, 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 protected by a substantial round cover. (*See 6-4.2.*)

Chapter 5 Vaporizers and Gas-Air Mixing

5-1 General.

5-1.1 Materials for vaporizers and gas-air mixing equipment shall comply with Chapter 4.

5-1.2 Liquefied petroleum gas storage containers shall not be directly heated with open flames.

5-1.3 Heating or cooling coils shall not be installed inside of a storage container.

5-1.4 Vaporizers shall not be equipped with fusible plugs for pressure relief.

5-1.5 Vaporizer houses shall not have drains to sewers or sump pits.

5-2 Vaporizers Not Directly Heated with Open Flames.

5-2.1 Vaporizers constructed in accordance with the requirements of the *ASME Unfired Pressure Vessel Code* shall be permanently marked as follows:

(a) With the code marking signifying the specifications to which vaporizer is constructed.

(b) With the maximum allowable working pressure and temperature for which the vaporizer is designed.

(c) With the sum of the outside surface area and the inside heat exchange surface area expressed in sq ft.

(d) With the name or symbol of the manufacturer, date of manufacture, and serial number.

5-2.2 Vaporizers having an inside diameter of 6 in. or less exempted by the *ASME Unfired Pressure Vessel Code* shall have a design working pressure not less than 250 psig and need not be permanently marked.

5-2.3 Building or structural enclosures in which vaporizers and/or gas-air mixers are installed shall be of

lightweight noncombustible construction with non-load-bearing walls. If rooms containing such equipment are located within or attached to buildings in which LP-Gases are not handled, i.e., control rooms, shops, boiler rooms, etc., 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), have no doors or other communicating openings, and shall have a fire resistance rating of at least one 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 cfm (0.47 L/s) of air per sq ft (0.09 m^2) of floor area.

5-2.4 A shutoff valve shall be installed on the liquid line to a vaporizer at least 50 ft (15.4 m) away from the vaporizer or a building housing a vaporizer.

5-2.5 The heating medium lines into and leaving the vaporizer shall be provided with suitable means for minimizing the effect of flow of gas into the heat system in the event of tube rupture in the vaporizer. Vaporizers shall be provided with suitable automatic means to prevent liquid passing from the vaporizers to the gas discharge piping.

5-3 Direct Fired Vaporizers.

5-3.1 Each vaporizer shall be marked to show the name of the manufacturer; rated British Thermal Unit input to burners; the area of the heat exchange surface in sq ft; the maximum vaporizing capacity in gal per hour; and date and serial number.

5-3.2 No direct fired vaporizers shall be located closer than 50 ft (15.4 m) to line of adjoining property upon which structures may be built. They shall also be located a minimum distance of 50 ft (15.4 m) away from any liquefied petroleum gas storage container.

5-3.3 No direct fired vaporizer shall be connected to a container that has a storage capacity in gal less than 10 times the hourly capacity of the vaporizer in gal. Vaporizers are permitted to be connected to the liquid section or the gas section of the storage container, or both; but in any case, there shall be at the container a manually operated valve in each connection to permit complete shutting off, when desired, of all flow of gas or liquid from container to vaporizer.

5-3.4 Vaporizers may be installed in buildings, rooms, housings, sheds, or lean-tos used exclusively for vaporizing LP-Gas.

5-3.4.1 Such buildings or structural enclosures in which vaporizers are installed shall be constructed and ventilated in accordance with 5-2.3.

5-3.4.2 These structures shall not have interior drains to sewers or sump pits.

5-3.5 Vaporizers shall be provided with suitable automatic means to prevent liquid passing from the vaporizer to the gas discharge piping of the vaporizer.

5-3.6 Vaporizers shall be provided with a means for turning off the gas to the main burner and pilot from a remote location.

5-3.7 Vaporizers shall be equipped with automatic safety devices to shut off the flow of fuel to main burners and pilot, if the ignition device should fail.

5-3.8 No direct fired vaporizer shall raise the product pressure over the designed working pressure of the vaporizer equipment.

5-4 Gas-Air Mixing.

5-4.1 Gas-air mixers shall be designed for air, vapor, and mixture pressures in accordance with good engineering design practice. Piping materials shall be in accordance with Chapter 4 of this standard. Gas-air mixers shall be so designed as to prevent the accidental formation of a flammable mixture.

5-4.2 Gas-air mixers shall be equipped with safety interlocks on both the LP-Gas and air supply lines to shut down the system if flammable limits are approached. Gas mixing control valves which provide tight shutoff of the LP-Gas and air supply lines when actuated by safety interlocks shall be considered as acceptable shutdown devices. Such valves shall fail in closed position.

5-4.3 A means shall be provided to prevent air from entering mixed gas lines without LP-Gas being present.

5-4.4 A means shall be provided to prevent backflow of gas into the air supply system. Check valves are not acceptable.

5-4.5 Where it is possible for condensation to take place between the vaporizer and the gas-air mixer, an interlock shall be provided to prevent LP-Gas liquid from entering the gas-air mixer.

5-4.6 Gas-air mixers which utilize the kinetic energy of the LP-Gas vapor to entrain air from the atmosphere and are so designed that maximum air entrainment is less than 85 percent of the mixture need not include the interlocks mentioned in 5-4.2 and 5-4.3 but shall be equipped with a check valve at the air intake to prevent the escape of gas to atmosphere when shut down. Gas-air mixers of this type receiving air from a blower, compressor, or any source of air other than direct from atmosphere shall include a means for preventing air without LP-Gas from entering the gas system.

5-4.7 Gas-air mixers may be installed in buildings or structural enclosures used exclusively for gas-air mixing or for vaporizing LP-Gas and mixing, provided that the vaporizer is not directly heated with open flame. Such buildings or structural enclosures shall be constructed in accordance with 5-2.3.

