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 1and 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/A516 [2] , *Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service*

DOT [3] , *Transportation Safety Act of 1974*, Part 173, Section 315

NBBI [4] , *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 30 [5] , *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 1709 [6] , *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 $^{3}/_{4}$.

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 vessel from the

potential fire exposure. Examples of such include (a) a submerged-motor, direct-coupled pump with no rotating element outside of the pump containment vessel; (b) a submersible pump inside an LPG tank.

5.1.3.3 Horizontal LPG pressure vessels with capacities of 12,000 gallons or greater shall not be formed into groups of more than six tanks each. Where multiple groups of horizontal LPG vessels are to be provided, each group shall be separated from adjacent groups by a minimum horizontal shell-to-shell distance of 50 ft.

NOTE Horizontal pressure vessels used to store LPG should be oriented so that their longitudinal axes do not point toward other facilities (such as containers, process equipment, control rooms, loading or unloading facilities, or flammable or combustible liquid storage facilities or offsite facilities located in the vicinity of the horizontal pressure vessel).

5.1.3.4 Process equipment containing LPG or LPG vapor shall be located at least 50 ft from any of the following:

— sources of ignition,

— a property line that can be built upon, or

— occupied structures.

5.1.3.5 Fired equipment shall be located at least 50 ft from any LPG spill containment or drainage system.

5.1.3.6 LPG loading and unloading connections shall be at least 50 ft from any of the following:

— sources of ignition,

— process areas,

— storage containers, or

— occupied structures.

5.2 Drainage

5.2.1 The ground under and surrounding an LPG tank or pressure vessel used to store LPG shall be graded to drain any liquid spills to a safe area away from the vessel and piping. The grading shall be at a slope of at least 1 %.

5.2.2 The drainage system shall be designed to prevent spilled liquid from one LPG tank or pressure vessel from flowing under any other LPG tank or pressure vessel. In addition, the drainage system design shall minimize the risk to piping from spilled LPG.

5.2.3 The spill drainage area shall not contain equipment, except as permitted by this standard.

5.2.4 Walls, dikes, trenches, or channels are permitted to assist in draining the area.

5.3 Spill Containment

5.3.1 Spill containment shall be considered for all locations and provided in locations in which either of the following conditions will result in a significant hazard.

a) The physical properties of the stored LPG make it likely that the liquid LPG will collect on the ground. (This would be the case if the LPG contains significant amounts of butane or pentane.)

b) Climatic conditions during portions of the year make it likely that liquid LPG will collect on the ground.

5.3.2 Provision should be made for safe dispersion of the vapor generated during an LPG spill. Considerations shall include at least location and type of nearby obstructions and ignition sources.

NOTE LPG vapor is normally heavier than air. It is known to follow grade contour and accumulate in low spots similar to the behavior of liquids. Dispersion requires heat input from surroundings or significant air movement.

5.3.3 The effects of thermal shock associated with spilling LPG (such as shock resulting from the auto-refrigeration temperature) shall be considered in the selection of materials for all components including structural supports of a spill containment facility.

5.3.4 If spill containment is to be provided, it shall be by remote impoundment of spilled material or by diking of the area surrounding the LPG tank or pressure vessel. The containment area shall not contain any other equipment, except as permitted by this standard.

5.3.5 If the impounding surface of any spill containment area will not allow rainwater to dissipate within 24 hours, a drainage system shall be installed. Any drainage system provided shall include a valve or shear gate located in an accessible position outside the spill containment area. The valve or shear gate shall normally be kept closed. The drainage system shall be one of the following types.

a) A vapor sealed catch basin within the spill containment area discharging to a closed drainage system outside the spill containment area.

b) A pipe through the dike or wall discharging to a drainage system outside the spill containment area.

5.3.6 The drainage system shall keep the contents of the tank from entering natural water courses and from entering systems incapable of safely containing LPG.

5.4 Remote Impoundment

If remote impoundment is to be used for spill containment, the remote impoundment facility shall be designed according to the requirements given in 5.4.1 through 5.4.4.

5.4.1 Grading of the area under and surrounding the LPG tanks or pressure vessels shall direct any liquid leaks or spills to the remote impoundment area. Grading shall be at a minimum of 1 % slope.

5.4.2 The use of walls, dikes, trenches, or channels to facilitate the draining of the area is permitted.

5.4.3 The remote impoundment area shall be located at least 50 ft from the LPG tanks or pressure vessels draining to it and from any hydrocarbon piping or other equipment.

5.4.4 The holdup of the remote impoundment area shall be at least 25 % of the volume of the largest vessel draining to it. If the material stored in the vessel has a vapor pressure that is less than 100 psia at 100 °F, the holdup for the remote impoundment facility shall be at least 50 % of the volume of the largest vessel draining to it. Larger holdups shall be provided in the remote impoundment facility at locations where the expected vaporization is less than that indicated by the material's vapor pressure because of climatic conditions or the physical properties of the material.

5.5 Diking

If diking around the LPG tanks or pressure vessel is to be used for spill containment, the diked area shall be designed according to the requirements given in 5.5.1 through 5.5.5.

5.5.1 Grading of the area under and surrounding the LPG tanks or pressure vessel shall direct any liquid leaks or spills to the edge of the diked area. Grading shall be at a minimum of 1 % slope. Within the diked area, grading should cause spills to accumulate away from the vessel and any piping located within the diked area.

5.5.2 If an LPG sphere is diked, each sphere shall be provided with its own diked area. If LPG is stored in horizontal pressure vessels, a single diked area may serve a group of vessels, as defined in 5.1.3.3.

5.5.3 The holdup of the diked area shall be at least 25 % of the volume of the largest pressure vessel within it. If the material stored in the pressure vessel has a vapor pressure that is less than 100 psia at 100 °F, the holdup for the diked area shall be at least 50 % of the volume of the largest vessel within it. Larger holdups shall be provided in the diked area at locations where the expected vaporization is less than that indicated by the material's vapor pressure because of climatic conditions or the physical properties of the material.

NOTE Larger holdups may also be provided when more than one vessel is located within the same diked area.

5.5.4 When dikes or walls are used as part of the spill containment system, the minimum height of a dike or wall constructed of earth shall be 1.5 ft and the minimum height of a dike or wall constructed of concrete, masonry, or another erosion-resistant material shall be 1 ft. Provisions shall be made for normal and emergency access into and out of the diked enclosure. Where dikes must be higher than 12 ft or where ventilation is restricted by the dike, provision shall be made for normal operation of valves and access to the top of the LPG tanks or pressure vessels without the need for personnel to enter into the area of the diked enclosure that is below the top of the dike. All earthen dikes shall have a flat top section not less than 2 ft wide.

5.5.5 Any dike or wall enclosure used for LPG containment shall include adequate access provisions (such as stairs for personnel and ramps for vehicles, if required), shall be designed to permit its free ventilation, and shall be constructed to retain the spilled liquid. Enclosures shall be designed to prevent unauthorized access by motor vehicles.

6 Foundations and Supports for LPG Storage Containers and Related Piping

6.1 Applicable Codes, Standards, and Specifications

6.1.1 The materials, principles, methods, and details of design and construction of foundations and supports for LPG storage and containers related piping shall meet the requirements stipulated in the codes, standards and specifications cited in individual sub-sections.

6.1.2 Where applicable local codes are more stringent, the local codes shall apply.

6.2 General Design Requirements

6.2.1 General

The foundation and support structures shall conform to the provisions set forth in 6.2 through 6.4.

6.2.2 Materials

Supporting structures shall be made of one or a combination of the following materials:

a) reinforced masonry;

b) reinforced concrete;

c) prestressed concrete;

d) metal plate, pipe, or structural shapes; and/or

e) other material as justified by design.

NOTE Guidance on the above structural material types can be found in References [3], [4], [9], [15], and [16] in the bibliography.

6.2.3 Loads and Load Combinations

6.2.3.1 The following loads shall be considered in the design of the support structures and foundations.

a) Static loads during erection plus expected wind, ice, and snow loads during the erection.

b) Static loads during hydrostatic testing plus 25 % of the wind, ice, and snow loads.

c) Static loads during operation (including the load due to fireproofing) plus applicable combinations of wind, ice, snow, and earthquake loads.

d) Loads resulting from expansion and contraction of the container due to internal pressure or temperature changes, or both.

e) Loads resulting from differential settlement across the supporting structures and foundations.

f) Static and dynamic loads during maintenance and operations.

g) Other relevant loads specific to the structure and foundation.

NOTE Guidance on load combinations for design of support structures, piping and foundations can be found in References [6], [7], [8], and [10] in the bibliography.

6.2.3.2 Unless local regulations, standards and codes dictate otherwise, the wind, ice, snow, and earthquake loads shall be determined in accordance with References [6] and [10] in the bibliography.

6.2.4 Support Structures

6.2.4.1 Loads on Supporting Structures

The loads and load combinations for design of support structures are presented in 6.2.3.

6.2.4.2 Support Design

6.2.4.2.1 The design of supports for vessels shall include provisions for expansion and contraction due to internal pressure, shrinkage, and temperature changes.

6.2.4.2.2 Flexibility shall be provided in the attached piping to avoid imposing excessive stress on vessel nozzles and associated piping as a result of vessel movement.

NOTE Guidance on additional materials regarding the design of supports for vessels is provided in Reference [8] in the bibliography.

6.2.4.3 Pressure retaining portions of storage containers should typically not contact concrete or masonry supports or concrete or masonry fireproofing, since these contact points may be sites for external corrosion. If such contact points are present, they should be identified for routine inspection.

6.2.5 Shell Loads

In the design of container supports, special attention shall be given to the loads imposed on the shell. Consideration shall be given to the following.

a) Secondary forces resulting from service temperatures or changes in temperatures.

b) Test and operating pressures.

c) Liquid loads, both with and without pressure applied.

d) Loads due to piping reactions.

e) Normal supporting loads.

f) Environmental loads due to snow, ice, wind, and seismic conditions.

g) Loads due to liquid sloshing (in earthquake zones).

6.2.6 Diagonal Members

Diagonal members, such as those used for bracing vertical columns, shall not be attached directly to a vessel unless adequate provisions are made for the resulting loads in the design of the vessel.

6.2.7 Saddles

When a horizontal tank is supported by saddles, the features specified in 6.2.7.1 through 6.2.7.4 shall be incorporated in the design.

6.2.7.1 Horizontal containers shall be supported at two locations.

6.2.7.2 Consideration shall be given to the placement of supports to obtain the most desirable stress distribution in the container shell.

6.2.7.3 The shape of the saddles shall conform to the fabricated shape of the containers to the steel pad attached to the container.

