NFPA No.
59A

STORAGE AND HANDLING

LIQUEFIED NATURAL GAS 1972

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Official NFPA Definitions

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Standard for the
Production, Storage and Handling of
Liquefied Natural Gas (LNG)

NFPA No. 59A — 1972

1972 Edition of No. 59A

This edition supersedes the 1971 edition. It was adopted at the NFPA Annual Meeting on May 17, 1972.

Changes, other than editorial, are denoted by a vertical line in the margin of the pages on which they appear.

The 1971 edition of this standard was approved by the American National Standards Institute under date of November 11, 1971 and designated ANSI Z225.1. The 1972 edition is being submitted for similar approval. The ANSI designation and date of approval will be printed on the front cover of copies of this edition printed after approval has been received.

Origin and Development of No. 59A

Work on this Standard was initiated by a Committee of the American Gas Association, Inc., about 1960. In the Fall of 1964, a draft was submitted to the NFPA with the request that it be considered as the basis for an NFPA standard. The Sectional Committee on Utility Gas prepared a standard which was tentatively adopted at the 1966 Annual Meeting at the recommendation of the Committee on Gases.

With the formation of the Committee on Fuel Gases in the Summer of 1966, this Standard was assigned to that Committee and its Subcommittee on Utility Gas Plants. The first official edition was adopted at the 1967 Annual Meeting under the sponsorship of the Committee on Fuel Gases.

By early 1969, it was apparent that the usage of LNG was being broadened considerably beyond the utility gas plant applications covered by the 1967 edition. The American Petroleum Institute suggested that its Standard 2510A be used to help develop a standard having a broader scope. The Committee on Liquefied Natural Gas was established to accomplish this. The 1971 edition was the first edition developed under the broadened scope.

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Scope: To develop codes, standards, recommended practices, or manuals, as may be considered desirable, covering safety and related aspects in the liquefaction of natural gas and the transport, storage, vaporization, transfer, and use of liquefied natural gas.

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Standard for the Production, Storage and Handling of Liquefied Natural Gas (LNG)

NFPA No. 59A — 1971

CHAPTER 1. INTRODUCTION

10. Preface

100. This Standard outlines basic methods of equipment fabrication and installation as well as operating practices for protection of persons and property and provides guidance to all persons concerned with the construction and operation of equipment for the production, storage, and handling of liquefied natural gas (LNG).

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

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

103. In the interest of safety, it is important that persons engaged in handling LNG understand the properties of this product and that they be thoroughly trained in safe practices for its handling.

104. At sufficiently low temperatures, natural gas liquefies. At atmospheric pressure, natural gas can be liquefied by reducing its temperature to approximately minus 260 F (minus 162 C).

105. Upon release from containment to the atmosphere, LNG will vaporize and release gas which, at ambient temperature, will have about 600 times the volume of the liquid vaporized. Generally at temperatures below approximately minus 170 F (minus 112 C) this gas is heavier than ambient air at 60 F (15.6 C). However, as its temperature rises, it then becomes lighter than air.

NOTE: The minus 170 F (minus 112 C) temperature value is for methane. If other constituents are present (see Definition of Liquefied Natural Gas), the temperature will be different.

106. Metric units in this Standard are based upon the ASTM Metric Practice Guide. Where clearance distances are to be determined, the conversion from English to Metric units shall be calculated to the nearest one-half (½) meter. Alternate usage of English and Metric units on a single project shall not be used to lessen clearance distances.

11. Scope

110. This Standard applies to the design, location, construction, and operation of facilities at any location for the liquefaction of natural gas and the storage, vaporization, transfer, handling, and truck transport of liquefied natural gas (LNG).

111. This Standard covers all except frozen ground containers as used for the storage of liquefied natural gas. Metal containers are classified in two groups:

(1) For operation at a pressure of 15 psig (.1034 MN/m^2) and less.

(2) For operation at a pressure more than 15 psig (.1034 MN/m^2).

Containers with insulation systems applying vacuum are included in these classifications.

12. Definitions

(1) ASME Code. The Boiler and Pressure Vessel Code (1971 Edition), including Addenda and applicable Code Interpretation Cases, promulgated and published by the American Society of Mechanical Engineers.

(2) Barrel. A unit of volume. One barrel equals 42 US gallons or 5.615 cubic feet (0.159 cubic meters).

(3) Bunkering. The loading of a ship's bunker or tank with fuel oil for use in connection with propulsion or auxiliary equipment.

(4) Cargo Tank Vehicle. A tank truck or trailer designed to transport liquid cargo.

(5) Container. A vessel for storing liquefied natural gas. Such a container may be aboveground, partially below or totally belowground.

(6) Container, Frozen Ground. A container in which the maximum liquid level is below the normal surrounding grade and is con-

structed essentially of natural materials, such as earth and rock, and dependent upon the freezing of water-saturated earth materials with appropriate methods for its tightness or impervious nature. (This type of storage is still under development. It is, therefore, not included in Chapter 4 at this time.)