Chapter 6 Relief Devices

6-1 General.

6-1.1 Relief devices on containers shall be so arranged 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 lbs per sq in. gauge at which the device is set to start to discharge, with the actual rate of discharge in cu ft per min of air at 60 °F and 14.7 psia, 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 psig and that its rate of discharge is 15,000 cu ft per min of air.

6-1.3 The rate of discharge of container relief valves shall be in accordance with Chapter 9.

6-1.4 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.

6-1.5 The size of the relief device outlet connection shall not be smaller in diameter than the nominal size of the relief outlet connection and shall not appreciably restrict flow through the relief.

6-1.6 All container relief devices shall be located on the containers and shall be connected with the vapor space of the container.

6-1.7 No shutoff valve shall be installed between the relief device and the container, equipment, or piping to which the relief device is connected except that a shutoff valve may be used where the arrangement of this valve is such that full required capacity flow through the relief device is always afforded.

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 shall allow either of the relief valves to be closed, but shall 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 which will allow full required flow from one relief valve at all times.

6-1.8 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 so arranged as not to unduly restrict the flow.

6-1.8.1 Return bends and restrictive pipe fittings shall not be permitted in relief device discharge vents.

6-1.9 Discharge lines from two or more relief devices located on the same unit or similar lines from two or more different units, except those located on storage containers, are permitted to be run into a common discharge header provided the header is designed with a flow capacity sufficient to limit the maximum back pressure to (a) not exceeding 10 percent of the lowest start-to-discharge pressure setting for conventional relief valves, and (b) 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.

6-1.9.1 Relief valve piping shall be designed so that liquid which may be trapped will not create dangerous back pressure when the relief valve operates.

6-1.10 All discharge vents from the safety relief valves or common discharge headers shall be installed in such a manner as to:

(a) Lead to the open air.

(b) Be protected against mechanical damage.

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

6-1.10.1 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 which:

(a) Will prevent possible flame impingement on containers, piping, equipment, and structures.

(b) Will prevent possible vapor entry into enclosed spaces.

(c) Will be above the heads of personnel who may be on the container or adjacent containers, stairs, platforms, or ground.

(d) Will be above the possible water level, if from underground containers where there is a possibility of flooding.

6-1.10.2 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.

6-2.1 Relief devices shall be tested for proper operation at intervals not exceeding five (5) years.

6-3 On Aboveground Containers.

6-3.1 Every container shall be provided with spring-loaded relief valves or their equivalent. ASME containers for LP-Gas shall be equipped with spring-loaded safety relief valves conforming with applicable requirements of UL 132, *Standard on Safety Relief Valves for Anhydrous Ammonia and LP-Gas, Standards for Safety Relief Valves of the Factory Mutual Research Corporation*; or other equivalent safety relief valve standards.

6-3.2 The discharge from the relief devices shall be vented away from the container and unobstructed to the open air in a manner to prevent any impingement of escap-

ing 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 may 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.

6-3.3 Container relief valves shall be set to start to discharge with relation to the design pressure of the container in accordance with Table 6.

Table 6

Containers	Minimum	Maximum
All *ASME Codes* prior to the 1949 Edition, and the 1949 Edition, paragraphs U-68 and U-69	110%	125%*
ASME Code, 1949 Edition, paragraphs U-200 and U-201, and all *ASME Codes* later than 1949	88%	100%*
ANSI/API 620		100%*

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

6-3.4 Relief devices on containers shall be constructed to discharge at not less than the rates shown in Chapter 9 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) permitted start to discharge pressure setting of the devices.

6-3.5 For refrigerated storage, consideration shall be given to making proper provisions for vacuum conditions.

6-4 On 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 may be reduced to a minimum of 30 percent of the specified rate of discharge shown in Chapter 9. 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 as 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 On Vaporizers.

6-5.1 Each vaporizer shall be provided with a relief device providing an effective rate of discharge in accordance with Appendix C.

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 Between Shutoff Valves.

6-6.1 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 which 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 psig (2.76 MPa) or more than 500 psig (3.45 MPa) unless installed in systems designed to operate above 350 psig (2.41 MPa). Hydrostatic relief valves for use in systems designed to operate above 350 psig (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 Liquefied petroleum gas in liquid form is permitted to be transferred from tank cars or tank trucks or storage within a utility plant either by liquid pump or by pressure differential.

7-1.1.1 Pumps and compressors used for transferring liquefied petroleum gas shall be designed for the product handled.

7-1.2 Under certain conditions, it may be necessary to create a pressure differential by using fuel gas, or inert gas, which is at a pressure higher than the pressure of the liquefied petroleum gas in the container being filled. This is permitted to be done under the following conditions:

7-1.2.1 Adequate precautions shall be taken to prevent liquefied petroleum gas from flowing back into the fuel gas or inert gas line or system by installing two back flow check valves in series in these lines at the point where they connect into the liquefied petroleum gas system. In addition, a manually operated positive shutoff valve shall be installed at this point.

7-1.2.2 Any fuel gas or inert gas used to obtain a pressure differential to move liquid liquefied petroleum gas shall be noncorrosive and dried to avoid stoppage by freezing.

7-1.2.3 Before any fuel gas or inert gas is placed in a tank car for unloading liquefied petroleum gas by pressure differential, permission shall be obtained from the vendor of the liquefied petroleum gas to introduce such vapors into the tank car or a tank truck.

7-1.3 Transfer operations shall be conducted by competent trained personnel. At least one competent person shall remain in attendance at or near the transfer operation from the time connections are made until the transfer is completed, shutoff valves are closed, and lines are disconnected.

