

Design and Construction of LPG Installations

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Foreword

This standard provides minimum requirements for the design and construction of installations for the storage and handling of liquefied petroleum gas (LPG) at marine and pipeline terminals, natural gas processing plants, refineries, petrochemical plants, and tank farms. This standard takes into consideration the specialized training and experience of operating personnel in the type of installation discussed. In certain instances, exception to standard practices are noted and alternative methods are described.

This standard does not include information on the production or use of liquefied petroleum gas.

It is not intended that this standard be retroactive or that it take precedence over contractual agreements. Wherever practicable, existing codes and manuals have been used in the preparation of this standard.

This standard requires the purchaser to specify certain details and features. Although it is recognized that the purchaser may desire to modify, delete, or amplify sections of the standard, it is strongly recommended that such modifications, deletions, and amplifications be made by supplementing this standard rather than by rewriting or incorporating sections of this standard into another complete standard.

As used in this standard, “shall” denotes a minimum requirement to conform to the specification. “Should” denotes a recommendation or that which is advised but not required to conform to the specification. “Shall consider” directly before a design or construction factor (such as a force or safety) indicates that the factor’s effects and significance shall be evaluated using good engineering judgment-through an examination or test if appropriate-and the design may or may not be adjusted accordingly.

Suggested revisions are invited and should be submitted to API, Standards Department, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001, standards@api.org.

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Design and Construction of LPG Installations

1 Scope

1.1 General

This standard covers the design, construction, and location of liquefied petroleum gas (LPG) installations at marine and pipeline terminals, natural gas processing plants, refineries, petrochemical plants, or tank farms. It also addresses the use of storage vessels, loading and unloading systems, piping, and related equipment.

1.2 Refrigerated Storage

Design and construction considerations specific to refrigerated storage are covered in Section 11 of this standard.

1.3 Pressurized Storage

Design and construction considerations specific to pressure vessel storage are covered in Section 4 of this standard.

1.4 Numerical Units Used

In this standard, numerical values are presented in the U.S. Customary (USC) units.

1.5 Excluded Items

1.5.1 This standard does not apply to the design, construction, or relocation of frozen earth pits, underground storage caverns or wells, and underground or mounded storage tanks.

1.5.2 This standard does not apply to the following installations.

- a) Those covered by NFPA 58 and NFPA 59.
- b) U.S. Department of Transportation (DoT) containers.
- c) Gas utility company facilities; refinery process equipment; refinery and gas plant processing equipment; and transfer systems from process equipment before upstream LPG storage.
- d) Those tanks with less than 2000 gallons of storage capacity.

1.6 Retroactivity

The provisions of this standard are intended for application to new installations. This standard can be used to review and evaluate existing storage facilities. However, the feasibility of applying this standard to facilities, equipment, structures, or installations that were already in place or that were in the process of construction or installation before the date of this publication, must be evaluated on a case-by-case basis considering individual circumstances and sites.

1.7 Characteristics of LPG

LPG is customarily handled in a liquid state achieved by its liquefaction under moderate pressure or refrigeration. Upon release of the pressure or warming of the refrigerated liquid, LPG is readily converted into the gaseous phase at normal ambient temperature.

1.8 Safety

The safety of LPG storage installations is enhanced by the employment of good engineering practices, such as those recommended by this standard, during design and construction.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API Recommended Practice 500, *Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2*

API Recommended Practice 505, *Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1 and Zone 2*

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

API Standard 520, *Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries*

API Standard 521, *Guide for Pressure-Relieving and Depressuring Systems*

API Recommended Practice 551, *Process Measurement Instrumentation*

API Standard 607, *Fire Test for Soft-Seated Quarter-Turn Valves*

API Standard 625, *Tank Systems for Refrigerated Liquefied Gas Storage*

API Recommended Practice 752, *Management of Hazards Associated with Location of Process Plant Permanent Buildings,*

API Recommended Practice 1102, *Steel Pipelines Crossing Railroads and Highways*

API Standard 2000, *Venting Atmospheric and Low-Pressure Storage Tanks*

API Recommended Practice 2003, *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents*

API Recommended Practice 2218, *Fireproofing Practices in Petroleum and Petrochemical Processing Plants*

API Publication 2510A, *Fire Protection Considerations for the Design and Operation of Liquefied Petroleum Gas (LPG) Storage Facilities*

API Specification 6FA, *Specification for Fire Test for Valves*

API, *MPMS, Chapter 5—Metering*

ASME B16.4 ¹, *Gray Iron Threaded Fittings Classes 125 and 250*

ASME B16.9, *Factory-Made Wrought Steel Buttwelding Fittings*

ASME B16.47, *Large Diameter Steel Flanges NPS 26 Through NPS 60 Metric/Inch Standard*

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

¹ ASME International, 3 Park Avenue, New York, New York 10016, www.asme.org.