(7) Container, Prestressed Concrete. A concrete container is considered to be prestressed when the stresses created by the different loadings or loading combinations do not exceed allowable stresses provided for in this Standard. Either circumferential prestressing or both circumferential and vertical prestressing may be required to meet these provisions.

(8) Deriming. Deriming, synonymous with defrosting or deicing, refers to the removal by heating and evaporation, sublimation, or solution, of accumulated constituents which form solids such as water, carbon dioxide, etc., from the low-temperature process equipment.

(9) Design Pressure. The pressure used in the design of equipment, a container or a vessel for the purpose of determining the minimum permissible thickness or physical characteristics of its different parts. When applicable, static head shall be included in the design pressure to determine the thickness of any specific part.

(10) Dike. A structure used to establish an impounding area.

(11) Failsafe. Design features which provide for the maintenance of safe operating conditions in the event of a malfunction of control devices or an interruption of an energy source.

(12) Fired Equipment. Any equipment in which the combustion of fuels takes place. Included, among others, are fired boilers, fired heaters, internal combustion engines, certain integral heated vaporizers, the primary heat source for remote heated vaporizers, gas fired oil foggers, fired regeneration heaters, and flared vent stacks.

(13) Fixed-Length Dip Tube. A pipe that has a fixed open end inside a container at a designated elevation that is intended to show a liquid level.

(14) Flame Spread Rating. The flame spread rating of materials as determined in accordance with NFPA No. 255, Method of Test of Surface Burning Characteristics of Building Materials.

(15) G. The normal or standard constant of gravity. At sea level, g equals approximately 32.2 ft/sec^2 (9.81 m/sec^2).

(16) GAS. Natural gas in the gaseous state.

(17) IGNITION SOURCE. Any item or substance capable of an energy release of type and magnitude sufficient to ignite any flammable mixture of gases or vapors which could occur at the site.

(18) Impounding Area. An area which may be defined through the use of dikes or the topography at the site for the purpose of containing any accidental spill of LNG or flammable refrigerants.

(19) LIQUEFIED NATURAL GAS. A fluid in the liquid state composed predominantly of methane and which may contain minor quantities of ethane, propane, nitrogen or other components normally found in natural gas.

(20) LNG. An abbreviation for "liquefied natural gas".

(21) MAXIMUM ALLOWABLE WORKING PRESSURE. The maximum gage pressure permissible at the top of completed equipment, a container or a vessel in its operating position for a design temperature.

(22) Meganewtons Per Square Meter (MN/m^2). The metric unit of pressure or stress. One pound-force per square inch (psi) equals 6.895×10^{-3} meganewtons per square meter (MN/m^2). The newton is that force which, when applied to a body having a mass of one kilogram, gives it an acceleration of one meter per second per second.

(23) PRIMARY COMPONENT. Primary components, as referred to in Chapter 4, include those which may be stressed to a significant level, those whose failure would permit leakage of the LNG being stored, those exposed to a temperature between −60 F (−51 C) and −270 F (−168C), and those subject to thermal shock. Primary components shall include, but will not be limited to, the following parts of a single-wall tank or of the inner tank in a double-wall tank; shell plates, bottom plates, roof plates, knuckle plates, compression rings, shell stiffeners, manways and nozzles including reinforcement, shell anchors, pipe, tubing, forgings, and bolting.

(24) PROCESS PLANT. All systems required to condition, liquefy, or vaporize natural gas in all areas of application as identified under the scope of this Standard.

(25) PSIA. Pounds per square inch absolute.

(26) PSIG. Pounds per square inch gage.

(27) Secondary Components. Secondary components, as referred to in Chapter 4, include those which will not be stressed to a significant level, those whose failure will not result in leakage of the LNG being stored, or those exposed to the boiloff gas and those having a design metal temperature of −60 F (−51 C) or higher.

CHAPTER 2. GENERAL PLANT CONSIDERATIONS

20. Plant Site — General

200. Some factors to be considered in selection of plant site locations are:

(1) Provision for minimum clearances as stated in this Standard between LNG containers, flammable refrigerant storage tanks, flammable liquid storage tanks, structures and plant equipment both with respect to plant property lines and each other.

(2) Accessibility to plant. At least one all-weather vehicular road shall be provided.

(3) The degree to which the plant can, within limits of practicality, be protected against forces of nature.

(4) Other factors applicable to the particular situation which could have a bearing on the safety of plant personnel and the surrounding public.

201. Site preparation shall include provisions for retention of spilled LNG; flammable refrigerants and flammable liquids within the limits of plant property and for surface water drainage.

202. At LNG facilities there shall be a protective enclosure such as a peripheral fence, building wall, or natural barrier enclosing major facility components, such as:

(1) LNG storage containers
(2) Flammable refrigerant storage tanks
(3) Flammable liquid storage tanks
(4) Other hazardous materials storage areas
(5) Outdoor process equipment areas
(6) Buildings housing process or control equipment
(7) On shore loading and unloading facilities.