6.2.7.4 Doublers or reinforcing plates may be installed between the container shell and the supports to avoid external corrosion of the shell, provide for wear caused by temperature-induced movement, or reduce the stress in the shell at the support points. If such plates are used, they shall be continuously welded to the container shell after any free moisture is removed from under the plates. A threaded weep hole shall be provided at the low point of each plate. Where corrosion plates are used, the plates shall extend beyond the limits of the supporting saddles to aid in distributing the support loads. The thickness of corrosion plates shall not be included in calculating the stress at the horn of the saddle.

NOTE Guidance on the design of saddles for horizontal steel tanks can be found in Reference [5] in the bibliography.

6.2.8 Vertical Container Skirts

6.2.8.1 Where vertical containers are supported by skirts, the skirts shall be provided with a single opening for inspection or access. The opening shall be as small as practicable.

6.2.8.2 Skirt openings shall be reinforced when required to prevent buckling or overstressing of the skirt as a result of imposed loads as covered in 6.3.1.

NOTE Guidance on additional material regarding the design of skirts is provided in Reference [8] in the bibliography.

6.3 Foundation Design

6.3.1 Loads

The loads and load combinations for foundation design are presented in 6.2.3.

6.3.2 Soil Information

The design of the foundation shall be based on the results of geotechnical engineering investigation from a Geotechnical engineer experienced in the foundation design. The allowable soil bearing, pile capacities, and

settlement estimates and other foundation design parameters shall be provided in the geotechnical report for foundation design.

NOTE Guidance on soil/geotechnical investigation can be found in Reference [9] in the bibliography.

6.3.3 Shallow Foundations vs Deep Foundations

Foundations can be designed to be either supported directly on competent or improved soil as shallow foundations or supported on piles when poor soils are identified in the site to minimize the differential foundation settlement.

NOTE Guidance on design of shallow and deep foundations can be found in Reference [9] in the bibliography.

6.3.4 Settlement of Foundation

The size and depth of the foundation shall be designed to limit settlement of the container to prevent excessive stresses in the container and connected piping. The type and size of the foundation shall be determined such that the settlements are within the respective allowable settlements of the container/structure to be supported. For multi-legged vessels or spheres, special attention shall be given to the differential settlement between the individual supports.

NOTE 1 Tank or pressure vessel/structure settlement should be monitored during the hydrostatic test.

NOTE 2 Guidance on the foundation settlements can be found in References [1], [2], and [14] in the bibliography. The foundation settlements shall also be within the Settlement Criteria set by the manufacturers.

6.3.5 Bottom of Foundation

The base of the foundation shall be below the frost line as applicable. Potential scour or settlement from external sources such as nearby sewers or lines having the potential for leakage or washout shall be mitigated.

6.3.6 Foundations for Multiple Containers

6.3.6.1 Continuous footings may be used for multiple container installations. In such instances, the loading of footings shall be calculated for various probable combinations of loads, such as the load that occurs when adjacent containers are full and the load that occurs when alternate containers are full.

6.3.6.2 Continuous piers shall not be used for multiple containers installations without the incorporation of special drainage provisions.

6.3.7 Anchorage

6.3.7.1 Anchorage to concrete foundation shall be designed per Reference [3] in the bibliography.

6.3.7.2 In areas where there is a risk of flooding, the container shall be anchored to the foundation or support to prevent floating in case of a flood. Anchorage shall not restrict vessel movements resulting from expansion and contraction of the container due to temperature changes and internal pressure.

6.3.7.4 Anchorage to the foundation or support shall be provided to resist any uplifting forces resulting from internal pressure in the container.

6.4 Corrosion Protection

6.4.1 Supports and their members shall be positioned to prevent the accumulation of water. Where this positioning is impractical, adequate drainage openings shall be provided to prevent such accumulation.

6.4.2 Enclosed spaces in which water might accumulate during construction or operation shall be provided with drainage openings.

7 Container Accessories, Including Pressure and Vacuum-Relieving Devices

7.1 Mandatory Equipment

7.1.1 General

Containers shall be fitted with the equipment described in 7.1.2 through 7.1.8. Equipment shall be suitable for use with LPG and designed for at least the maximum service conditions to which it may be subjected.

7.1.2 Liquid-level Gauging Equipment

Each LPG container shall be provided with liquid-level gauging equipment as specified in 7.1.2.1 through 7.1.2.4.

7.1.2.1 Each container shall be equipped with a reliable level-indicating system. The need for a second, independent level-indicating system shall be determined by a safety analysis.

7.1.2.2 An independent high-level alarm shall be provided. The alarm shall be set to give the operator sufficient time to stop the flow before the maximum permissible filling height is exceeded (see 7.1.3). The alarm shall be located so that it is audible and visible to the operating personnel controlling the filling operation.

7.1.2.3 For containers that cannot be removed from service, provisions shall be included for testing, repairing, and replacing primary gauges and alarms while the tank is in service.

7.1.2.4 In containers that have a high-level cutoff, the cutoff device shall be in addition to and independent of the high-level alarm specified in 7.1.2.2.

7.1.3 Maximum Liquid Level

The maximum permissible filling height of an LPG containers shall be set to provide adequate vapor space to accommodate any thermal expansion that may occur after filling is completed. The maximum filling height shall be set so that when a tank filled to that level at the minimum anticipated storage temperature the thermal expansion of the liquid will not cause the LPG level to exceed 98 % of the liquid full level.

7.1.4 Level Gauges

Columnar glass level gauges shall not be used. Reflex and see-through level gauges shall be equipped with a ball check valve or a similar protective device.

7.1.5 Pressure Gauge

On each container a suitable pressure gauge should be considered. When used it should be connected to the vapor space.

7.1.6 Pressure- and Vacuum-Relieving Devices

7.1.6.1 General

Each container shall be provided with one or more spring-loaded or pilot-operated pressure relief valves. The pressure relief valve or valves shall be set to discharge as required by the ASME code. Pilot-operated pressure relief devices shall be designed so that the main valve will open automatically and protect the tank if the pilot valve fails. Pilot-operated valves shall be provided with a backflow preventer if the possibility exists that the internal pressure can drop below the relief valve backpressure. Containers that may be damaged by internal vacuum shall be provided with vacuum-relieving devices. Weight and lever pressure-relieving devices shall not be used.

7.1.6.2 Pressure Relief Valve Flow Capacities

Pressure relief valves installed on LPG containers shall be designed to provide adequate flow capacity to protect the tank during fire exposure. Other causes of tank overpressure, such as overfilling and introduction of material with a higher vapor pressure in a common piping system, shall be considered in determining design flow capacity. Pressure relief valves shall be designed and sized in accordance with API Standard 520, Part I and API Standard 521.

7.1.6.3 Pressure Relief Valve Information

Each pressure relief valve shall be marked as required by the applicable ASME code, API standard, or API recommended practice.

7.1.6.4 Pressure Relief Valve Installation

Pressure relief valves shall be installed in accordance with API Standard 520, API Standard 521, and the requirements of 7.1.6.4.1 through 7.1.6.4.5.

7.1.6.4.1 The pressure relief valve shall be installed to provide direct connection to the vapor space and to minimize liquid carry-over during vapor relief, especially when the tank is nearly full. This shall be achieved by locating the pressure relief valve connections as close as practical to the top of the vapor space.

7.1.6.4.2 The possibility of tampering with the adjustment mechanism shall be minimized. If the adjustment mechanism is external, it shall be sealed.

7.1.6.4.3 The inlet and outlet piping for the pressure relief valve shall be designed to pass the rated capacity of the valve without exceeding the allowable pressure-drop limits.

7.1.6.4.4 The pressure relief system shall be protected from the closure of any block valves installed between the tank and the pressure relief valve or between the pressure relief valve and its discharge vent outlet. This protection may be achieved by one of the following procedures.

a) Installing the pressure relief valve without block valves.

b) Providing excess pressure relief valve capacity with multiway valves, interlocked valves, or sealed block valves arranged so that isolating one pressure relief valve will not reduce the capacity of the system to below the required relieving capacity.

c) Locking or sealing the block valves open without installing excess relieving capacity, as follows. The valve seals or locks should be checked routinely to ensure they are in place and locks are operable. The valves shall only be closed by an authorized person who shall remain stationed in audible and visual contact with the vessel, and in a position to correct or arrest potential overpressure events while the valves are closed, and the tank is in operation and shall lock or seal the valves open before leaving. The authorized person shall be able to observe the operating pressure while the valves remain blocked and shall be ready to take emergency action if required.

7.1.6.4.5 The stem of any gate valve installed in the pressure relief system shall be in a horizontal or below-centerline position.

7.1.6.5 Discharge Vents

Discharge vents from the pressure relief valves or common discharge headers shall be designed to meet the requirements of API Standard 520 and API Standard 521 and shall be installed in accordance with the requirements given in 7.1.6.5.1 through 7.1.6.5.5.

7.1.6.5.1 Discharge vents shall lead to the open air or to a flare system. Discharging directly to the atmosphere is unacceptable if liquid LPG might be released into the atmosphere, unless the discharge is through thermal

relief valves. Positive design and operational steps shall be taken to prevent the discharge of liquid LPG from atmospheric vents. Such steps include automatic shutdown of filling operations prior to overfilling.

7.1.6.5.2 Discharge vents shall be protected against mechanical damage.

7.1.6.5.3 If discharge vents relieve to the atmosphere, they shall be designed to prevent entry of moisture and condensate. This design may be accomplished by the use of loose-fitting rain caps and drains. Drains shall be installed so that the discharge from the drain will not impinge on the tank or adjoining tanks, piping, equipment, and other structures.

7.1.6.5.4 Discharge vents shall be designed to handle any thrust developed during venting. Discharge shall not be less than 10 ft (3 m) above the operating platform.

7.1.6.5.5 Discharge shall be to an area that has the following characteristics.

a) The area prevents flame impingement on tanks, piping, equipment, and other structures.

b) The area prevents vapor entry into enclosed spaces.

c) The area is above the heads of any personnel on the tank, adjacent tanks, stairs, platforms, or the ground.

7.1.6.6 Pressure Setting

Pressure relief valves shall be tested for correct set pressure before being placed in service. See API Standard 520.

7.1.7 Shutoff Valves

7.1.7.1 Shutoff valves shall conform to the criteria specified in 7.1.7.1.1 through 7.1.7.1.3.

7.1.7.1.1 Shutoff valves shall be provided for all tank connections except the following:

a) Connections on which safety valves are mounted.

b) Connections containing a restriction orifice, plug, or thermometer well where the opening has a maximum diameter of 0.25 in.

7.1.7.1.2 Shutoff valves shall be located as close to the tank as is practical. The preferred location is at the shell nozzle. Shutoff valves shall be readily accessible for operation and maintenance.

7.1.7.1.3 Shutoff valves shall conform to the material and construction requirements of 8.6.

7.1.7.2 All shutoff valves located on nozzles below the maximum liquid level shall be designed to provide a visual indication of the valve position and shall be capable of maintaining an adequate seal under fire conditions. Valves meeting the requirements of API Standard 607 or Specification 6FA have the required fire resistance.