ASME B31.4, *Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia, and Alcohols*

ASME BPVC, *Section II—Materials*

ASME BPVC, *Section VIII—Rules of Construction for Pressure Vessels, Division 1 and Division 2*

ASTM A516M/A516², *Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service*

DOT³, *Transportation Safety Act of 1974*, Part 173, Section 315

NBBI⁴, *National Board Inspection Code, Part 1, Installation*

NBBI, *National Board Inspection Code, Part 2, Inspection*

NBBI, *National Board Inspection Code, Part 3, Repairs and Alterations*

NFPA 15, *Standard for Water Spray Systems for Fire Protection*

NFPA 24, *Standard for Installations of Private Service Mains and their Appurtenances*

NFPA 30⁵, *Flammable and Combustible Liquids Code*

NFPA 58, *Storage and Handling of Liquefied Petroleum Gases*

NFPA 59, *Storage and Handling of Liquefied Petroleum Gases at Utility Gas Plants*

NFPA 59A, *Production, Storage and Handling of Liquefied Natural Gas (LNG)*

NFPA 70, *National Electrical Code*

UL 1709⁶, *Standard for Rapid Rise Fire Tests of Protection Materials for Structural Steel*

3 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

3.1

aboveground container

a container all or part of which is exposed above grade.

3.2

auto-refrigeration

the chilling effect of vaporization of pressurized LPG when it is released or vented to a lower pressure.

3.3

container

a refrigerated tank, pressure vessel, or refrigerated pressure vessel for storage of LPG.

² ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, www.astm.org.

³ U.S. Department of Transportation. The Act is available from the U.S. Government Printing Office, Washington, D.C. 20402.

⁴ National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Avenue Columbus, Ohio 43229-1183.

⁵ National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02269-9101.

⁶ Underwriters Laboratories, 333 Pfingsten Road, Northbrook, Illinois 60062, www.ul.com.



3.4

installations

tanks, vessels, pumps, compressors, accessories, piping, and all other associated equipment required for the receipt, transfer, storage, and shipment of LPG.

3.5

liquefied petroleum gas (LPG or LP-gas)

any material in liquid form that is composed predominantly of any of the following hydrocarbons or of a mixture thereof: propane, propylene, butanes (normal butane or isobutane), and butylenes.

3.6

mounded tank or vessel

a tank or vessel located above or partially above the general grade level but covered with earth, sand, or other suitable material.

3.7

pressure vessel

a vessel in accordance with ASME BPVC Section VIII for storage of LPG at pressures exceeding 15 psig.

3.8

primary liquid container

the container in continuous contact with product, i.e.: 1) the refrigerated container of the single containment tank; 2) the refrigerated or non-refrigerated container of the pressure vessel; and 3) the inner refrigerated container of the double containment tank, or full containment tank.

3.9

refrigerated tank storage

storage in a tank at a pressure below 15 psig and at an artificially maintained temperature necessary to maintain a liquid state.

3.10

refrigerated vessel

Vessel using both pressure exceeding 15 psig and artificially maintained low temperature to maintain the LPG in liquid state.

3.11

secondary liquid container

the container in contact with product only in event of a failure of primary liquid container, i.e.: 1) the bund walls for single containment tanks and pressure vessels; and 2) the outer container of double and full containment tanks.

3.12

tank

tank is synonymous with "refrigerated tank," a container used for storing LPG.

3.13

tank system

equipment designed for the purpose of storing refrigerated LPG consisting of one or more containers together with all other necessary components within the scope of this standard.

3.14

underground container

A tank or vessel where all parts are completely buried below the general grade of the facility.

3.15

upstream LPG storage

LPG storage container at or near well head for the exploration, production, recovery, handling, processing, treatment, or disposal, or transmission of LPG or any associated substances.

3.16

vessel

vessel is synonymous with “pressure vessel.”

4 Design of LPG Pressure Vessels

4.1 Applicable Design Construction Codes

4.1.1 Vessels for pressurized storage shall meet the requirements of the ASME BPVC Section VIII, Division 1 or 2.

4.1.2 When complete rules for any specific design are not given, the manufacturer, subject to the approval of the purchaser, shall provide a design as safe as would be provided in the currently applicable code listed in 4.4.1.