7-1.4 The maximum vapor pressure of the product at 100 °F (37.8 °C) which may be transferred into a container shall be in accordance with 2-2.1 or 2-2-2 and 2-2.3.

7-1.5 Unloading piping or hoses shall be provided with suitable bleeder valves or other means for relieving pressure before disconnection.

7-1.6 Precaution shall be exercised to assure that only those gases for which the system is designed, examined, and listed are employed in its operation, particularly with regard to pressures.

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 (US Dept. of Transportation)[1] 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 unloading into storage containers shall be at least 25 ft (7.6 m) from the container and so positioned that the shut-off 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 Fire Protection, Safety, and Security

8-1 General.

8-1.1* Fire Protection shall be provided for all utility gas plants. The extent of such protection shall be determined by an evaluation based upon the type (refrigerated or non-refrigerated), 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, 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 type 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.

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

8-1.2 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.

8-1.3 A detailed emergency procedure manual shall be prepared to cover the potential emergency conditions which may 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, and

(e) duties of personnel.

8-1.3.1 The emergency procedure 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 updated as required by changes in equipment or procedures.

8-1.4 All personnel shall be trained in their respective duties contained in the emergency manual. Those personnel responsible for the use of fire protection or other plant emergency equipment shall be trained in the use of that equipment. Refresher training shall be conducted at least on an annual basis.

8-1.5 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.

8-1.6 Gas fires shall normally not be extinguished until the source of the burning gas has been shut off.

8-2 Ignition Source Control.

8-2.1 Control of ignition sources shall comply with Section 1-9.

[1]Formerly ICC (Interstate Commerce Commission). Published in Federal Code of Regulations — Title 49 — Parts 171-190. In Canada, the regulations of the Canadian Transport Commission for Canada apply.

8-3 Fire and Leak Detection.

8-3.1 Those areas, including enclosed buildings, which have a potential for flammable gas concentrations and fire shall be monitored as appropriate.

8-3.2 Continuously monitored flammable gas detection systems shall sound an alarm at the plant site and at a constantly attended location if the plant site is not continuously manned. Flammable gas detection systems shall sound this alarm at not more than 25 percent of the lower flammable limit of the gas or vapor being monitored.

8-3.3 Fire detectors shall sound an alarm at the plant site and at a constantly attended location if the plant site is not continually manned.

8-3.4 Detection systems, when used, shall be designed, installed, and maintained in accordance with the following NFPA standards, as applicable:

(a) NFPA 72A, *Local Protective Signaling Systems.*

(b) NFPA 72B, *Auxiliary Protective Signaling Systems.*

(c) NFPA 72C, *Remote Station Protective Signaling Systems.*

(d) NFPA 72D, *Proprietary Protective Signaling Systems.*

(e) NFPA 72E, *Automatic Fire Detectors.*

(f) NFPA 1221, *Public Fire Service Communication Systems.*

8-4 Container Protection.

8-4.1 Nonrefrigerated storage containers shall be considered adequately protected against fire exposure if they are buried or mounded in accordance with 2-5.3 or insulated. (*See Appendix D.*)

8-5 Fire Protection Water Systems.

8-5.1 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 8-1.1 indicates the use of water is unnecessary or impractical.

8-5.2 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 gpm (63 L/s) shall be available for hand hose streams for a period of not less than 2 hours.

(a) Manually actuated monitors may be used to augment hand hose streams.

8-5.3 Nonrefrigerated storage containers that are not adequately protected per 8-4.1 shall be analyzed based on availability of water supply, the probable effectiveness of plant fire brigades and the time of response and probable effectiveness of 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 which may be present. If the analysis indicates additional water protection is needed, it shall comply with 8-5.4.

8-5.4 Special Protection.

8-5.4.1 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.

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

8-5.4.2 If mounding is utilized, the provisions of 3-2.3.7 of NFPA 58 shall constitute adequate protection.

8-5.4.3 If burial is utilized, the provisions of 2-4.2 shall constitute adequate protection.

8-5.4.4 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 have a capability for manual actuation.

8-5.4.5 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 have a capability for manual actuation.

8-5.5 Fire protection water systems, when 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, *Installation of Sprinkler Systems.*

(b) NFPA 13A, *Inspection, Testing, and Maintenance of Sprinkler Systems.*

(c) NFPA 14, *Standpipe and Hose Systems.*

(d) NFPA 15, *Water Spray Fixed Systems.*

(e) NFPA 20, *Centrifugal Fire Pumps.*

(f) NFPA 22, *Water Tanks for Private Fire Protection.*

(g) NFPA 24, *Private Fire Service Mains and Their Appurtenances.*

(h) NFPA 26, *Supervision of Valves Controlling Water Supplies.*

(i) NFPA 1961, *Fire Hose.*

(j) NFPA 1962, *Care, Use, and Maintenance of Fire Hose.*

(k) NFPA 1963, *Screw Threads and Gaskets for Fire Hose Connections.*

8-6 Fire Extinguishing and Other Fire Control Equipment.

8-6.1 Portable or wheeled fire extinguishers suitable for gas fires, preferably of the dry chemical type, shall be available at strategic locations, as determined in accordance with 8-1.1, within the facility and on cargo vehicles. The minimum size portable dry chemical extinguisher shall be 20 pounds with a B:C rating. These extinguishers shall be provided and maintained in accordance with NFPA 10, *Portable Fire Extinguishers*.

8-6.2 Fixed fire-extinguishing and other fire control systems may be appropriate for the protection of specific hazards as determined in accordance with 8-1.1. If provided, such systems shall be designed, installed, and maintained in accordance with the following NFPA standards, as applicable:

(a) NFPA 11, *Foam Extinguishing Systems and Combined Agent Systems*.

(b) NFPA 11A, *Medium and High Expansion Foam Systems*.