7.1.7.3 When the capacity of the vessel exceeds 10,000 gallons, all shutoff valves on inlet and outlet piping located below the maximum liquid level shall either close automatically or be remotely operable during the first 15 minutes of fire exposure. This may require fireproofing of the control system (see 10.11). These valves shall also be manually operable at the installed location. Check valves installed on dedicated fill lines are suitable for meeting the requirements of this paragraph.

7.1.8 Temperature Indicators

Each tank shall be fitted with a suitable thermometer well.

7.2 Tank Accessory Materials

Ductile (nodular) iron, cast aluminum, malleable iron, and brass shall not be used in any pressure-retaining tank accessories.

8 Flammable Product Piping Requirements

8.1 American Society of Mechanical Engineers Code for Pressure Piping

Piping at facilities covered under this standard shall conform to the provisions of ASME B31.3; except for piping that falls under the exclusion provided in 300.1.3(e) of ASME B31.3 shall be constructed in accordance with the provisions of ASME B31.4. The additional provisions of this section apply to piping constructed in accordance with ASME B31.3.

8.2 Flammable Piping—General

8.2.1 Piping Design Conditions

Determination of piping design pressures and temperatures shall include normal operating conditions, start up and shutdown conditions, auto refrigeration, and temperature effects from the environment.

8.2.2 Piping Manufacture

Piping shall be seamless, electric-resistance-welded, electric fusion welded or submerged-arc-welded pipe. Pipe to be used in piping applications of 2 in. or smaller shall be seamless.

8.2.3 Piping Materials

Pipe materials shall be selected with mechanical properties and chemical composition necessary to ensure the material is compatible with product that it carries.

8.2.4 Piping Joints

Pipe joints shall meet the requirements of 8.2.4.1 through 8.2.4.7.

8.2.4.1 The number of joints of any type between the vessel and the first block valve shall be minimized.

8.2.4.2 Welded joints shall be used where practical.

8.2.4.3 The number of flanged joints shall be minimized.

8.2.4.4 Joints in pipe NPS 2 or larger shall be butt welded or flanged.

8.2.4.5 Joints in pipe smaller than NPS 2 shall be socket-welded, butt-welded, or flanged.

8.2.4.6 Piping gaskets shall be of the self-centering or confined type and shall be resistant to LPG.

8.2.4.7 Threaded connections are not allowed for pipe containing LPG product.

NOTE Threaded connections may be used for connections NPS $1^{1}/_{2}$ and smaller at instrumentation and specialty devices which are downstream of a block valve.

8.2.5 Minimum Specifications for Wall Thickness

The pipe wall thickness shall be equal to or greater than that required by ASME B31.3. The minimum requirements specified in 8.2.5.1 and 8.2.5.3 shall also apply.

8.2.5.1 Pipes made from materials subject to brittle-failure, such as carbon steel, shall have the following minimum wall thickness.

a) Nominal pipe size less than NPS 2—Schedule 80.

b) NPS 2 to 5—Schedule 40.

c) NPS 6—Schedule 40.

d) NPS 8 to 12—Schedule 20.

e) NPS 14 or larger—Schedule 10.

8.2.5.2 Pipes made from materials not subject to brittle-failure, such as stainless steel, shall have the following minimum wall thicknesses.

a) NPS $^{3}/_{4}$ or less—Schedule 80S.

b) NPS 1, 1½, or 2—Schedule 40S.

c) NPS larger than 2—Schedule 10S.

8.2.5.3 Nominal pipe sizes 1¼, 2½, 3½, and 5 shall not be used, except if needed for equipment or vessel connections.

8.2.6 Pressure Tubing

Tubing shall be constructed of steel. If tubing will be exposed to a corrosive atmosphere, stainless steel shall be used.

8.3 Fittings

8.3.1 Butt-welding Fittings

Butt-welding fittings shall be made from seamless steel or equivalent material, shall be of at least the same thickness and schedule as the piping, and shall conform to ASME B16.9.

8.3.2 Socket-welding Fittings

Socket-welding fittings smaller than 2 in. such as elbows, tees, and couplings; shall be of forged steel and shall have a working pressure rating of at least 2000 psi.

8.3.3 Packed-sleeve and Resilient-sealed Couplings

Packed-sleeve and resilient-sealed couplings shall not be used.

8.3.4 Flanges

Weld-neck flanges are preferred. Socket-weld flanges NPS 2 and smaller are acceptable. If slip-on flanges are used, they shall be welded both inside and outside. Flanges up to 24 in. shall meet the requirements of ASME B16.5. Flanges with a diameter > 24 in. to 60 in. shall meet the requirements of ASME B16.47 Series A.

8.4 Plugs

Plugs shall be solid and constructed of steel.

8.5 Unions

Unions shall be of forged steel, shall have a working pressure of at least 3000 psi, and shall have ground metal-to-metal seats. Gasket unions shall not be used. Unions shall not be used between the vessel container and the first valve.

8.6 Valves

8.6.1 Primary Shutoff Valves

8.6.1.1 The primary shutoff valves (specifically the valves nearest the container that can shut off flow) shall be made from steel. Valves constructed of free-machining steel similar to AISI Series 1100 and 1200 shall not be used.

8.6.1.2 Union or screwed-bonnet valves shall not be used unless they are equipped with bonnet retainers or the bonnets are tack welded.

8.6.1.3 Valves that are sandwiched between two flanges by long, exposed bolts shall not be used, unless the valves have lug-type bodies that cover the bolts.

8.6.1.4 Ball valves shall meet the requirements of API Standard 607.

8.6.2 Check Valves

Check valves shall be installed on the discharge side of all centrifugal pumps.

8.6.3 Pressure Relief Valves

Pressure relief valves shall be constructed of steel.

8.6.4 Thermal Relief Valves

Suitable thermal relief valves shall be considered on liquid lines that can be blocked between two shutoff valves. Other equipment that can be blocked between shutoff valves shall be provided with protection from overpressure due to thermal expansion of the liquid. Where liquid is trapped in valve cavities, the need for pressure relief shall be considered.

8.7 Location, Installation, and Flexibility of Piping, Valves, and Fittings

8.7.1 Piping shall be provided with adequate flexibility to accommodate the following.

a) Settling of containers or shifting of foundations.

b) Expansion or contraction of containers or piping with changes in temperature.

c) Soil movement.

d) Cooling or heating of unloading connections, vent connections, or loading and unloading headers.

8.7.2 Headers located on piers shall be designed to permit unrestrained movement of the piping in the direction of expansion or contraction except at necessary anchor points.

8.7.3 All water drawoffs shall be extended so that they do not terminate under the vessel. Drain lines shall not be directed into a public sewer or into a drain not designed to contain flammable materials. Double valves shall be provided for upstream block valves, downstream throttling to facilitate valve closure if throttling valve ices up due to auto-refrigeration. When drain lines are supported by any type of support not directly attached to the tank,

adequate flexibility shall be provided in the lines to accommodate differential settlement. Stress imposed on the vessel nozzle by the drain lines shall be minimized.

8.7.4 Water drain lines and similar small lines shall be adequately supported or shall be fabricated with sufficient strength to be self-supporting under operating conditions, including the condition of maximum flow reaction thrust. Stress imposed on the container by the drain lines shall be minimized.

8.7.5 Freeze protection shall be considered for all drain lines and potential water collection points. Abnormal operating conditions, such as conditions that might occur during abnormally cold weather, should be considered where water might collect and freeze protection is needed.

9 Loading, Product Transfer, and Unloading Facilities

9.1 General

Section 9 covers the design and construction of facilities that transfer LPG as follows:

a) from a pipeline to stationary storage,

b) from truck or railcar racks and marine docks to stationary storage,

c) from stationary storage to truck or railcar racks or marine docks, and

d) from stationary storage to a pipeline.

9.2 Rates of Loading and Unloading

9.2.1 Sizing

Pumps and loading devices shall be sized to provide rates of flow appropriate to the capacity of the facility. Care shall be taken to ensure that the rates of flow give the operator enough time to follow the course of loading and unloading at all times and to shut down the facility before containers are completely emptied or before they are filled beyond their maximum filling height.

9.2.2 Design

The transfer system shall incorporate a means for rapidly and positively stopping the flow in an emergency. Transfer systems shall be designed to prevent dangerous surge pressures when the flow in either direction is stopped.

9.3 Transfer, Loading, and Unloading Equipment

9.3.1 Pumps

9.3.1.1 Pumps may be centrifugal, reciprocating, gear, submersible or may be another type designed for handling LPG. The design pressure and construction material of the pumps shall be capable of safely withstanding the maximum pressure that could be developed by the product, the transfer equipment, or both. When centrifugal pumps are used, mechanical seals are recommended. Positive displacement pumps shall have a suitable relief device on the discharge side unless other provisions are made for protection of the equipment.

9.3.1.2 When submersible pumps are used, each interface between the LPG system and an electrical conduit or wiring system shall be sealed or isolated to prevent passage of LPG to another portion of the electrical installation. See NFPA 59A for further information.

9.3.2 Compressors

Compressors for loading and unloading LPG shall be designed for the maximum outlet pressure to which they may be subjected. Each centrifugal compressor discharge connection shall be equipped with a check valve. Each centrifugal compressor shall be evaluated for conditions that may cause overpressure, and a relieving device shall be provided if required. Each positive displacement compressor shall be equipped with a pressure-relieving device on the discharge side upstream of the first block valve. A suitably sized scrubber or liquid knockout drum shall be installed immediately upstream of vapor compressors. The scrubber shall be equipped with a high-liquid-level device to shut down the compressor.

9.3.3 Pressure Gauges

Pressure gauges shall be provided in enough locations in the liquid and vapor lines to enable the operator to monitor operating pressure and pressure differentials constantly to ensure safe operation.

9.3.4 Emergency Shutoff Valves

9.3.4.1 Emergency shutoff valves shall be provided in the loading-unloading system for tank cars, trucks, and marine facilities and shall incorporate the following means of closing.

a) Manual shutoff at the installed location.

b) Manual activation from a location accessible during an emergency.

9.3.4.2 A safety analysis shall be the basis for determining the need for the following:

a) Automatic shutoff in the event of an LPG release.

b) Automatic shutoff through thermal (fire) actuation.

9.3.4.3 Installation practices for emergency shutoff valves shall include those specified in 9.3.4.3.1 and 9.3.4.3.2.

9.3.4.3.1 When hose or swivel piping is used for liquid or vapor transfer, an emergency shutoff valve shall be installed in the fixed piping of the transfer system within 20 linear ft of pipe from the end to which the hose or swivel piping is connected. Where the flow is in one direction only, a check-valve may be used in place of an emergency shutoff valve if the check valve is installed in a dedicated storage vessel fill line or vapor return line. When two or more hoses or swivel piping arrangements are used, either an emergency shutoff valve or a check-valve (for unloading lines only) shall be installed in each leg of the piping.