The provisions of 202 may be met by either one continuous enclosure or several independent enclosures. When the enclosed area exceeds 1250 square feet, at least two exit gates or doors shall be provided for rapid escape of personnel in the event of an emergency.

21. Major Site Provisions for Spill and Leak Control

210. General

2100. One of the following provisions shall be made to minimize the possibility of accidental discharge of LNG at containers from endangering adjoining property or important process equipment and structures, or reaching waterways (see 2102):

(a) An impounding area surrounding the container(s), which is formed by a natural barrier, dike, impounding wall (or combination thereof), complying with 211 and 212, or

(b) An impounding area formed by a natural barrier, dike, excavation, impounding wall (or combination thereof) complying with 211 and 212, plus a natural or man-made drainage system surrounding the container(s) that complies with 211 and 212, or

(c) Where the container is constructed below the surrounding grade, an impounding area formed by the excavation complying with 211 and 212.

2101. The following areas shall be graded and drained in a manner that will minimize the possibility of accidental spills and leaks from endangering important structures or equipment or adjoining property or from reaching waterways (see 2102):

(a) Process areas

(b) Vaporization areas

(c) In-plant LNG, flammable liquid, and flammable refrigerant transfer areas.

(d) Areas immediately surrounding flammable refrigerant and flammable liquid storage tanks.

If impounding areas are also required in order to comply with 201, such areas shall be in accordance with 211 and 212.

2102. In particular installations, the provisions of 2100 and 2101 applicable to adjoining property or waterways, may be waived or altered at the discretion of the authority having jurisdiction when the change does not constitute a distinct hazard to life or property or conflict with applicable Federal, State and local regulations.

2103. Flammable liquid and flammable refrigerant storage tanks shall not be located within an LNG container impounding area.

211. Impounding Area and Drainage System Design and Capacity

2110. The minimum volumetric capacity of an impounding area serving LNG storage containers, including any useful holding capacity of the drainage system, shall equal the volume of liquid in the largest container which could empty into the area assuming that the container is full. Allowance shall be made for the displacement of other containers and equipment.

2111. Impounding areas designed to serve only vaporization, process, or LNG transfer equipment areas, shall have a capacity at least equal to the greatest volume of LNG, flammable refrigerant, or flammable liquid which could be discharged into the area during a 10-minute period from any single accidental source.

2112. Enclosed drainage channels for LNG are prohibited.

2113. Dikes, impounding walls and drainage channels for LNG and flammable refrigerant containment shall be of compacted earth, concrete, metal and/or other suitable materials. They may be independent of the container or they may be mounded, integral to, or constructed against the container. They shall be designed to withstand the full hydrostatic head of impounded LNG or flammable refrigerant, the effect of rapid cooling to the temperature of the liquid to be confined, any anticipated fire exposure, and natural forces such as earthquake, wind and rain. Thin wall outer shells of double wall tanks shall not be considered as satisfying the requirements of 2100.

2114. Dikes, impounding walls and drainage channels for flammable liquid containment shall conform to NFPA No. 30, Flammable and Combustible Liquids Code.

2115. To assure that any accidentally discharged liquid stays confined within a diked or impounding walled area and yet provide a reasonably wide margin for area configuration design, the dike or impounding height and distance from containers shall be determined in accordance with Figure 2-1.

2116. Provision shall be made to clear rain or other water from the impounding area. Automatically controlled sump pumps are permitted if equipped with an automatic cutoff device which shall prevent their operation when exposed to LNG temperatures. Piping, valves and fittings whose failure could permit liquid to escape from the impounding area shall be suitable for continuous exposure to LNG temperatures.

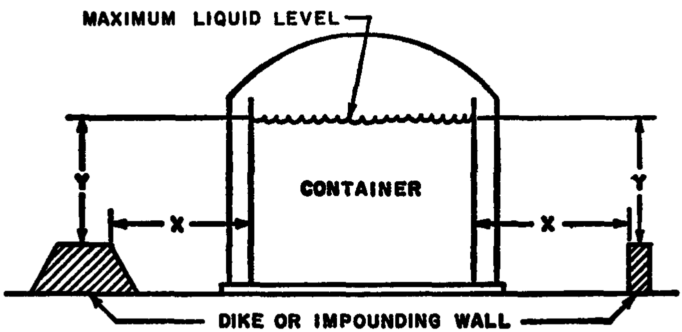

Figure 2-1

Dike or Impounding Wall Proximity to Containers

Notes to Figure 2-1:

Dimension "X" must equal or exceed 0.6 times dimension "Y".

Dimension "X" is the distance from the inner wall of the container to the closest face of the dike or impounding wall.

Dimension "Y" is the distance from the maximum liquid level in the container to the top of the dike or impounding wall.

212. Impounding Area Spacing

2120. Except as permitted in 2121, 2122, and 2123, impounding areas shall be sited in accordance with Formula 1.

Formula 1

$$d = 0.8 \sqrt{A}$$

Where:

d = distance, in feet, to property line which may be built upon from nearest edge of impounded liquid. The distance (d) shall not be less than 50 feet (15 meters) to the near edge of a navigable waterway as defined by Federal Regulations.