(c) NFPA 12, *Carbon Dioxide Extinguishing Systems*.

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

(e) NFPA 12B, *Halon 1211 Fire Extinguishing Systems*.

(f) NFPA 16, *Deluge Foam-Water Sprinkler and Spray Systems*.

(g) NFPA 17, *Dry Chemical Extinguishing Systems*.

8-7 Maintenance of Fire Protection Equipment.

8-7.1 Facility operators shall prepare and implement a maintenance program for all plant fire protection equipment.

8-8 Personnel Safety.

8-8.1 Personnel shall be advised of the danger of frostbite which can result upon contact with LP-Gas liquid or cold refrigerants.

8-8.1.1 Suitable protective clothing and equipment shall be available.

8-8.2 Those employees who will be involved in emergency activities, as determined in accordance with 8-1.1, shall be equipped with the necessary clothing and equipment. Protective clothing shall comply with NFPA 1971, *Protective Equipment for Structural Fire Fighting*, and have an impermeable outer shell. Those employees requiring such protective clothing shall also be equipped with helmets, face shields, gloves, and boots suitable for the intended exposure.

8-8.3 Self-contained breathing apparatus shall be provided for those employees who may be required to enter an atmosphere which could be injurious to health during an emergency. Such apparatus shall comply with NFPA 1981, *Self-Contained Breathing Apparatus for Fire Fighters*, and be maintained in accordance with the manufacturer's instructions.

8-8.4 A portable flammable gas detector shall be readily available.

8-9 Security.

8-9.1 The facility operator shall provide a security system with controlled access which shall be designed to minimize entry by unauthorized persons.

8-9.2 A protective enclosure including a peripheral fence (equal to at least a 6-ft high industrial fence), building wall, or natural barrier shall be provided enclosing major facility components, such as:

(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 housing 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 alternate to fencing the operating area, suitable devices which 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.

8-9.3 The provisions of 8-9.2 may 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.

8-9.4 Provisions shall be made for the ready access to the facility by emergency personnel or services.

8-9.5 Illumination shall be provided as necessary in the vicinity of protective enclosures and in other areas to promote security of the facility.

Chapter 9 Relief Device Sizing

9-1 Nonrefrigerated Containers.

9-1.1 Table 7 shall apply.

Table 7

Minimum required rate of discharge in cu ft per min of air at 120 percent of the maximum permitted start to discharge pressure for safety relief devices to be used on nonrefrigerated containers other than those constructed in accordance with US Department of Transportation specifications.

Surface Area Sq Ft	Flow Rate CFM Air	Surface Area Sq Ft	Flow Rate CFM Air	Surface Area Sq Ft	Flow Rate CFM Air
20 or less	626	170	3620	600	10170
25	751	175	3700	650	10860
30	872	180	3790	700	11550
35	990	185	3880	750	12220
40	1100	190	3960	800	12880
45	1220	195	4050	850	13540
50	1330	200	4130	900	14190
55	1430	210	4300	950	14830
60	1540	220	4470	1000	15470
65	1640	230	4630	1050	16100
70	1750	240	4800	1100	16720
75	1850	250	4960	1150	17350
80	1950	260	5130	1200	17960
85	2050	270	5290	1250	18570
90	2150	280	5450	1300	19180
95	2240	290	5610	1350	19780
100	2340	300	5760	1400	20380
105	2440	310	5920	1450	20980
110	2530	320	6080	1500	21570
115	2630	330	6230	1550	22160
120	2720	340	6390	1600	22740
125	2810	350	6540	1650	23320
130	2900	360	6690	1700	23900
135	2990	370	6840	1750	24470
140	3080	380	7000	1800	25050
145	3170	390	7150	1850	25620
150	3260	400	7300	1900	26180
155	3350	450	8040	1950	26750
160	3440	500	8760	2000	27310
165	3530	550	9470		

Table Notes:

Surface Area = Total outside surface area of container in sq ft.

When the surface area is not stamped on the nameplate or when the marking is not legible, the area can be calculated by using one of the following formulas:

1. Cylindrical container with hemispherical heads

   Area = Overall length × outside diameter × 3.1416

2. Cylindrical container with other than hemispherical heads

   Area = (Overall length + .3 outside diameter) × outside diameter × 3.1416

3. Spherical container

   Area = Outside diameter squared × 3.1416

Flow Rate-CFM Air = Required flow capacity in cu ft per min of air at standard conditions, 60 °F (16 °C), and atmospheric pressure [14.7 psia (101 kPa)].

The rate of discharge may be interpolated for intermediate values of surface area. For containers with total outside surface area greater than 2,000 sq ft, the required flow rate can be calculated using the formula, Flow Rate-CFM Air = $53.632\ A^{0.82}$

Where

A = total outside surface area of the container in sq ft.

Valves not marked "Air" have flow rate marking in cu ft per min of liquefied petroleum gas. These can be converted to ratings in cu ft per min of air by multiplying the liquefied petroleum gas ratings by the factors listed below. Air flow ratings can be converted to ratings in cu ft per min of liquefied petroleum gas by dividing the air ratings by the factors listed below.

Air Conversion Factors

Container Type	100	125	150	175	200
Air Conversion Factor	1.162	1.142	1.113	1.078	1.010

9-2 Refrigerated Containers.

NOTE: The safety relief valve capacity in addition to preventing excessive pressure in the event of fire exposure also protects the container from excessive pressure in event the refrigeration system does not function.

9-2.1 The minimum required rate of discharge in cu ft per min of air at 120 percent of the maximum permissible start-to-discharge pressure as specified in 6-3.3 for safety relief devices to be used on refrigerated containers shall be computed by the following formula:

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

Where

Qa = Minimum required flow capacity of air, in cu ft per min, at 60°F and 14.7 psia.