NOTE If check valves are used in place of emergency shutoff valves, the owner/operator should have a program to ensure the reliability of these devices.

9.3.4.3.2 The emergency shutoff valves or backflow check valves shall be installed in the fixed piping so that any break resulting from a pull will occur on the hose or swivel piping side of the connection while the valves and piping on the plant side of the connection remain intact. This may be accomplished using concrete bulkheads or equivalent anchorage or using a weakness or shear fitting.

9.3.4.4 Facility boundary limit block valves and check valves shall be provided if the feed or product is transported by pipeline. If block valves are manually operated, they shall be accessible during an emergency.

9.4 Grounding and Bonding

9.4.1 Static Electricity

Protection from discharge of static electricity is not required when a tank car, a tank truck, or marine equipment is loaded or unloaded through tight (top or bottom) outlets using a conductive or nonconductive hose, flexible

metallic tubing, or pipe connection because no spark gap exists while product is flowing (see API Recommended Practice 2003).

9.4.2 Stray Currents

If stray currents are present or if impressed currents are used on the loading and unloading systems for cathodic protection, protective measures shall be taken in accordance with API Recommended Practice 2003.

9.4.3 Lightning Protection

Aboveground metallic LPG storage containers do not require lightning protection. To protect personnel and foundations where the piping might not provide grounding, grounding rods shall be provided for tanks supported on nonconductive foundations. See API Recommended Practice 2003 for additional information on lightning protection.

9.5 Hose and Other Flexible Connectors for Product Transfer

9.5.1 Hose

9.5.1.1 Hose shall be fabricated of materials resistant to LPG in both liquid and vapor form. If wire braid is used for reinforcement, it shall be made from corrosion-resistant material such as stainless steel.

9.5.1.2 The correctness of design, construction, and performance of hose shall be determined. Only hose listed by Underwriters Laboratories or another nationally recognized testing laboratory shall be used for LPG transfer applications. Hose used in marine applications shall be approved by the U.S. Coast Guard.

9.5.1.3 Hose, hose connections, and flexible connectors used for transferring LPG liquid or vapor at pressures in excess of 5 psig shall conform to the criteria specified in 9.5.1.3.1 through 9.5.1.3.3.

9.5.1.3.1 Hose shall be designed for a minimum working pressure of 350 psig and a minimum bursting pressure of 1750 psig. Hose shall be marked “LPG” or “LP-gas” at intervals of not more than 10 ft.

9.5.1.3.2 After the installation of connections, hose assemblies shall be tested to a maximum pressure of 1.5 times the MAWP of the lowest rated component in the system.

9.5.1.3.3 Hose assemblies shall be visually inspected before each use for damage or defects. Hose assemblies shall be tested at least annually at whichever is greater, the maximum pump discharge pressure or the relief valve setting.

9.5.2 Hose Protection

Hose shall be protected from the elements and physical damage. Particular attention shall be given to the prevention of potentially damaging ice formation on the corrugations of metallic hose.

9.5.3 Support of Loading Arms or Hoses

Provisions shall be made for adequately supporting the loading hose or arm. The weight of ice formations on uninsulated hoses or arms shall be considered in the design of counterweights.

9.5.4 Flexible Pipe Connection

Each flexible pipe connection shall be capable of withstanding a test pressure of 1½ times the design pressure for its part of the system.

9.6 Blowdown or Venting of Loading and Unloading Lines

Each hose or pipe connection(s) with flexible joints used in the loading and unloading of LPG between stationary and mobile tanks shall be equipped with a blowdown or bleeder valve. The valve shall enable the emptying of the hose or pipe connection(s) after the block valves on each side of the hose or pipe connection(s) have been closed. The blowdown or bleeder valve shall be sized and installed so that venting does not create a hazard.

9.7 Marking of Valves in Loading and Unloading Systems

When more than one product is handled at a loading or unloading rack, the lines shall be marked or designated so that the operator can identify the various lines and valves without having to trace them to their source or destination.

9.8 Metering Equipment Used in Loading and Unloading

When liquid meters are used to measure the volume of LPG that is being transferred from one container to another or that is being transferred to or from a pipeline, the meters and accessory equipment shall be installed in accordance with the procedures stipulated by API Recommended Practice 551, and Chapter 5 of the API *Manual of Petroleum Measurement Standards*.

9.9 LPG Odorization

If specified, a stationary LPG storage facility designed to transfer LPG to tanks, trucks, railroad tank-cars, or marine containers through loading racks or docks shall have equipment that enables the addition of odorant as specified by NFPA 58 and the Transportation Safety Act of 1974, Part 173, Section 315.

10 Fire Protection

10.1 General

Fire protection provisions shall be based on a safety analysis of local conditions, exposure from or to other sites, availability of a water supply, and effectiveness of fire brigades and fire departments. The analysis shall include possible but realistic accident scenarios that may occur, including scenarios of vapor release, ignition, and fire.

NOTE For additional information, background, and guidance, see API Publication 2510A.

10.2 Access for Firefighting

The layout of the facility, including the arrangement and location of plant roads, walkways, doors, and operating equipment, shall be designed to permit personnel and equipment to reach any area affected by fire rapidly and effectively. The layout shall permit access from at least two directions. Emergency escape as well as access for firefighting shall be considered.

10.3 Fire Water Use

Storage facilities for LPG shall be provided with a fire water system unless a safety analysis shows this protection to be unnecessary or impractical.

NOTE See API Publication 2510A for additional information.

10.3.1 System Design

The design of the fire water system shall be in accordance with 10.3.1.1 through 10.3.1.10.

10.3.1.1 A looped fire water system shall be provided around the storage and handling portions of an LPG facility.

10.3.1.2 Sufficient isolation valves shall be provided in the fire water grid to prevent loss of the grid due to a single break in the water main. Block valves shall be arranged so that all parts of the plant can be protected by a portion of the fire water main system when an impaired section is isolated for repair.

10.3.1.3 The fire water grid shall be designed so that at least half the water required by the single largest incident can be delivered if any single section of the fire water main is lost.

10.3.1.4 The capacity of the fire water system shall be equal to the amount of fire water required to cool the largest vessel being protected (or if multiple vessels are on a commonly activated fixed deluge or spray system, the capacity of the system), plus the amount required to cool adjacent vessels, plus reserve capacity for up to two additional 500 gallon-per-minute fire water monitors. Where the capacity of the fire water system is determined by the requirement for LPG storage, the system is permitted to be sectionalized to reduce the maximum simultaneous requirement for fire water.

10.3.1.5 Pipe used for fire water mains and branch lines to hydrants shall be at least 6 NPS in size. Branch lines to deluge, monitor, or spray systems are permitted to be smaller, provided hydraulic calculations show that the size selected will supply the design demand at the required pressure.

10.3.1.6 The fire water system shall be functional in all seasons and shall be capable of delivering 100 % of the design rate for at least 4 hours. The fire water system shall be suitably protected from freezing where necessary.

10.3.1.7 Regardless of the fire water application method used, the location of hydrants shall be arranged so that each storage vessel can be reached from at least two directions by at least three cooling streams none of which uses more than 300 ft of hose.

10.3.1.8 The fire water system shall be designed to provide water for cooling to the protected equipment within 60 seconds of activation and to achieve design water delivery rates within 10 minutes of system activation.

10.3.1.9 The fire water system shall be designed to facilitate testing to ensure reliability, adequate flow rate, and adequate coverage of the protected equipment.

10.3.1.10 The fire water systems shall be tested to verify that their performance is as designed. Since the capacity of the water grid can deteriorate gradually as a result of scale buildup in the water mains, a Hazen-Williams coefficient no greater than 100 shall be used for unlined steel pipe.

10.3.2 Fire Water Application Methods

LPG storage vessels shall be protected by water deluge systems, fixed monitors, water spray systems, or any combination of these systems. Portable equipment may be used but shall not be a primary method of water application.

10.3.2.1 Water Deluge System

A water deluge system is a system in which all the water is applied at the top of the vessel and allowed to run down the sides. When a water deluge system is selected for the protection of LPG storage facilities, it shall include the design features described in 10.3.2.1.1 through 10.3.2.1.5.

10.3.2.1.1 The system shall be designed so that under non-fire conditions, the water flows evenly over the entire surface of the vessel. The adequacy of the water coverage shall be determined by means of performance tests.

10.3.2.1.2 If weirs are used to improve distribution, they shall be provided with drainage to prevent standing water, which may increase corrosion.

10.3.2.1.3 Pipe used for main water distribution lines shall have a diameter of at least 3 in. and shall be of welded construction with flanged type joints.

10.3.2.1.4 Top-mounted water distribution nozzles shall be at least 1½ in. and shall be provided with suitable deflectors or weirs to achieve good water distribution.

10.3.2.1.5 The system shall be manually operated from a safe location that is outside the spill containment area and be at a minimum of 50 ft from the vessel being protected. The location of the actuating valve shall be clearly and prominently marked. In locations with unattended or partially attended operations, consideration shall be given to additional methods of system activation such as automatic or remote operation. When the system is remotely or automatically operated, a full-size manually operated bypass valve shall also be provided in an accessible, safe location.

10.3.2.2 Fixed Monitors

Fire water monitors permanently connected to the fire water grid can be used to apply cooling water to the shell of LPG storage vessels. Where protection by means of monitors is selected, the system shall include the design features described in 10.3.2.2.1 through 10.3.2.2.4.

10.3.2.2.1 The monitors shall provide the minimum firewater application rate to all portions of the vessel surface to be protected. There shall be no gaps of coverage on the vessel shell.

10.3.2.2.2 Each monitor shall be accessible during a fire or shall be remotely activated. They may also be remotely controlled.

10.3.2.2.3 Monitor nozzles shall be adjustable for fog or straight stream, as required, to provide the most effective coverage of the protected vessel.

10.3.2.2.4 In freezing climates, monitors shall be suitably protected against freezing (e.g. heat traced or drained water free).

10.3.2.3 Oscillating Monitors

Certain fire hazards require the cooling of large hazard areas using water application. This can be achieved by using oscillating monitors that provide coverage to a larger area instead of a specific location as they oscillate in a horizontal plane. Oscillating Monitors use gear boxes and mechanical means to oscillate the monitor in a preset angle. The power for movement can be an external power source or can be aqua powered (i.e. using a small quantity of the water supplied to the monitor). Aqua powered units are preferable as they do not require any external power source.

10.3.2.4 Water Spray Systems

A water spray system uses many spray nozzles arranged in a grid pattern to distribute the water evenly over the LPG vessel. When a water spray system is selected for the protection of LPG storage facilities, it shall include the design features described in 10.3.2.4.1 through 10.3.2.4.7.