4.2 Design Pressure and Temperature

4.2.1 The design pressure of LPG pressure vessels shall not be less than the vapor pressure of the stored product at the maximum product design temperature. The additional pressure resulting from the partial pressure of non-condensable gases in the vapor space and the hydrostatic head of the product at maximum fill shall be considered. Ordinarily, the latter considerations and the performance specifications of the relief valve require a differential between design pressure and maximum product vapor pressure that is adequate to allow blowdown of the pressure relief valve (see API Standard 520).

4.2.2 Both a minimum design temperature and a maximum design temperature shall be specified. In determining a maximum design temperature, consideration shall be given to factors such as ambient temperature, solar input, and product run down temperature. In determining a minimum design temperature, consideration shall be given to the factors noted in the preceding sentence as well as the auto-refrigeration temperature of the stored product when it flashes to atmospheric pressure.

4.2.3 ASME BPVC Section VIII, Division 1 UCS-66(b) and Division 2, 3.11.2.5 provide adjustment curves that allow the impact test exemption temperatures to be reduced in increasing measure as pressures are reduced. Conservative application of those adjustment curves in conjunction with LPG vapor pressure curves allow the following auto-refrigeration conclusion. The reduced auto-refrigeration temperature will not mandate impact testing of the vessel material for LPG storage vessels that satisfy the requirements in 4.2.3.1 through 4.2.3.5.

4.2.3.1 Design pressure is 200 psig or greater.

4.2.3.2 Service conditions will not involve more than 5 psi partial pressure of non-condensable gases such as nitrogen.

4.2.3.3 Normalized or quench and tempered materials or as rolled A516 including Gr 55, Gr 60, Gr 65 or Gr 70 are employed.

4.2.3.4 The thickness of the vessel does not exceed 4 in.

4.2.3.5 Satisfying the above criteria will ensure that the allowable minimum design metal temperature (MDMT) of the vessel material will be less than the adiabatic flash temperature of the LPG. When the vessel is re-pressurized, this must be done slowly to allow the temperature to increase as the pressure is increased.

4.3 Design Vacuum

LPG pressure vessel design shall consider vacuum effects and be designed accordingly. Where an LPG pressure vessel is not designed for full vacuum, some alternatives in order of preference are shown in 4.3.1 through 4.3.3.

4.3.1 Design for partial vacuum condition. This alternative is applicable when the vacuum conditions are caused by ambient temperature conditions. The design external pressure shall be equal to 14.7 psi minus the minimum

vapor pressure of the product at the minimum ambient temperature. In this situation, no additional protection against vacuum is needed.

4.3.2 Design for partial vacuum with a vacuum relief valve and a connection to a reliable supply of hydrocarbon gas. This alternative may compromise product quality.

4.3.3 Design for partial vacuum with a vacuum relief valve that admits air to the pressure vessel. This alternative, under some conditions, may present a hazard from the presence of air in the LPG storage vessel, and this hazard shall be considered in the design of the facility.

4.4 Materials of Construction

4.4.1 All materials of construction shall meet the requirements of Section II of the ASME BPVC.

4.4.2 Low-melting-point materials of construction, such as aluminum and brass, shall not be used for LPG pressure vessels.

4.5 Vessel Connections

4.5.1 The number of penetrations in any pressure vessel shall be minimized, particularly those located below the working liquid level (i.e. below the vapor space).

4.5.2 Flange connections shall be a minimum of ASME class 150. All fittings shall be a minimum of NPS $\frac{3}{4}$.

4.5.3 Refer to Section 8 for piping requirements.

4.6 Previously Constructed Vessels

API 510 or NBIC Code shall be used for inspection, rating, repair, and/or alteration when an existing pressure vessel is to be relocated or reused in a new service.

5 Siting Requirements and Spill Containment

5.1 Siting

5.1.1 General

5.1.1.1 Site selection is meant to minimize the potential risk to adjacent property presented by the storage facility and the risk presented to the storage facility by a fire or explosion on adjacent property. The following factors shall be considered in site selection.

- a) Proximity to populated areas.
- b) Proximity to public ways.
- c) Risk from adjacent facilities.
- d) Storage quantities.
- e) Present and predicted development of adjacent properties.
- f) Topography of the site, including elevation and slope.
- g) Access for emergency response.
- h) Availability of needed utilities.

- i) Requirements for the receipt and shipment of products.
- j) Local codes and regulations.
- k) Prevailing wind conditions.

5.1.1.2 A potential LPG incident, and in context of this publication a more relevant one, is leakage from piping or other components attached to or near a storage tank or vessel followed by ignition, a flash fire or vapor cloud explosion, and a continuing pool fire and pressure (torch) fire.