F = A composite environmental factor, as tabulated in Table 8.

To take 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 1,500°F. 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 the case of spheres or spheroids, to the elevation of maximum horizontal diameter of the tank, in sq ft.

L = Latent heat of gas at *flowing* conditions in Btu/lb.

C = Constant for gas which is a function of the ratio of specific heats at standard conditions. While not strictly applicable to flows at pressures under 15 psig, its use will produce conservative results.

k = $\frac{Cp}{Cv}$ (value for C is then taken from graph of k versus C as shown in Figure 2).

Z = Compressibility factor at *flowing* conditions.

T = Absolute temperature at *flowing* conditions.

M = Molecular weight of gas.

Table 8 Environmental Factors

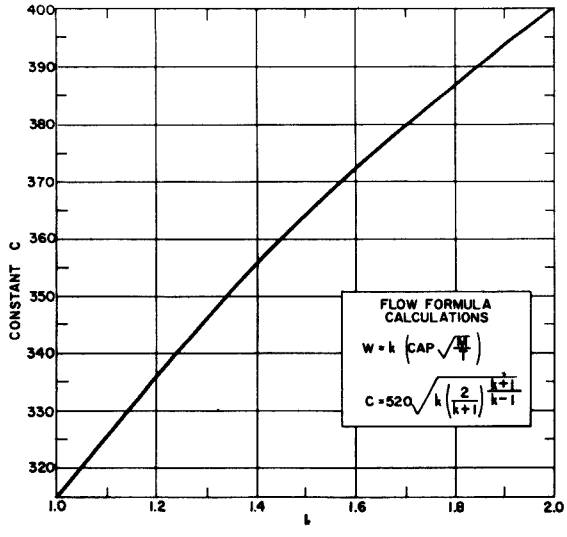
	Environment	Factor F
1.	Bare container	1.0
2.	Insulated containers with the following typical conductance values in Btu per hr per sq ft per degree Fahrenheit, based on 1,600 degrees Fahrenheit temperature difference:	
	4.0	0.3
	2.0	0.15
	1.0	0.075

9-3 Vaporizers.

9-3.1 The minimum required rate of discharge for relief valves for liquefied petroleum gas vaporizers (steam heated, water heated, and direct fired) shall be determined as follows:

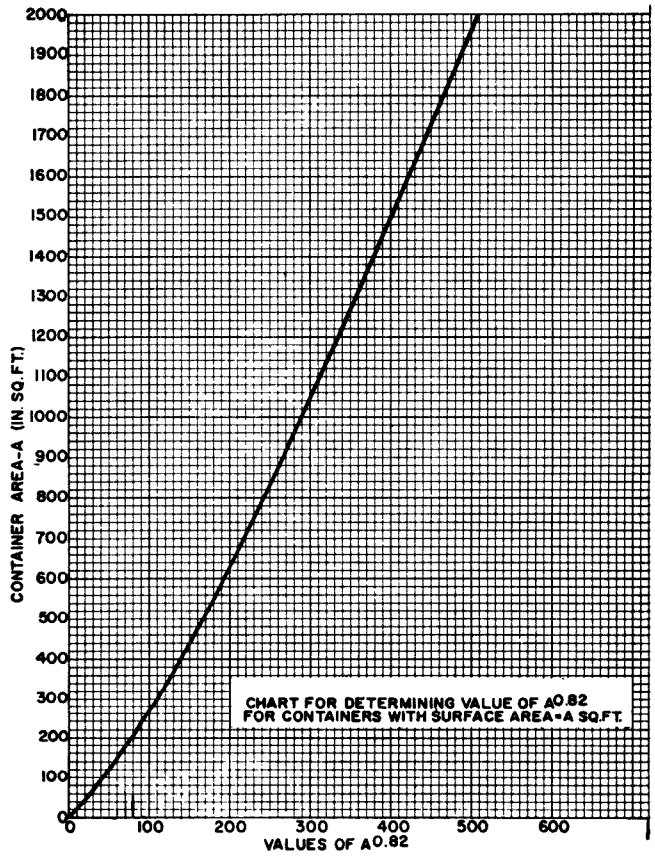
1. Obtain the total surface area by adding the surface area of vaporizer shell in sq ft directly in contact with liquefied petroleum gas and the heat exchange surface area in sq ft directly in contact with liquefied petroleum gas.

2. Obtain the minimum required rate of discharge in cu ft of air per min, at 60 °F (16 °C) and 14.7 psia (101 kPa), from Section 9-1 for this total surface area.



k	Constant C	k	Constant C	k	Constant 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		

Figure 2



1 sq ft = 0.0929 m²

Figure 3

Chapter 10 Referenced Publications

10-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

10-1.1 NFPA Publications. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

NFPA 10-1988, *Standard for Portable Fire Extinguishers*

NFPA 11-1988, *Standard for Low Expansion Foam and Combined Agent Systems*

NFPA 11A-1988, *Standard for Medium and High Expansion Foam Systems*

NFPA 12-1985, *Standard on Carbon Dioxide Extinguishing Systems*

NFPA 12A-1987, *Standard on Halon 1301 Fire Extinguishing Systems*

NFPA 12B-1985, *Standard on Halon 1211 Fire Extinguishing Systems*

NFPA 13-1987, *Standard for the Installation of Sprinkler Systems*

NFPA 14-1986, *Standard for the Installation of Standpipe and Hose Systems*

NFPA 15-1985, *Standard for Water Spray Fixed Systems for Fire Protection*

NFPA 16-1986, *Standard on Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*

NFPA 17-1985, *Standard for Dry Chemical Extinguishing Systems*

NFPA 20-1987, *Standard for the Installation of Centrifugal Fire Pumps*

NFPA 22-1988, *Standard for Water Tanks for Private Fire Protection*

NFPA 24-1987, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*

NFPA 51B-1984, *Standard for Fire Prevention in Use of Cutting and Welding Processes*