10.3.2.4.1 The system shall be designed so that the water is applied evenly over the entire surface of the vessel that may be exposed to fire. Allowance for rundown is permitted. The adequacy of the water coverage shall be determined by performance tests.

10.3.2.4.2 The spray system shall be an open-head system, with all nozzles supplied from the top of the supply branch line and each branch line shall be from the top of the water distribution main line. Spray orifice size shall be at least 0.25 in. Larger orifice sizes will reduce the tendency of the nozzles to become clogged.

10.3.2.4.3 The system shall be manually operated from a safe location that is outside the spill containment area and that is at least 50 ft from the vessel being protected. The location of the actuating valve shall be clearly and prominently marked. In locations with unattended or partially attended operations, consideration shall be given to additional methods of system activation such as automatic or remote operation. When the system is remotely or automatically operated, a full-size manually operated bypass valve shall also be provided in an accessible, safe location.

10.3.2.4.4 Flush-out connections shall be installed in the system to permit flushing at periodic intervals. Accessible low-point drain connections shall also be provided.

10.3.2.4.5 The sizing of all piping shall be based on hydraulic calculations. Pipe used for main water distribution lines shall have a diameter of at least 3 in. Pipe used for branch lines to spray heads shall not be less than NPS $^{3}/_{4}$.

10.3.2.4.6 A full-flow strainer with a valved blow-off connection shall be installed in the main feeder line to the spray system. The maximum size of the opening in the strainer shall be 0.25 in. A full-size valved bypass shall be provided. Galvanized piping shall be used downstream of the strainers to reduce the potential for rust scale plugging spray nozzles.

10.3.2.4.7 In freezing climates, water spray system components shall be suitably protected against freezing (e.g. heated enclosure, heat trace, or drained water free).

10.3.2.5 Portable Equipment

Portable equipment, such as fire hoses and portable monitors, shall not be used as the only means of protecting exposed LPG vessels. It is permitted to use portable equipment when vessels are fireproofed as outlined in 10.7.

10.3.2.5.1 Portable streams can be a useful supplement to fixed systems to:

a) compensate for wind effects,

b) compensate for partial damage to the fixed system when extinguishing small fire, or

c) apply additional water to locations subject to the impingement of an LPG jet fire.

NOTE Refer to API Publication 2510A for additional information.

10.3.3 Fire Water Application Rates

10.3.3.1 The minimum required fire water application rate depends on the method of application.

10.3.3.2 In determining fire water application rates, the surface area of the vessel that could be exposed to fire shall be the surface area of the vessel above the level of the liquid contents at the vessel's lowest operating level.

10.3.3.3 Fixed deluge or water spray systems shall be designed to protect against pool fire exposure to the vessel with a minimum fire water application rate of 0.25 gpm/ft^2 of exposed vessel surface. If there is concern or risk of a vessel being engulfed by flame or subject to substantial flame contact, supplemental cooling streams should be provided.

10.3.3.4 To compensate for losses due to wind and vaporization that occur before the stream reaches the vessel wall, fire water monitor systems shall be designed to protect against pool fire exposure to the vessel with a minimum water application rate of 0.20 gpm/ft^2 of exposed vessel surface.

10.3.3.5 Hydrocarbon vapors in a flammable mixture with air can ignite if exposed to a source of ignition. Water spray systems are only used to keep vessel contents cool from exposure to an external heat source. The purpose is to avoid heating the contents, resulting in a reduced probability of release of combustible gas from vessel due to exposure to an external fire or heat source. Refer to API Recommended Practice 2030 and NFPA 30 for additional information regarding vapor suppression.

10.4 Fire Detection Systems

A safety analysis shall be used to determine the need for fire and hydrocarbon detection systems. Where provided, fire and hydrocarbon detection systems shall be arranged to sound their alarms whenever fire or hydrocarbons

are present. It is permitted to use detection systems to automatically activate isolation or fire protection systems in remote or unattended facilities.

10.5 Fire Extinguishers

10.5.1 Portable fire extinguishers shall be used to extinguish an LPG fire only after the source of LPG has been shut off, to prevent the formation of a hazardous vapor cloud.

10.5.2 Dry chemical fire extinguishers shall be provided at strategic locations such as those near pumps and loading racks so that they are readily available for operator use.

10.6 Fire-fighting Foam

Fire-fighting foam shall not be used to extinguish LPG fires.

10.7 Fireproofing of LPG Vessels

10.7.1 Except for remote facilities, which require no protection, fireproofing shall be used to protect vessels if portable equipment is the only means of applying fire water.

10.7.2 Where fireproofing is used, it shall provide protection of the support structure or LPG vessel for the time period required for operation of fire water systems.

10.7.3 When fireproofing is used, it shall comply with the provisions of 10.7.3.1 through 10.7.3.5.

10.7.3.1 Outside surfaces of LPG vessels that may be exposed to fire shall be covered with a fireproofing material that is suitable for the temperatures to which the vessel will be exposed. Refer to API Recommended Practice 2218 for additional information on fireproofing.

10.7.3.2 The thickness of the fireproofing material shall be equivalent to a minimum fire endurance of 1½ hours per UL 1709 when tested on a 10W49 column.

10.7.3.3 Thermal insulation used for fireproofing shall be jacketed with rust-resistant steel.

10.7.3.4 The fireproofing material shall be suitably protected against weather damage and sealed to prevent water entry.

10.7.3.5 The fireproofing system shall be capable of withstanding exposure to direct flame impingement and shall be resistant to dislodgment by direct impingement of fire water streams. Refer to NFPA 58, Annex H, *Procedure for Torch Fire and Hose Stream Testing of Thermal Insulating Systems for LP-Gas Containers*, for further information.

10.8 Fireproofing of Structural Supports

Except for remote facilities, which require no protection, structural supports shall be provided with fireproofing, as specified in 10.8.1 through 10.8.8.

10.8.1 Fireproofing shall be provided on the aboveground portions of the vessel's supporting structures. The fireproofing shall cover all support members required to support the static load of the full vessel. Fireproofing shall not encase the points at which the supports are welded to the vessel. Refer to API Recommended Practice 2218 for additional information on fireproofing.

10.8.2 Fireproofing shall be provided on horizontal vessel saddles where the distance between the bottom of the vessel and the top of the support structure is greater than 12 in. Where such fireproofing is provided, it shall not encase the points at which the saddles are welded to the vessel. Fireproofing shall also cover all above ground steel support structure required to support the static load of the full vessel.

10.8.3 When a vertical vessel is supported by a skirt, the exterior of the skirt shall be fireproofed.

10.8.4 Fireproofing shall be provided on all pipe supports within 50 ft of the vessel and on all pipe supports within the spill containment area of the vessel.

10.8.5 To be considered as adequately fireproofed, support structures of concrete or masonry shall meet the criteria of 10.8.7.

10.8.6 Fireproofing is not required for diagonal bracing, including tie rods, or for redundant members that are not necessary for supporting static loads.

10.8.7 The thickness of the fireproofing material shall be equivalent to a minimum fire endurance of 1½ hours per UL 1709 when tested on a 10W49 column.

10.8.8 Fireproofing material shall be suitably protected against weather damage and sealed to prevent water entry. It shall be resistant to dislodgment by direct impingement of fire water streams.

10.9 Burying and Mounding

CAUTION — LPG vessels buried below grade or mounded above grade to reduce exposure to an external fire require special precautions, careful preparation, and special design features. Adequate protection against corrosion, leaks, and mechanical damage when the vessel is uncovered for inspection shall be provided. Burying and mounding for protection of LPG storage vessels shall be specially engineered and arranged to meet the provisions of NFPA 58 for buried or mounded tanks.

10.10 Electrical Installations and Equipment

All electrical installations and equipment shall conform to the provisions of NFPA 70. Refer to API Recommended Practice 500 or Recommended Practice 505 for guidance in the classification of electrical areas.

10.11 Critical Wiring and Control Systems

10.11.1 Electrical, instrument, and control system equipment that are required to operate in the event of a fire and that are not designed to fail to a safe state in such a fire shall be protected from fire damage to provide sufficient operational capability in a fire to start, stop, or divert production flow or activate alarms or water systems. For example, if the control cabling for motor-operated valves that must be operated in an emergency is at risk during the first 15 minutes of a fire, the control cable should be fire resistant and it should be fire proofed for a 15-minute exposure.

10.11.2 Where fire protection is required, wiring shall be protected by selective routing, burying, fireproofing, or a combination of these methods.

10.12 Safety Precaution Signs

Appropriate safety precaution signs shall be placed to provide notification and instructions concerning safety requirements and emergency systems.

10.13 Lighting

In all storage and operating areas, lighting that is adequate for operations under normal conditions shall be provided. In addition, lighting that is sufficient to enable safe operations during an emergency shall be provided.

10.14 Fencing

Any LPG storage installation that is not within a fenced plant area or otherwise isolated from the public shall be fenced, and at least two means of exit shall be provided. Exits shall be located so that a single emergency cannot prevent egress from any part of the installation.

10.15 Roadways

Suitable roadways or other means of access for fire-fighting equipment such as wheeled extinguishers or fire trucks shall be provided. Access to LPG handling and storage areas shall be restricted or controlled.

11 Refrigerated Storage

11.1 General

This section contains specific requirements for refrigerated tank systems for storage of LPG. Also, unless specifically superseded or expanded upon in this section, the requirements of previous sections apply to refrigerated storage.

11.2 Design Requirements

11.2.1 Code Requirements

Refrigerated tank systems shall conform to API Standard 625.

11.2.2 Design Pressure

11.2.2.1 The design pressure of a refrigerated tank system is determined by the product's vapor pressure at the storage temperature. The set pressure of the pressure-relieving device shall be at least 5 % greater than the operating pressure.

11.2.2.2 The tank section above the maximum liquid level shall be designed for a pressure of at least that at which the pressure relief valves are to be set and for the maximum partial vacuum that can be developed. All portions of the tank below the maximum liquid level shall be designed for at least the most severe combination of gas pressure (or partial vacuum) and static liquid head affecting each element of the tank.

11.2.3 Design Temperature

The design temperatures for various components of a refrigerated LPG tank system shall be in accordance with API Standard 625, Section 6.4.6.

11.3 Siting Requirements

11.3.1 Minimum Distance Requirements for Refrigerated LPG Tanks

11.3.1.1 The minimum horizontal distance between the shell of a refrigerated LPG tank and the line of adjoining property that may be developed shall be 200 ft. Where residences, public buildings, places of assembly, or industrial sites are located on adjacent property, greater distances or other supplemental protection shall be evaluated.

11.3.1.2 The minimum horizontal distance between the shells of adjacent refrigerated LPG tank systems shall be half the diameter of the larger tank.