A = surface area, in square feet, of impounded liquid.

2121. The spacing requirement for impounding areas serving containers of less than 70,000 gallons capacity may be reduced to one-half that calculated from Formula 1.

2122. The spacing requirement for impounding areas serving only LNG containers that are fitted with "over-the-top" fill and withdrawal connections and which have no tank penetrations below the liquid level, may be computed from Formula 1 where "A" is determined by assuming the quantity of impounded LNG to be that which could be pumped into the impounding area during a 10-minute period with the pumps considered to be delivering full-rated capacity.

2123. The spacing requirement for impounding areas serving only LNG containers that are fitted with internal shutoff valves in accordance with 6222 may be computed from Formula 1 where "A" is determined by using a volume, Q, calculated from Formula 2.

Formula 2

$$Q = 80 d^2 \sqrt{h}$$

Where:

Q = quantity, in cubic feet, of liquid

d = diameter, in inches, of largest container or tank penetration below the liquid level

h = height, in feet, of liquid above penetration in container or tank when full

213. Container Spacing

2130. LNG containers and tanks containing flammable refrigerants shall be sited in accordance with Table 2-1.

Table 2-1

<table>
<tr><th></th><th colspan="2">Minimum Clear Distances</th></tr>
<tr><th>Water Capacity per Container</th><th>From Container to Property Line Which May Be Built Upon</th><th>Between Adjacent Containers</th></tr>
<tr><td>Less than 125 gals. (1)</td><td>None</td><td>None</td></tr>
<tr><td>125 to 250 gallons</td><td>10 feet</td><td>None</td></tr>
<tr><td>251 to 500 gallons</td><td>10 feet</td><td>3 feet</td></tr>
<tr><td>501 to 2,000 gallons</td><td>25 feet</td><td>3 feet</td></tr>
<tr><td>2,001 to 30,000 gals.</td><td>50 feet</td><td>5 feet</td></tr>
<tr><td>30,001 to 70,000 gals.</td><td>75 feet</td><td rowspan="2">¼ of sum of diameters of adjacent containers but not less than 25 feet.</td></tr>
<tr><td>Above 70,000 gallons</td><td>0.7 times the container diameter but not less than 100 feet.</td></tr>
</table>

(1) If the aggregate water capacity of a multicontainer installation is 501 gallons or greater, the minimum distance shall comply with the appropriate portion of this table, applying the aggregate capacity rather than the capacity per container. If more than one installation is made, each installation shall be separated from another installation by at least 25 feet. Do not apply the Minimum Distances Between Adjacent Containers to such installations.

214. Vaporizer Spacing (See Chapter 5 for vaporizer classification).

2140. Vaporizers and their primary heat sources, unless the intermediate heat transfer fluid is nonflammable, shall be located at least 50 feet (15 meters) from any other source of ignition. In multiple vaporizer installations, an adjacent vaporizer or primary heat source is not considered to be a source of ignition.

(a) Process heaters or other units of fired equipment are not considered to be sources of ignition with respect to vaporizer siting, provided they are interlocking so that they cannot be operated when a vaporizer is operating or when the piping system serving the vaporizer is either cooled down or being cooled down.

2141. Integral heated vaporizers shall be located at least 100 feet (30.5 meters) from a property line which may be built upon (see 2143) and at least 50 feet (15 meters) from:

(a) any impounded LNG, flammable refrigerant, or flammable liquid (see 213) or the paths of travel of such fluids between any other source of accidental discharge and the impounding area;

(b) LNG, flammable liquid, flammable refrigerant, or flammable gas storage containers or tanks, unfired process equipment containing such fluids, or loading and unloading connections used in the transfer of such fluids;

(c) control of buildings, offices, shops, and other occupied or important plant structures.

2142. Heaters or heat sources of remote heated vaporizers shall comply with 2141 except, if the intermediate heat transfer liquid is nonflammable, the property line clearance and 2141(c) do not apply.

2143. Remote heated, ambient, and process vaporizers shall be located at least 100 feet (30.5 meters) from a property line which can be built upon. Remote heated and ambient vaporizers may be located within an impounding area.

2144. Vaporizers used in conjunction with LNG containers having a capacity of 70,000 gallons (265 kiloliters) or less shall be located in accordance with Table 2-1 considering the vaporizer as a container of the same size.

2145. In multiple heated vaporizer installations, a clearance of at least 5 feet (1.5 meters) shall be maintained between vaporizers.

215. Process Equipment Spacing

2150. Process equipment containing LNG, refrigerants, flammable liquids or flammable gases shall be located at least 50 feet (15 meters) from sources of ignition, a property line which may be built upon, from control rooms, offices, shops and other occupied structures; except that control rooms may be located in a building housing flammable gas compressors if the building construction complies with 2200.

2151. Fired equipment and other sources of ignition shall be located at least 50 feet (15 meters) from any impounding area or container drainage system.