NFPA 58-1989, *Standard for the Storage and Handling of Liquefied Petroleum Gases*

NFPA 70-1987, *National Electrical Code*

NFPA 72A-1987, *Local Protective Signaling Systems for Guard's Tour, Fire Alarm, and Supervisory Service*

NFPA 72B-1986, *Auxiliary Protective Signaling Systems for Fire Alarm Service*

NFPA 72C-1986, *Remote Station Protective Signaling Systems*

NFPA 72D-1986, *Proprietary Protective Signaling Systems*

NFPA 72E-1987, *Standard on Automatic Fire Detectors*

NFPA 78-1986, *Lightning Protection Code*

NFPA 1961-1987, *Standard for Fire Hose*

NFPA 1962-1988, *Standard for the Care, Use, and Maintenance of Fire Hose Including Connections and Nozzles*

NFPA 1963-1985, *Standard for Screw Threads and Gaskets for Fire Hose Connections*

NFPA 1971-1986, *Standard on Protective Clothing for Structural Fire Fighting*

NFPA 1981-1987, *Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Fighters.*

10-1.2 Other Publications.

10-1.2.1 ANSI Publications. American National Standards Institute, 1430 Broadway, New York, NY 10018.

ANSI A58.1-1982, *Minimum Design Loads in Buildings and Other Structures*

ANSI B31.3-1988, *Chemical Plant and Petroleum Refinery Piping.*

10-1.2.2 API Publications. American Petroleum Institute, 2101 L St., NW, Washington, DC 20037.

API 620-1982, *Recommended Rules for the Design and Construction of Large, Welded, Low-Pressure Storage Tanks*

API RP 2003-1982, *Protection Against Ignitions Arising Out of Static, Lightning and Stray Currents.*

10-1.2.3 ASME Publication. American Society for Mechanical Engineers, 345 East 47th St., New York, NY 10017.

"Rules for the Construction of Unfired Pressured Vessels," Section VIII, *ASME Boiler and Pressure Vessel Code*-1986.

10-1.2.4 ASTM Publications. American Society for Testing and Materials, 1916 Race St., Philadelphia, PA 19103.

ASTM A48-1983, *Specification for Gray Iron Castings*

ASTM A395-1980, *Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures*

ASTM A536-1984, *Specifications for Ductile Iron Castings.*

10-1.2.5 US Government Publication. Superintendent of Documents, US Government Printing Office, Washington, DC 20401.

Code of Federal Regulations, Title 49, Parts 171-190.

10-1.2.6 ICBO Publication. International Conference of Building Officials, 5360 South Workman Rd., Whittier, CA 90601.

Uniform Building Code (UBC), 1988.

10-1.2.7 NACE Publication. National Association of Corrosion Engineers, PO Box 218340, Houston, TX 77084.

RP-01-69 (1983 Rev.), *Control of External Corrosion of Underground or Submerged Metallic Piping Systems.*

10-1.2.8 UL Publication. Underwriters Laboratories, Inc., 333 Pfingsten Rd., Northbrook IL 60062.

UL 132-1984, *Standard on Safety Relief Valves for Anhydrous Ammonia and LP-Gas.*

Appendix A

A-1-4.1 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 1-4.1 by tests or experience. Where qualifying is by tests, such tests should be certified to by an approved laboratory not associated with the odorant manufacturer. Experience has shown that ethyl mercaptan in the ratio of 1.0 lb (0.45 kg) per 10,000 gal (37.8 kL) of liquid LP-Gas has been recognized as an effective odorant. Other odorants and quantities meeting the provisions of 1-4.1 may be used. Research* on odorants has shown that thiophane (tetrahydrothiophene) in a ratio of at least 6.4 lb (2.9 kg) per 10,000 gal (37.8 kL) of liquid LP-Gas may satisfy the requirements of 1-4.1.

*"A New Look at Odorization Levels for Propane Gas," BERC/RI-77/1, United States Energy Research & Development Administration, Technical Information Center, September, 1977. Available from National Technical Information Service, US Dept. of Commerce, Springfield, VA 22161.

A-8-1.1 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 which may be present.

NOTE: 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 can also be used to control unignited gas leakage.

Appendix B

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

Method of calculating maximum liquid volume which can be placed in a container at any liquid temperature.

The quantity of gas which may be placed in a container is dependent upon 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 aboveground 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 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 may 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 only be used 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) which shall 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) placed in container.

F = correction factor from following table for correcting liquid volume from 60 °F (15.6 °C) to volume at temperature T. The correction factor is obtained 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 till the actual liquid temperature T is found. The correction factor corresponding to this specific gravity and 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 gal, Q_T, of LP-Gas which may be placed in a container is obtained by multiplying the water capacity of the container by $\frac{V}{100}$

Where

Q_T = actual gal at liquid temperature T.

Example:

Assume an aboveground container with 10,000-gal water capacity.

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

Filling density from 2-8.1 for aboveground container having a capacity greater than 1,200 gal in which a product having a specific gravity at 60 °F (15.6 °C) of 0.508 is to be placed is 45 percent.