11.3.1.3 The minimum horizontal distance between the shell of a refrigerated LPG tank system and the shell of another nonrefrigerated or partially refrigerated hydrocarbon pressure vessel shall be the largest of the following distances, with the exception noted in 11.3.1.4.

a) If the other storage is pressurized, three quarters of the larger tank 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.

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

11.3.2 Siting of Refrigerated LPG Tanks

Refrigerated LPG tank systems shall not be located within buildings, within the spill containment areas of other flammable or combustible liquid storage tanks as defined in NFPA 30, or within the spill containment areas of pressurized storage tanks. Additionally, per API Standard 625, Section 5.6, the selection of the tank system storage concept, as defined in API Standard 625, Section 5, shall be based on a risk assessment which accounts for siting and overall facility plan.

11.3.3 Spill Containment

11.3.3.1 Refrigerated LPG tank systems shall be provided with spill containment facilities. To prevent the accumulation of flammable material under or near a refrigerated LPG tank system, the ground under and surrounding the tank shall be sloped to drain any spills to a safe area away from the tank.

11.3.3.2 Spill containment shall be provided by the remote impoundment of spilled material, or by the diking of the area surrounding the refrigerated tank system, or by the provision of a secondary liquid container in the context of a double containment, full containment, or full containment with penetrations tank system as defined in API Standard 625, Section 5.

11.3.4 Remote Impoundment

If remote impoundment is to be used for spill containment, the remote impoundment facility shall be designed according to the guidelines given in 11.3.4.1 through 11.3.4.4.

11.3.4.1 The grading of the area under and surrounding the vessels shall direct any leaks or spills to the remote impoundment area. The grading shall be a minimum of 1 % slope.

11.3.4.2 Toe walls, dikes, trenches, or channels may be used to assist in draining the spilled product from the area of the tank to a remote impoundment area. However, the use of trenches or channels shall be minimized.

11.3.4.3 The remote impoundment area shall be located at least 50 ft from the vessels draining to it and from any piping or other equipment.

11.3.4.4 The holdup of the remote impoundment area shall be at least 100 % of the volume of the largest vessel draining to it.

11.3.5 Diking

If diking around the vessel is to be used for spill containment, the diked area shall be designed according to the guidelines given in 11.3.5.1 through 11.3.5.3.

11.3.5.1 The grading of the area under and surrounding the refrigerated tank system shall direct any leaks or spills to the edge of the diked area. The grading shall be a minimum of 1 % slope. Within the diked area, the grading shall cause spills to accumulate away from the tank and any piping located within the diked area.

11.3.5.2 Each refrigerated LPG tank system shall be provided with its own diked area. The holdup of the diked area shall be at least 100 % of the volume of the tank.

NOTE More than one tank may be enclosed within the same diked area provided provisions are made to prevent low temperature exposure resulting from leakage from any one tank from causing subsequent leakage from any other tank.

11.3.5.3 When dikes are used as part of the spill containment system, the minimum height shall be 1.5 ft, measured from the inside of the diked area. Where dikes must be higher than 6 ft, provisions shall be made for normal and emergency access into and out of the diked enclosure. Where dikes must be higher than 12 ft or where ventilation is restricted by the dike, provision shall be made for normal operation of valves and access to the top of the tank or tanks without the need for personnel to enter into the area of the diked enclosure that is below the top of the dike. All earthen dikes shall have a flat top section at least 2 ft wide.

11.3.6 Secondary Liquid Container

When a double containment, full containment, or full containment with penetrations tank system is used, the secondary liquid container shall be in accordance with API Standard 625, Section 5 and Section 6.

11.4 Thermal Considerations

Tank foundation shall be designed to prevent thermal effects such as base heave and thermal expansion as described in API Standard 625, Section 6.7.

11.5 Tank Accessories

11.5.1 Pressure/Vacuum-Relieving Devices

11.5.1.1 Relief devices for refrigerated tank systems shall be designed and installed in accordance with API Standard 2000 and the requirements of API Standard 625, Section 7.4.

11.5.1.2 Loading LPG into a partially full refrigerated LPG tank system, where the LPG being loaded has a different composition than that of the existing tank contents, can generate large quantities of vapor. If this condition can exist, the vapor generation rate shall be calculated and included in the sizing of the tank pressure relief valves. As a minimum, the pressure relief valves shall be sized to discharge vapor at a rate no less than 3 % of the full tank liquid capacity in 24 hours.

11.5.1.3 When a closed inner-tank design is used with an outer vapor-tight shell, the outer shell shall be equipped with one or more pressure/vacuum-relieving devices.

11.6 Instrumentation

Each tank shall be equipped with instrumentation per the requirements of API Standard 625, Section 7.5.

11.6.1 Sampling Connections

If sampling connections are required, they shall be installed on the tank piping rather than on the tank.

11.6.2 Tank Accessory Materials

Low-ductility material such as cast iron, semi-steel, and malleable iron, shall not be used in any pressure-retaining accessory parts.

11.7 Piping Requirements

11.7.1 Valves

Shutoff valves and accessory equipment shall be constructed of material suitable for the operating pressure and temperature extremes to which they may be subjected.

11.7.2 Insulation

The insulation shall comprise or contain a vapor barrier and shall be weatherproofed. Insulation and weatherproofing shall be fire retardant when required by design. Steel surfaces covered by insulation shall be properly coated to prevent corrosion when required by design (reference API Recommended Practice 583).

11.7.3 Location

When cold piping is routed below grade, trenches, casing, or other means shall be used to permit expansion and contraction of the piping.

11.7.4 Multiple Product Types

When a storage facility handles more than one type of product, dedicated loading and unloading lines between tanks and racks shall be considered for each type of product.

11.8 Refrigeration System

11.8.1 LPG Temperature

The refrigeration system shall maintain the LPG at a temperature at which the LPG's vapor pressure does not exceed the tank's design pressure.

11.8.2 Sizing

The sizing of the refrigeration system shall consider the following factors.

a) Heat flow from the following sources:

  1. the difference between the design ambient temperature and the design storage temperature;
  2. maximum solar radiation;
  3. receipt of product that is warmer than the design temperature, if such an operation is expected;
  4. foundation heaters; and
  5. connected piping.

b) Vapor displacement during filling and vapor return during product transfer;

11.8.3 Vapor Handling

An alternate handling method shall be provided for an excess in the LPG vapor load resulting from insufficient refrigeration or loss of refrigeration.

11.8.4 Pressure-Relieving Devices

Refer to API Standard 520, Parts I and II, for the proper design of pressure-relieving devices and systems for process equipment used in liquefaction and vaporization facilities.

Annex A
(informative)

Piping, Valves, Fittings, and Optional Equipment

A.1 Optional Equipment

A.1.1 General

Containers may be fitted with the optional equipment described in A.1.2 through A.1.7. Any optional equipment selected for use shall be suitable for use with LPG and designed for at least the maximum service conditions to which it may be subjected.

A.1.2 Sampling Connections

Sampling connections may be provided on containers. As an alternative, the connections on gauging equipment may be used for sampling if they are suitably located. Adequate bracing of small connections and piping in sampling lines shall be provided to minimize vulnerability to mechanical damage. The inlet piping to sample containers shall be double valved. Sample connection locations should not be under the container. Connections shall be oriented so that purge vapors do not engulf the operator or approach an ignition source.

A.1.3 Automatic and Remote Devices

Automatic shutoff valves, remotely operated shutoff valves, automatic warning devices, pump shutdown switches, or a combination of these may be used where containers are operated remotely, where they receive LPG at a high rate of flow, or for other circumstances in which the designer considers it advisable. Fireproofing of the control systems may be required for these devices to be effective during fire exposure. See 10.11 for additional information.

A.1.4 Stairs, Ladders, Walkways, and Platforms

Suitable stairs, ladders, walkways, and platforms should be provided to allow access to operating valves and equipment.

A.1.5 Common Discharge Header

Pressure relief valve lines for one or more containers may be connected to a common discharge header provided the LPG is being discharged to a flare. Common discharge headers shall be designed in accordance with API Standard 521 and shall comply with the provisions of 7.1.6.5. Back pressures that could develop during relief valve discharge shall be taken into account when determining the size of the relief device and of the discharge header. For pilot-operated relief valves discharging into a common header, the effects of backflow should be considered, and a backflow preventer should be provided if required.

CAUTION — Common headers should not be used for venting to the atmosphere. Common discharge headers shall be sized for full relief capacity of all containers that could be involved in a single emergency. Liquid traps in the common header shall be prevented. Other vents, drains, bleeders, and pressure relief devices shall not be tied into the common discharge header if back pressures can develop that may prevent proper functioning of the pressure relief devices on the container. See API Publication 2510A for additional information.

A.1.6 Water Drawoffs

Facilities for removing water from LPG storage containers should be provided. These water drawoffs shall be designed to prevent freezing of water within them. See 8.7.4, 8.7.5, and API Publication 2510A for additional information.

A.1.7 Water Flood Connection

Each LPG storage container may be provided with a water flood connection. The water flood connection may be provided either into the vapor space of the container or directly into the product line to the bottom of the container. When the water flood connection is provided on the product line, the possibility of water freezing shall be considered in the design. The water flood connection shall extend outside the spill containment system and shall include (in physical order starting at the container) a block valve, a check valve, and provision for connection to the water system.

A.2 Location, Installation, and Flexibility of Piping, Valves, and Fittings

A.2.1 Recommended Practices

The practices described in A.2.1.1 through A.2.1.10 concerning location, installation, and flexibility of piping, valves, and fittings are recommended.

A.2.1.1 The design of header piping and container loading and unloading connections should be as simple as possible. The number of connections to the storage container should be minimized. Operating errors increase as the complexity of the piping installation and the number of connections increase.

A.2.1.2 Shutoff valves that must be used during normal operations should be accessible to the operator and should be as close to the containers, pumps, compressors, and other components as practical. This recommendation should not be construed as discouraging installation of remotely operated shutoff valves or other safety devices.

A.2.1.3 Headers may be installed on piers, supported by stanchions, or buried, as specified by the owner. Buried lines have the advantage of being protected from fires and explosions but have the disadvantages of the possibility of soil corrosion, inaccessibility for inspection, and reduction in flexibility because of the binding action of the earth. Buried lines should be installed below the frost line and protected from corrosion.

A.2.1.4 Piping should not be laid under concrete floors or slabs. When piping must extend through a concrete wall or below a floor slab, it should be protected by a suitable casing.

A.2.1.5 Lines laid under railroad tracks, highways, access roads, or loading slabs should be installed in accordance with API Recommended Practice 1102.