216. Loading and Unloading Facility Spacing

2160. A pier or dock used for pipeline transfer of LNG shall be located so that any marine vessel being loaded or unloaded is at least 100 feet (30.5 meters) from any bridge crossing a navigable waterway. The loading or unloading manifold shall be at least 200 feet (61 meters) from such a bridge.

2161. LNG and flammable refrigerant loading and unloading connections shall be at least 50 feet (15.2 meters) from uncontrolled sources of ignition, process areas, storage containers, control buildings, offices, shops and other occupied or important plant structures. This does not apply to structures or equipment directly associated with the transfer operation.

22. Buildings and Structures

220. Buildings or structural enclosures in which LNG, flammable refrigerants and flammable gases are handled shall be of lightweight noncombustible construction with nonload-bearing walls.

2200. If rooms containing such fluids are located within or attached to buildings in which such fluids are not handled, i.e., control rooms, shops, etc., the common walls shall be limited to no more than two in number, shall be designed to withstand a static pressure of at least 100 psf ($480N/m^2$), have no doors or other communicating openings, and shall have a fire resistance rating of at least one hour.

221. Such buildings or structural enclosures shall be ventilated to minimize the possibility of hazardous accumulations of flammable gases or vapors in accordance with 2210 through 2212.

2210. Ventilation may be by means of:

(a) A continuously operating mechanical ventilation system, or

(b) A combination gravity ventilation system and normally off mechanical ventilation system which is energized by suitable combustible gas detectors in the event combustible gas is detected, or

(c) A dual rate mechanical ventilation system with the high rate energized by suitable gas detectors in the event flammable gas is detected.

(d) A gravity ventilation system composed of a combination of wall openings and roof ventilators. If there are basements or depressed floor levels a supplemental mechanical ventilation system shall be provided.

2211. The ventilation rate shall be at least 1 cfm of air per square foot of floor area.

2212. If vapors heavier than air can be present, a suitable part of the ventilation must be from the lowest level exposed to such vapors.

23. Designer and Fabricator Competence

230. Designers and fabricators of LNG facilities shall have competence in the design or fabrication of LNG containers, process equipment, refrigerant storage and handling equipment, loading and unloading facilities, fire protection equipment, and other components of the facility.

2300. Adequate supervision shall be provided for the fabrication and all acceptance tests of facility components to the extent necessary to assure that they are structurally sound, suitable for the service, and otherwise in compliance with this Standard.

2301. Sufficient soil and general investigations shall be made to determine the adequacy of the intended site for the facility.

24. Soil Protection for Cryogenic Equipment

240. LNG containers, coldboxes, piping and pipe supports and other cryogenic apparatus shall be properly designed and constructed to prevent damage to these structures and equipment from freezing or frost heaving in the soil, or suitable means shall be provided to prevent damaging forces from developing.

Note: Soil movements due to freezing of water are of two general types: (1) The freezing of *in situ* water can cause about two percent volumetric expansion of a moist soil; (2) Frost heave is caused by migration of water to a zone of freezing and a continual growth of ice lenses. If heat or air circulation are not supplied at the soil surface, consideration of a qualified soils engineer shall be given to the depth of the freezing zone and possibility of soil movement by freezing.

Examples of suitable means for preventing damaging freezing forces are: (1) Frost heave susceptible soil may be replaced for an adequate distance, or (2) heating coils may be provided to stabilize the freezing isotherm at adequate distance from the container.

25. Falling Ice and Snow

250. Where appropriate, suitable measures shall be taken to protect personnel and equipment from falling ice or snow which may have accumulated on high structures.

CHAPTER 3. PROCESS SYSTEMS

30. General

300. Process system equipment containing LNG, flammable refrigerants or flammable gases should be installed outdoors for ease of operation, to facilitate manual fire fighting, and facilitate dispersal of accidentally released liquids and gases.

3000. If such systems are installed indoors, the enclosing structures shall comply with 220 and 221.

31. Pumps and Compressors

310. Pumps and compressors shall be constructed of materials suitable for the temperature and pressure conditions which might be encountered.

311. Valving shall be installed so that each pump or compressor can be isolated for maintenance. Where pumps or centrifugal compressors are installed for operation in parallel, each discharge line shall be equipped with a check valve.

312. Pumps and compressors shall be provided with a pressure relieving device on the discharge to limit the pressure to the maximum safe working pressure of the casing and downstream equipment unless the casing and downstream piping are designed for the maximum shutoff pressure.

313. Each pump shall be provided with an adequate vent and/or relief valve which will prevent overpressuring the pump case during the maximum possible rate of cooldown.

314. The foundations and sumps for cryogenic pumps shall be designed and constructed to prevent frost heaving.

315. Pumps used for transfer of liquids at temperatures below minus 20 F (minus 28.9 C) shall be provided with suitable means for precooling to reduce effect of thermal shock.

32. Flammable Refrigerant and Flammable Liquid Storage

320. Installation of storage tanks for flammable refrigerants and liquids shall comply with NFPA Nos. 30, 58 or 59 or American Petroleum Institute (API) Standard 2510,* as appropriate, or with Section 21 of this Standard.