To determine maximum quantity that may be placed in container when the liquid temperature is 60 °F (15.6 °C).

$$Q_{60F} = \frac{45 \times 10{,}000}{0.508 \times 100} = 8{,}860 \text{ gal}$$

When liquid temperature is 82 °F (27.8 °C) find correction factor in the table on next page for specific gravity at 60 °F (15.6 °C) of 0.508 and a liquid temperature of 82 °F (27.8 °C) which is 0.963.

$$Q_{82F} = \frac{45 \times 10{,}000}{0.508 \times 0.963 \times 100} = 9{,}200 \text{ gal}$$

Liquid Volume Correction Factors

Observed Temperature Degrees Fahrenheit	SPECIFIC GRAVITIES AT 60° F./60° F.												
	0.500	Propane 0.5079	0.510	0.520	0.530	0.540	0.550	0.560	iso-Butane 0.5631	0.570	0.580	n-Butane 0.5844	0.590
	VOLUME CORRECTION FACTORS												
–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	1.076	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	1.056	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
74	0.976	0.976	0.977	0.978	0.980	0.980	0.982	0.983	0.983	0.984	0.985	0.985	0.985
76	0.972	0.973	0.974	0.975	0.977	0.978	0.979	0.980	0.981	0.981	0.982	0.982	0.983
78	0.969	0.970	0.970	0.972	0.974	0.975	0.977	0.978	0.978	0.979	0.980	0.980	0.981
80	0.965	0.967	0.967	0.969	0.971	0.972	0.974	0.975	0.976	0.977	0.978	0.978	0.979
82	0.961	0.963	0.963	0.966	0.968	0.969	0.971	0.972	0.973	0.974	0.976	0.976	0.977
84	0.957	0.959	0.960	0.962	0.965	0.966	0.968	0.970	0.971	0.972	0.974	0.974	0.975
86	0.954	0.956	0.956	0.959	0.961	0.964	0.966	0.967	0.968	0.969	0.971	0.971	0.972
88	0.950	0.952	0.953	0.955	0.958	0.961	0.963	0.965	0.966	0.967	0.969	0.969	0.970
90	0.946	0.949	0.949	0.952	0.955	0.958	0.960	0.962	0.963	0.964	0.967	0.967	0.968
92	0.942	0.945	0.946	0.949	0.952	0.955	0.957	0.959	0.960	0.962	0.964	0.965	0.966
94	0.938	0.941	0.942	0.946	0.949	0.952	0.954	0.957	0.958	0.960	0.962	0.962	0.964
96	0.935	0.938	0.939	0.942	0.946	0.949	0.952	0.954	0.955	0.957	0.959	0.960	0.961
98	0.931	0.934	0.935	0.939	0.943	0.946	0.949	0.952	0.953	0.954	0.957	0.957	0.959
100	0.927	0.930	0.932	0.936	0.940	0.943	0.946	0.949	0.950	0.952	0.954	0.955	0.957
105	0.917	0.920	0.923	0.927	0.931	0.935	0.939	0.943	0.943	0.946	0.949	0.949	0.951
110	0.907	0.911	0.913	0.918	0.923	0.927	0.932	0.936	0.937	0.939	0.943	0.944	0.946
115	0.897	0.902	0.904	0.909	0.915	0.920	0.925	0.930	0.930	0.933	0.937	0.938	0.940
120	0.887	0.892	0.894	0.900	0.907	0.912	0.918	0.923	0.924	0.927	0.931	0.932	0.934
125	0.876	0.881	0.884	0.890	0.898	0.903	0.909	0.916	0.916	0.920	0.925	0.927	0.928
130	0.865	0.871	0.873	0.880	0.888	0.895	0.901	0.908	0.909	0.913	0.918	0.921	0.923
135	0.854	0.861	0.863	0.871	0.879	0.887	0.894	0.901	0.902	0.907	0.912	0.914	0.916
140	0.842	0.850	0.852	0.861	0.870	0.879	0.886	0.893	0.895	0.900	0.905	0.907	0.910

Appendix C

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

Method of calculating maximum volume of liquefied petroleum gas which can be placed in a container for which length of fixed dip tube is set.

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 may be installed either in a vertical or horizontal position. Knowing the maximum permitted filling volume in gal, 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 as determined by the following formula:

2. Formula for determining maximum volume of liquefied petroleum gas for which a fixed length of dip tube shall be set.

$$\frac{\text{Water Cap. (Gal) of Container* } \times \text{ Filling Density**}}{\text{Sp. Gr. of liquefied petroleum gas* } \times \text{ Volume Correction Factor } \dagger \times 100} = \text{Maximum Volume of liquefied petroleum gas}$$

Example: Assume a 30,000-gal total water capacity container for aboveground storage of propane having a specific gravity of 0.510 at 60 °F (15.6 °C).

$$\frac{30{,}000 \times 45}{0.510 \times 1.031 \times 100} = \frac{1{,}350{,}000}{52.58}$$

$\frac{1{,}350{,}000}{52.58}$ = 25,675 gal propane, the maximum amount permitted to be placed in a 30,000-gal total water capacity aboveground container equipped with a fixed dip tube.

Volume Correction Factors

Specific Gravity	Aboveground	Underground
0.500	1.033	1.017
.510	1.031	1.016
.520	1.029	1.015
.530	1.028	1.014
.540	1.026	1.013
.550	1.025	1.013
.560	1.024	1.012
.570	1.023	1.011
.580	1.021	1.011
.590	1.020	1.010

*Measured at 60 °F (15.6 °C)

**From 2-8.1, "Filling Densities."

†For aboveground containers the liquid temperature is assumed to be 40 °F (4.4 °C) and 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 paragraph 4-4.6 shall be used.