A.2.1.6 Interconnected piping between containers or container accessories should be installed to permit flexibility in all planes. For example, loading and unloading headers should not be connected to a container by short, straight rigid piping, regardless of whether the piping is screwed or welded. Equalizing piping should not be connected by short, straight piping between containers. Vent or relief piping should not have straight piping between adjacent containers. Piping should include adequate lengths of pipe, with changes in direction obtained by the use of elbows or bends, to provide for possible vertical and horizontal movement of the header relative to the containers.

A.2.1.7 In piping where thermal expansion and contraction are expected to occur, each line should be designed with an adequate expansion bend, angular offset, or other provision to allow for linear movement. Expansion bends may be fabricated from straight lengths of pipe and welding elbows or U-bends. Suitable bellows-type

expansion joints, properly anchored and guided, should be used only where space limitations prevent installation of loops or bends.

A.2.1.8 To minimize the amount of material that can be spilled in the event of a line or equipment failure, emergency shutoff valves should be installed in long runs of piping that are used to carry liquids.

A.2.1.9 Low points in piping, in which water can accumulate, should be avoided to the greatest extent practical. In freezing climates, appropriate freeze protection should be provided where low points cannot be avoided.

A.2.1.10 The second valve in a water drain line should be self-closing (that is, it should be a deadman valve).

A.2.2 Refrigeration System

A.2.2.1 The vapor load from a refrigerated system may be handled by one or a combination of the following methods.

a) Recovery by a liquefaction system.

b) Use as a fuel.

c) Use as process feedstock.

d) Disposal by flaring or another safe method.

A.2.2.2 Alternative handling methods shall be provided to dispose of vented vapors in case of failure of the normal methods. If compressors are used, castings shall be designed to withstand a suction pressure of at least 121 % of the container design pressure.

A.2.2.3 A refrigerated LPG system should incorporate the following accessories.

a) An entrainment separator in the compressor suction line.

b) An oil separator in the compressor discharge line (unless the compressor is a dry type).

c) A drain and a gauging device for each separator.

d) A non-condensable gas purge for the condenser.

e) Automatic compressor controls and emergency alarms to signal at the following times:

    1. when any container’s pressure approaches the maximum or minimum allowable container working pressure or the pressure at which the vacuum vent will open, or

    2. when excess pressure builds up at the condenser because of a failure of the cooling medium.

Annex B
(informative)

Applicability of API 2510 and NFPA 58

API 2510 and NFPA 58 have scopes that cover common areas of design for LPG installations. Common areas include marine, petrochemical and pipeline facilities. The following annex clarifies the application of API 2510 and NFPA 58 with regard to the common areas of LPG installations. [12, 13]

B.1 Pipeline Terminal that Receives LP Gas from Pipeline for Delivery to Transporters, Distributors, or Users

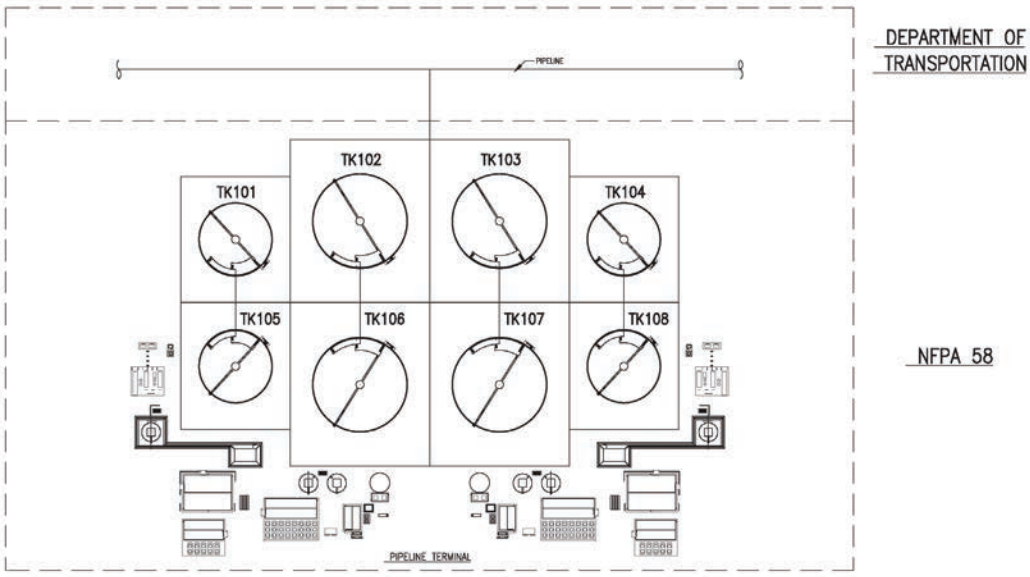

Figure B.1—Pipeline Terminal that Receives LP Gas from Pipeline for Delivery to Transporters, Distributors, or Users

B.2 Pipeline Terminal Associated with Refineries, Petrochemical Plants, or Gas Plants

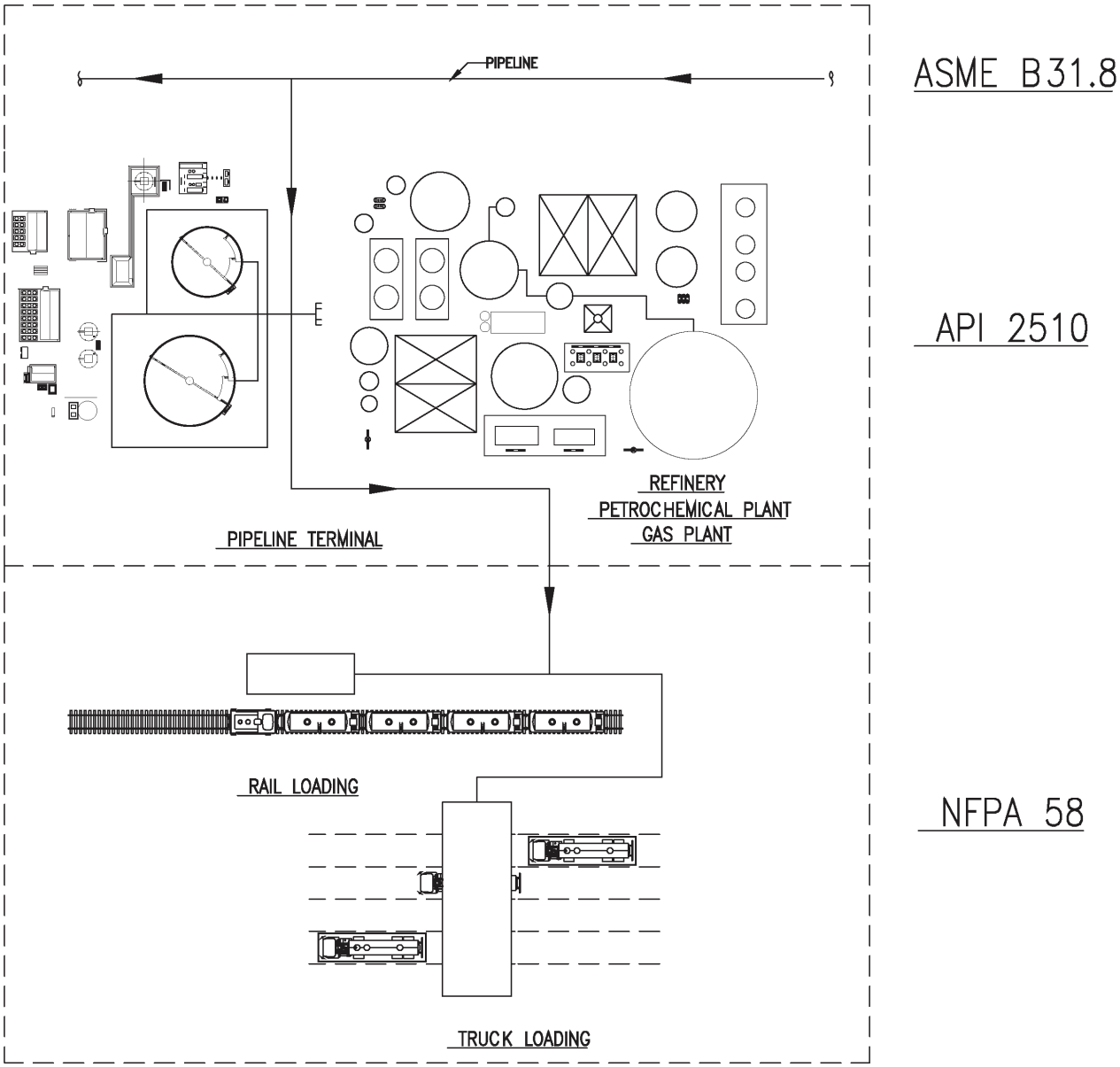

Figure B.2—Pipeline Terminal Associated with Refineries, Petrochemical Plants, or Gas Plants

B.3 Marine Terminal Whose Purpose is the Receipt of LP Gas for Delivery to Transporters, Distributors, or Users

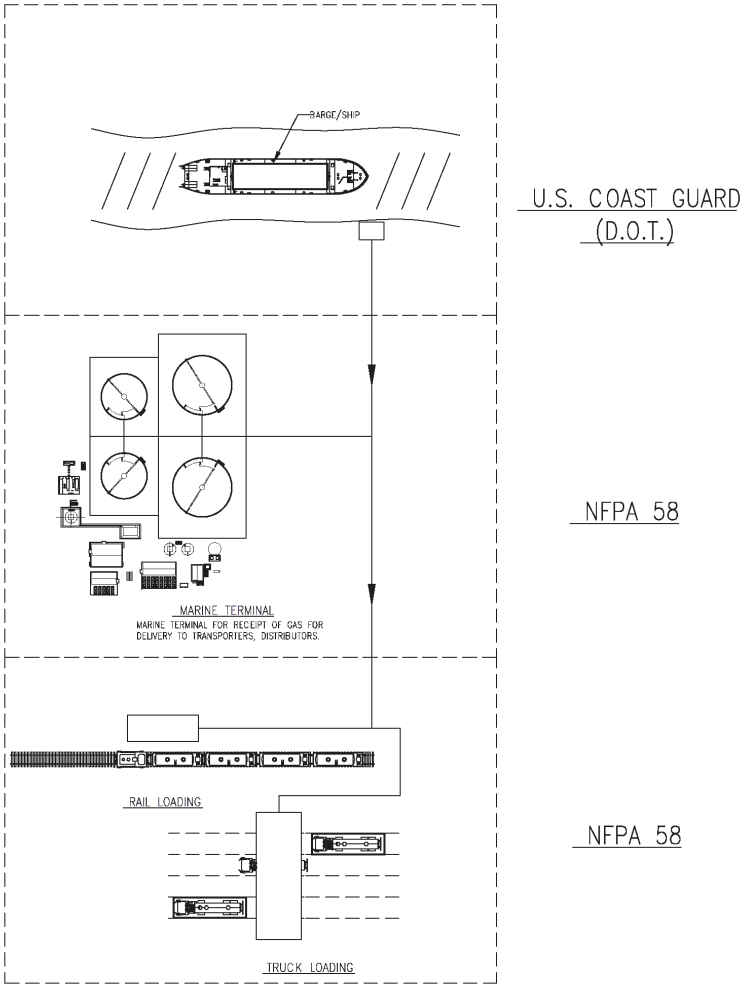

Figure B.3—Marine Terminal Whose Purpose is the Receipt of LP Gas for Delivery to Transporters, Distributors, or Users