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*See Appendix B for availability.

33. Process Equipment

330. Process equipment shall be sited in accordance with Section 21.

331. Boilers shall be designed and fabricated in accordance with Section I and pressure vessels shall be designed and fabricated in accordance with Section VIII, Division 1, of the ASME Code (see Definitions), and shall be Code stamped.

332. Shell and tube heat exchangers shall be designed and fabricated in accordance with the Standards of the Tubular Exchanger Mfrs. Association (TEMA) 1968 edition.* The shells and internals of all exchangers shall be pressure tested, inspected and stamped in accordance with Section VIII, Division 1, of the ASME Code (see Definition), when such components fall within the jurisdiction of this Code.

333. Installation of internal combustion engines or gas turbines shall conform to the Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines, NFPA No. 37.

334. A boiloff and flash gas handling system separate from container relief valves shall be installed for the safe disposal of vapors generated in the process equipment and LNG containers.

3340. LNG containers shall have their boiloff and flash gases discharged safely into the atmosphere or into a closed system. The boiloff venting system shall be designed so that it cannot normally inspirate air during operation.

3341. Provision may be made to introduce gas into the container in the event a vacuum is experienced if the gas is so introduced will not create a flammable mixture within the container.

335. Consideration shall be given to provisions for depressurizing equipment containing gases and liquids in case of fire or failure of the equipment (see 901 and 932). Consideration shall be given to a safe disposal location for gases and liquids.

3350. Emergency controls to effect the depressurization shall be conspicuously marked with their function designated and shall be accessible under emergency conditions.

*See Appendix B for availability.

3351. The discharge of flammable gases or liquids from relief devices shall be directed into a closed system or to a point of safe disposal. Flammable gases may be discharged directly to atmosphere. (See Section 47.)

336. A coldbox structure and its contents shall be constructed of materials which do not support combustion.

3360. Cold boxes shall be purged in accordance with Section 45, treating the cold box as a container. If a flammable mixture is detected within the cold box at any time, purge gas shall be introduced until the mixture is outside of the flammable range.

337. Compression equipment handling flammable gases shall be provided with vents from all points where gases may normally escape. Vents shall be piped outside of buildings to a point of safe disposal.

34. Air Injection

340. In those cases where air may have been injected into the plant inlet natural gas stream, provision shall be made to prevent a flammable mixture from occurring under any operating condition.

CHAPTER 4. STATIONARY LNG STORAGE CONTAINERS

40. General

400. Inspection

4000. Prior to initial operation, containers shall be inspected to the extent necessary to assure compliance with the engineering design, and with the material, fabrication, assembly, and test provisions of this Standard. The operator shall be responsible for this inspection.

4001. The operator may delegate performance of any part of the inspection to inspectors who may be employees of his own organization, or an engineering or scientific organization, or of a recognized insurance or inspection company.

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

402. Storage containers for LNG shall be designed for the minimum temperature of the LNG product to be stored when it is at atmospheric pressure.

403. All materials used in intimate contact with LNG shall be physically, chemically and thermally compatible with LNG.

404. Where two or more containers are sited in a common dike, the container foundations shall be capable of withstanding contact with LNG or shall be protected against contact with an accumulation of LNG which might endanger structural integrity.

405. The density of the liquid shall be assumed at the actual weight per cubic foot at the minimum storage temperatures except that in no case will the density assumed be less than 29.3 pounds per cubic foot (470 kilograms per cubic meter).

406. When applicable, seismic loads shall be considered in the design. The Uniform Building Code, Volume 1, 1970 Edition,* shall apply.

407. Any exposed insulation shall be noncombustible, shall contain, or inherently shall be, a vapor barrier, be water free and shall resist dislodgment by fire hose streams. When an outer shell is used to retain loose insulation, the shell shall be constructed of steel or concrete. Exposed weatherproofing shall have a flame spread rating not greater than 25 (see Definition of Flame Spread Rating).

*See Appendix B for availability.

408. The maximum filling volume of an LNG container shall be in accordance with Figure 4-1. The liquid capacity is the volume of liquid to its maximum permissible level.

NOTE (1) After filling a container, the gas pressure may be less than the maximum allowable working pressure. Expansion of the liquid will occur when the liquid subsequently warms and the pressure rises to the maximum allowable working pressure. The operator shall limit the maximum filling volume as indicated by the graph to avoid overfilling when this expansion occurs.

NOTE (2) For containers with maximum allowable working pressures less than about 2 psig (about 0.014 MN/m²) the correction for maximum filling volume is negligible and may be omitted.