5.1.1.3 With the exception of spacing, the design features discussed in this standard are intended to prevent a major incident. Spacing is intended to minimize both the potential for small leak ignition and the exposure risk presented to adjacent vessels, equipment, or installations in case ignition occurs. Spacing is not intended to provide protection from a major incident.

5.1.1.4 Safety analysis and dispersion modeling are useful tools in estimating setback distances to limit the exposure risk to adjacent facilities.

5.1.2 Minimum Distance Requirement

5.1.2.1 The minimum horizontal distance between the shell of an LPG pressure vessel and the line of adjoining property that may be developed shall be as shown in Table 1. For minimum distances of refrigerated LPG tanks from property lines, see 11.3.1.

5.1.2.1.1 Where residences, public buildings, places of assembly, or industrial sites are located on adjacent property, greater distances or other supplemental protection shall be provided.

5.1.2.2 The minimum horizontal distance between the shell of an LPG pressure vessel and a) the shell of another LPG pressure vessel; or b) the shell of any other pressurized hazardous material pressure vessel; or c) the shell of a flammable product storage tank shall be as follows:

5.1.2.2.1 Between two spheres, between two vertical vessels, or between a sphere and a vertical vessel, 5 ft or one half of the diameter of the larger vessel, whichever is greater.

5.1.2.2.2 Between two horizontal vessels, or between a horizontal vessel and a sphere or vertical vessel, 5 ft or three quarters of the diameter of the larger vessel, whichever is greater.

5.1.2.3 The minimum horizontal distance between the shell of an LPG pressure vessel and the shell of any other non-pressurized hazardous material or flammable product storage tank shall be the largest of the following, with the exception noted in 5.1.2.3.1.

- a) If the other storage is refrigerated, three quarters of the greater diameter.
- b) If the other storage is in atmospheric tanks and is designed to contain material with a flash point of 100 °F or less, one diameter of the larger tank.
- c) If the other storage is in atmospheric tanks and is designed to contain material with a flash point greater than 100 °F, half the diameter of the larger tank.
- d) 100 ft.

5.1.2.3.1 The minimum horizontal distance between shells need not exceed 200 ft.

5.1.2.4 The minimum horizontal distance between the shell of an LPG vessel and a regularly occupied building shall be as follows:

- a) If the building is used for the control of the storage facility, 50 ft.

- b) If the building is used solely for other purposes (unrelated to control of the storage facility), 100 ft.
- c) Compliance with API Recommended Practice 752 may be used in lieu of the requirements in Items a) and b) directly above.

5.1.2.5 The minimum horizontal distance between the shell of an LPG vessel and facilities or equipment not covered in 5.1.2.1 through 5.1.2.4 shall be as follows.

- a) For process vessels, 50 ft.
- b) For flares or other equipment containing exposed flames, 100 ft.
- c) For other fired equipment, including process furnaces and utility boilers, 50 ft.
- d) For rotating equipment, 50 ft; except for pumps taking suction from the LPG vessels, 10 ft.
- e) For overhead power transmission lines and electric substations, 50 ft. In addition, siting shall be such that a break in the overhead lines shall not cause the exposed ends to fall on any vessel or equipment.
- f) For loading and unloading facilities for trucks and railcars, 50 ft.
- g) For navigable waterways, docks, and piers, 100 ft.
- h) For stationary internal combustion engines, 50 ft.

5.1.2.6 The minimum horizontal distance between the shell of an LPG vessel and the edge of a spill containment area for flammable or combustible liquid storage tanks shall be 10 ft.

NOTE 1 If the spill containment is by the use of dikes or walls, the edge of the spill containment area for the purpose of spacing is defined as the centerline of the dike or wall. If the spill containment is by sloping, grading, or channels, the edge of the spill containment area for the purpose of spacing is defined as the outer edge of the wetted area at the design incident for the spill containment facility.

Table 1—Minimum Horizontal Distance between Shell of an LPG Pressure Vessel and Line of Adjoining Property That May Be Developed

Water Capacity of Each Pressure Vessel (gallons)	Minimum Distance (ft)
2000 to 30,000	50
30,001 to 70,000	75
70,001 to 90,000	100
90,001 to 120,000	125
120,001 or greater	200

NOTE 2 Minimum horizontal distance (spacing) for LPG tanks is covered in 11.3.1.

5.1.3 Siting of LPG Pressure Vessels and Equipment

5.1.3.1 LPG pressure vessels shall not be located within buildings, within the spill containment area of flammable or combustible liquid storage tanks as defined in NFPA 30, or within the spill containment area for refrigerated storage tanks.

5.1.3.2 Compressors and pumps taking suction from LPG pressure vessels shall not be located within the spill containment area of any storage facility unless provisions are made protect the LPG pressure vessels from