B.4 Refinery, Petrochemical Plant, or Gas Plant

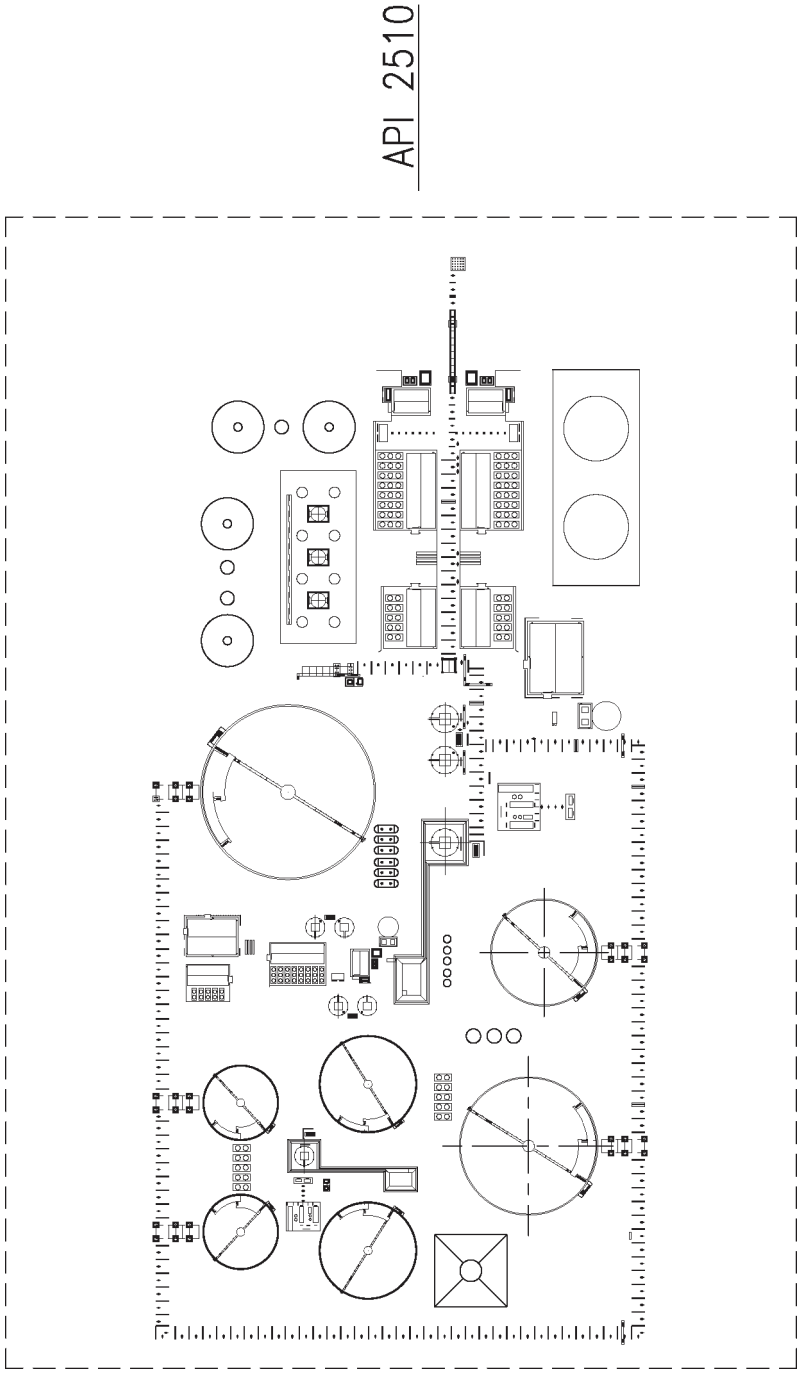

Figure B.4—Refinery, Petrochemical Plant, or Gas Plant

B.5 Marine Terminal Supplying Refineries, Petrochemical or Gas Facilities or Delivery of LP Gas to Marine Vessels

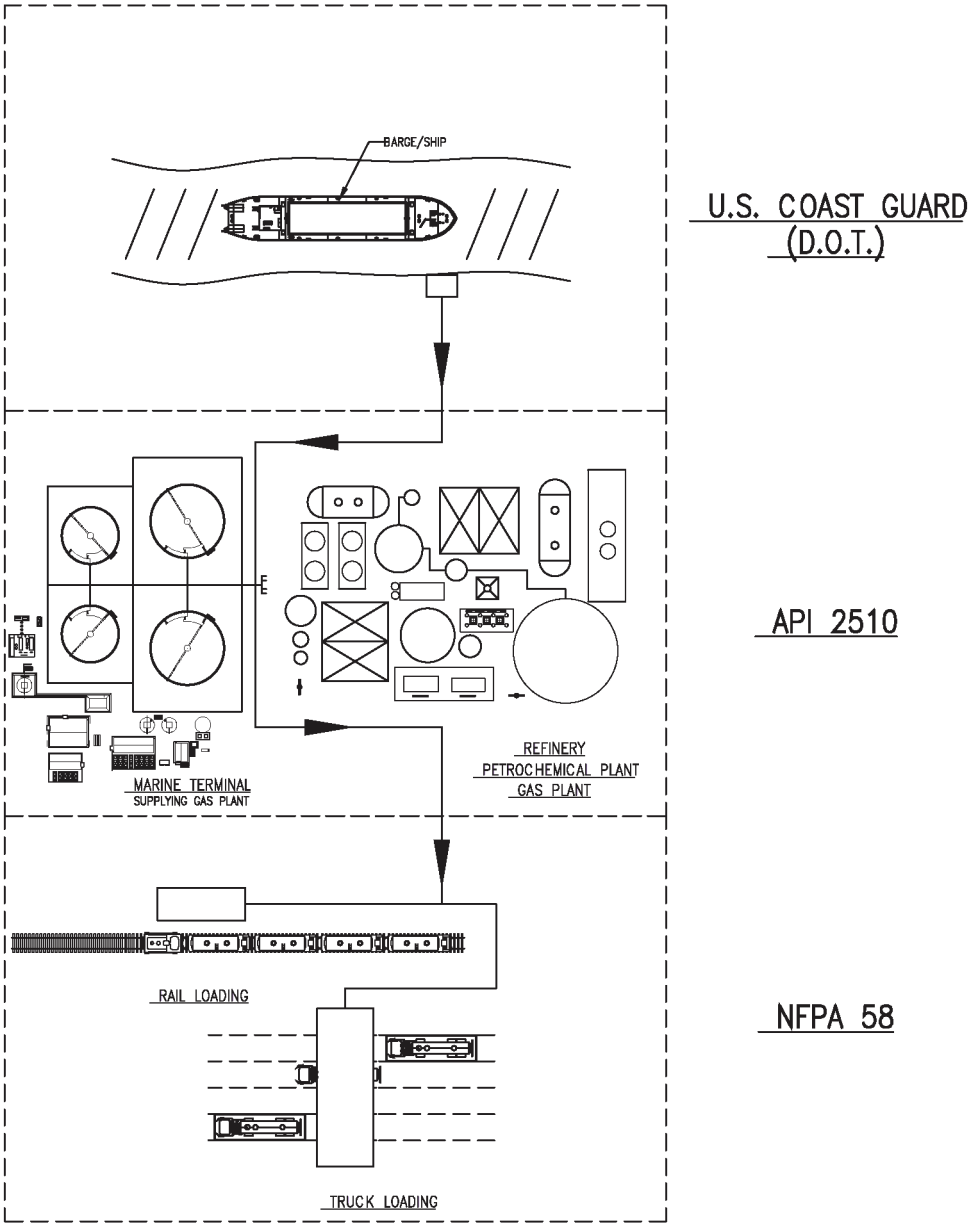

Figure B.5—Marine Terminal Supplying Refineries, Petrochemical or Gas Facilities or Delivery of LP Gas to Marine Vessels

Bibliography

[1] API 625, *Tank Systems for Refrigerated Liquefied Gas Storage*

[2] API 653, *Tank Inspection, Repair, Alteration, and Reconstruction*

[3] ACI 318-11 [7] , *Building Code Requirements for Structural Concrete and Commentary,* Appendix D

[4] AISC 360 [8] , *Specification for Structural Steel Buildings*

[5] AISI [9] , *Steel Plate Engineering Data — Design of Plate Structures*

[6] ASCE/SEI 7 [10] , *Minimum Design Loads for Buildings and Other Structures*

[7] ASME B31.3 [11] , *Process Piping*

[8] ASME, *BPVC Section VIII-Rules for Construction of Pressure Vessels, Division 1 and Division 2*

[9] ICC [12] , *International Building Code*, *Chapter 18, Soils and Foundations*, Sections 1803, 1808 through 1810, 2015

[10] ICC, *International Building Code, Chapter 16, Structural Design,* Section 1605, 2015

[11] ICC, *International Building Code*, *Chapter 21, Masonry,* 2015

[12] NFPA 58, *Liquefied Petroleum Gas Code, Sections 1.3.1 (3), 1.3.1 (4), and 1.3.2 (2)*

[13] NFPA 58, *LP-Gas Code Handbook, Section A.1.3.1 (3) and A.1.3.1 (4),* 2014

[14] PIP STE03020 [13] , *Guidelines for Tank Foundation Designs, Section 6.8 and Appendix C*

[15] TMS 402-16 [14] , *Building Code Requirements for Masonry Structures*

[16] TMS 602-16, *Specification for Masonry Structures*

[7] American Concrete Institute, PO Box 9094, Farmington Hills, Michigan, 48333, www.aci-int.org.
[8] American Institute of Steel Construction, One East Wacker Drive, Suite 700, Chicago, Illinois 60601, www.aisc.org.
[9] American Iron and Steel Institute, 25 Massachusetts Avenue NW, Suite 800, Washington, DC 20001.
[10] American Society of Civil Engineers, 1801 Alexander Bell Drive, Reston, Virginia 20191.
[11] American Society of Mechanical Engineers, Two Park Avenue, New York, New York 10016-5990.
[12] International Code Council, 500 New Jersey Avenue NW, Suite 300, Washington, DC 20001.
[13] Process Industries Practices, 3925 West Braker Lane (R4500), Austin, Texas 78759.
[14] The Masonry Society, 105 South Sunset Street, Suite Q, Longmont, Colorado 80501-6172.

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