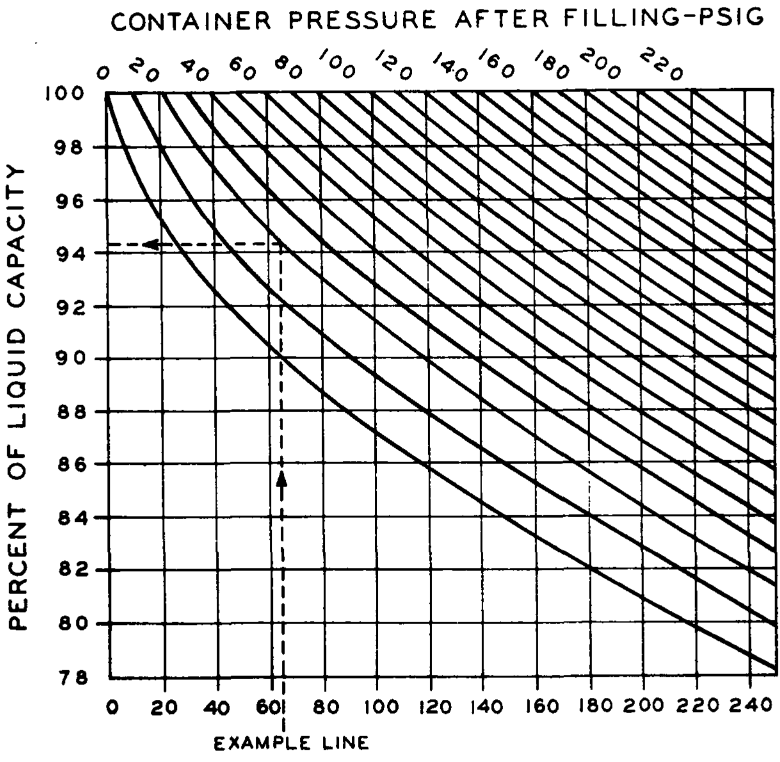

Figure 4-1. Maximum Filling Volume for Pressure Containers

Example: A container designed for a maximum allowable working pressure of 65 psig has the relief valve set at 65 psig. After filling, the gas pressure at the top is 20 psig. From the chart, the maximum filling volume is 94.3% of the liquid capacity.

41. Metal Containers

410. Foundations

4100. Aboveground LNG containers shall be supported on suitable foundations designed by a qualified engineer. The design shall comply with American Petroleum Institute (API) Standard 620,* Appendix Q, Paragraphs Q.9 through Q.9.4.

NOTE: Appendix C, API Standard 620, contains general information on foundations for low pressure containers.

411. Containers Designed for Operation at 15 Psig and Less

4110. Welded containers designed for not more than 15 psig shall comply with API Standard 620.* Appendix Q of this Standard is specifically applicable for LNG.

412. Containers Designed for Operation at More than 15 Psig

4120. Containers may be double-walled with the inner container holding the LNG surrounded by insulation contained within the outer jacket. The insulation may be evacuated or purged.

4121. The inner container shall be of welded construction and shall conform to the provisions of Section VIII, Division 1, of the ASME Code (see Definition).

(a) Any of the materials authorized for minus 260 F (minus 162 C) service by the ASME Code are acceptable.

(b) In the case of vacuum insulation, the design pressure shall be the sum of the required working pressure, 15 psig (0.103MN/m²) for vacuum allowance and the hydrostatic head of LNG. In the case of nonvacuum insulation, the design pressure shall be the sum of the required working pressure and the hydrostatic head of LNG.

4122. The outer jacket shall be of welded construction.

(a) Any of the carbon steels authorized in the UCS Section of the ASME Code are acceptable if suitable for anticipated ambient temperatures.

(b) In the case of vacuum insulation, the jacket shell shall be designed by the procedures outlined in UG-28, UG-29 and UG-30 of the ASME Code using an external pressure of not less than 7.5 psi (0.052 MN/m²) (differential). ASME Code Case 1290 may also be used. Spun heads which meet the tolerance provisions of UG-81 may be designed by the procedures outlined in UG-33 of the ASME

*See Appendix B for availability.

Code using an external pressure of not less than 7.5 psi (0.052 MN/m². Heads and spherical jackets which are formed in segments and are assembled by welding shall be designed using an external pressure of 15 psi (0.103 MN/m²).

(c) In the case of nonvacuum insulation and a positive pressure purge, the jacket shall be designed for adequate structural support of the inner tank and the insulation and the maximum positive pressure of the purge gas.

(d) The jacket shall be equipped with a relief device or other device to release internal pressure. The discharge area must be at least 0.00024 square inches per pound (0.0034 square centimeters per kilogram) of water capacity of the inner tank but the area need not exceed 300 square inches (2000 square centimeters). Such a device must function at a pressure not exceeding the internal design pressure of the jacket, the external design pressure of the inner tank, or 25 psi (0.172 MN/m²), whichever is less.

(e) When it is possible that the jacket temperature may go below its design temperature because of conduction from cold lines, thermal barriers shall be provided between the lines and the jacket.

(f) Saddles and legs shall be designed in accord with recognized structural engineering practices. Consideration shall be given to shipping loads, erection loads, seismic loads, wind loads, and thermal loads.

4123. The space between the inner tank and the jacket shall contain insulation that is compatible with LNG and natural gas and does not form a flammable mixture even if any concentration of air is present. The insulation shall be such that a fire external to the jacket will not cause significant deterioration to the insulation thermal conductivity by melting, settling, etc.