3. The maximum volume of liquefied petroleum gas which can be placed in a container when determining the length of the dip tube expressed as a percentage of total water content of the container is calculated by the following formula:

$$\frac{\text{Maximum Vol. of liquefied petroleum gas (From Formula in Par. 2 preceding)} \times 100}{\text{Total water content of container in gal}} = \text{Maximum Percent of liquefied petroleum gas}$$

4. The maximum weight of liquefied petroleum gas which may be placed in a container *for determining the length of a fixed dip tube* is determined by multiplying the maximum volume of liquefied petroleum gas obtained by the formula in paragraph 2 preceding by the lbs of liquefied petroleum gas in a gal of 40 °F (4.4 °C) for aboveground and at 50 °F (10 °C) for underground containers. For example, typical lbs per gal are specified below:

	Aboveground lbs per gal	Underground lbs per gal
Propane	4.37	4.31
Butane	4.97	4.92

Appendix D Procedure for Torch Fire and Hose Stream Testing of Thermal Insulating Systems for LP-Gas Containers

A. *Performance Standard.* Thermal protection insulating systems, proposed for use on LP-Gas containers as a means of "Special Protection" under paragraph 3-10.3.1 of NFPA 58, are required to undergo thermal performance testing as a precondition for acceptance. The intent of this testing procedure is to identify insulation systems which retard or prevent the release of the container's contents in a fire environment of a 50 minute duration; and which will resist a concurrent hose stream of a 10 minute duration.

B. *Reference Test Standards.* The testing procedure described herein was taken with some modification from segments of the two following test standards:

1. *Code of Federal Regulations* — Title 49, Part 179.105-4, "Thermal Protection."

2. *National Fire Code* — NFPA Standard No. 252, Chapter 4, Part 4-3, "Hose Stream Test."

C. *Thermal Insulation Test.*

1. A torch fire environment shall be created in the following manner:

(i) The source of the simulated torch shall be a hydrocarbon fuel. The flame temperature from the simulated torch shall be 2,200 °F ± 100 °F throughout the duration of the test. Torch velocities shall be 40 miles per hour ± 10 miles per hour throughout the duration of the test.

(ii) An uninsulated square steel plate with thermal properties equivalent to ASME pressure vessel steel shall be used. The plate dimensions shall be not less than 4 feet by 4 feet by nominal ⅝ inch thick. The plate shall be instrumented with not less than 9 thermocouples to record the thermal response of the plate. The thermocouples shall be attached to the surface not exposed to the simulated torch, and shall be divided into 9 equal squares with a thermocouple placed in the center of each square.

(iii) The steel-plate holder shall be constructed in such a manner that the only heat transfer to the back side of the plate is by heat conduction through the plate and not by other heat paths. The apex of the flame shall be directed at the center of the plate.

(iv) Before exposure to the torch fire, none of the temperature recording devices shall indicate a plate temperature in excess of 100 °F or less than 32 °F.

(v) A minimum of two thermocouples shall indicate 800 °F in a time of 4.0 ± 0.5 minutes of torch fire exposure.

2. A thermal insulation system shall be tested in the torch fire environment described in paragraph (1) of this section in the following manner:

(i) The thermal insulation system shall cover one side of a steel plate identical to that used under paragraph C.1.(ii) of this section.

(ii) The back of the steel plate shall be instrumented with not less than 9 thermocouples placed as described in paragraph C.1.(ii) of this section to record the thermal response of the steel.

(iii) Before exposure to the torch fire, none of the thermocouples on the thermal insulation system steel plate configuration shall indicate a plate temperature in excess of 100 °F or less than 32 °F.

(iv) The entire outside surface of the thermal insulation system shall be exposed to the torch fire environment.

(v) A torch fire test shall be run for a minimum of 50 minutes. The thermal insulation system shall retard the heat flow to the steel plates so that none of the thermocouples on the uninsulated side of the steel plate indicates a plate temperature in excess of 800 °F.

D. *Hose Stream Resistance Test.*

1. After 20 minutes exposure to the torch test, the test sample shall be hit with a hose stream concurrently with the torch for a period of 10 minutes. The hose stream test shall be conducted in the following manner:

(i) The stream shall be directed first at the middle and then at all parts of the exposed surface, making changes in direction slowly.

(ii) The hose stream shall be delivered through a 2½ inch (64 mm) hose discharging through a National Standard Playpipe of corresponding size equipped with 1⅛ in. (29 mm) discharge tip of the standard-taper smooth-bore pattern without shoulder at the orifice. The water pressure at the base of the nozzle and for the duration of the test shall be 30 psi. (Estimated delivery rate is 205 gallons per minute.)

(iii) The tip of the nozzle shall be located 20 ft (6 m) from and on a line normal to the center of the test specimen. If impossible to be so located, the nozzle may be on a line deviating not to exceed 30 degrees from the line normal to the center of the test specimen. When so located the distance from the center shall be less than 20 ft (6 m) by an amount equal to 1 ft (0.3 m) for each 10 degrees of deviation from the normal.

(iv) Subsequent to the application of the hose stream, the torching shall continue until any thermocouple on the uninsulated side of the steel plate indicates a plate temperature in excess of 800 °F.

(v) The thermal insulation system shall be judged to be resistant to the action of the hose stream if the time from initiation of torching for any thermocouple on the uninsulated side of the steel plate to reach in excess of 800 °F is 50 minutes or greater.

(vi) One (1) successful combination torch fire and hose stream test shall be required for certification.

Appendix E Referenced Publications

E-1 The following documents or portions thereof are referenced within this standard for informational purposes only and thus are not considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

E-1.1 NFPA Publications. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

NFPA 13A-1987, *Recommended Practice for the Inspection, Testing, and Maintenance of Sprinkler Systems*

NFPA 26-1988, *Recommended Practice for the Supervision of Valves Controlling Water Supplies for Fire Protection*

NFPA 77-1988, *Recommended Practice on Static Electricity.*

E-1.2 Other Publications.

E-1.2.1 A New Look at Odorization Levels for Propane Gas, BERC/R1-77-1, United States Energy Research and Development Administration, Technical Information Center, September, 1977. Available from National Technical Information Service, US Department of Commerce, Springfield, VA 22161.

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