(a) Consideration shall be given to the external pressure created by the insulation and from a dry gas purge, if utilized. The inner tank shall be designed to withstand this loading without collapse.

4124. Stress concentrations from the support system shall be minimized by the use of pads, load rings, etc. Consideration shall be given to the expansion and contraction of the inner tank and the support system shall be so designed that thermal stresses imparted to the inner tank are minimized.

4125. Internal lines (those between the inner container and the jacket and within the insulation space) shall be designed for the pressure rating of the inner container with allowance for the thermal stresses created by the minus 260 F (minus 162 C) temperature including both line contraction and contraction movement of the inner container. No bellows are permissible within the insulation space.

(a) Lines shall be of materials satisfactory for minus 260 F (minus 162 C) as determined by the ASME Code. No liquid line external to the jacket shall be of aluminum or copper or a copper alloy unless protected against a two-hour fire exposure. Transition joints may be used.

4126. The inner container shall be supported essentially concentrically within the jacket by either a metallic or a nonmetallic system which is capable of sustaining the maximum loading of 4126(a) or (b).

(a) For shipping load, the supports shall be designed for the maximum number of g's (see Definition) to be encountered multiplied by the empty weight of the inner container.

(b) For operating load, the supports shall be designed for the total weight of the inner container plus the maximum lading. Appropriate seismic factors shall be included. The weight of contained liquid shall be based upon the maximum density of the specified liquid within the range of operating temperatures except that the minimum density shall be at least 29.3 pounds per cubic foot (470 kilograms per cubic meter).

(c) The allowable design stress in support members shall be the lesser of ⅓ the tensile strength or ⅝ of the yield strength at room temperature. For threaded members the minimum area at the root of the threads shall be used.

42. Concrete Containers

420. Scope

4200. This section applies to the design and construction of prestressed concrete containers for any operating pressure, whether externally or internally insulated, and for prestressed concrete protective walls surrounding any type of container.

421. Foundations

4210. Concrete LNG containers shall be installed on foundations or supports of concrete, steel or a suitable foundation of aggregate which shall have been designed by a qualified engineer and constructed in accordance with recognized structural engineering practices to ensure a stable foundation. Flotation forces which may exist due to the difference in density between the LNG and the displaced ground shall be considered and suitable anchorage shall be provided if necessary.

422. Container Structure

4220. Design of the concrete containers shall comply with American Concrete Institute standard, Building Requirements for

Reinforced Concrete (ACI 318–63)*, the provisions of ACI Committee Report 344* "Design and Construction of Circular Prestressed Concrete Structures," and be in accordance with 4221, 4222, and 4223.

4221. Allowable stresses for normal design considerations shall be based upon room temperature strength values.

4222. Reinforcing bars under tension in zones which may reach LNG temperatures shall be limited to the following maximum allowable stresses:

#4 and smaller	— 12,000 psi (82.7 MN/m^2)
#6	— 10,000 psi (68.9 MN/m^2)
#8 and larger	— 8,000 psi (55.2 MN/m^2)

4223. Steel wire or strands, as specified in 4233 and used as unstressed reinforcement, shall be designed with a maximum allowable stress as follows:

Crack control applications	— 30,000 psi (206.8 MN/m^2)
Other applications	— 80,000 psi (522 MN/m^2)

4224. External forces imposed upon the container by backfill restraint during warm-up shall be considered.

423. Materials Subject to LNG Temperature

4230. Concrete shall be as specified by *Recommended Practice for Measuring, Mixing, and Placing of Concrete* (ACI 614–59)*; *Minimum Requirements for Thin-Section Precast Concrete Construction* (ACI 525–63)*; and *Building Code Requirements for Reinforced Concrete* (ACI 318–63)*, concerning construction requirements, specifications, and tests.

(a) It is recommended that tests be carried out for the compressive strength and for the coefficient of contraction of the concrete at the projected low temperature, unless prior test data on these properties are available.

4231. Aggregate shall be as specified by *Concrete Aggregates* (ASTM C33–67)*. Aggregate shall be dense and physically and chemically sound to provide a high strength and durable concrete.

4232. Pneumatic Mortar shall be as specified in *Recommended Practice for Shotcreting* (ACI 506–66)*.

4233. High tensile strength elements for prestressed concrete shall be as specified by *Hard-Drawn Steel Mechanical Wire* (ASTM A227–68)*; *Specifications for Uncoated Stress-Relieved Wire for Pre-*

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*See Appendix B for availability.

stressed Concrete (ASTM A421–65)*; and *Specifications for Uncoated Wire Stress-Relieved Strands for Prestressed Concrete* (ASTM A416–68)*. In addition, any material acceptable for service at LNG temperature, such as those materials specified for "Primary Components" in American Petroleum Institute (API) 620*, or any material shown by test to be acceptable for LNG service may be used.

4234. Reinforcing steel for reinforced concrete shall be as specified in *Specifications for Billet-Steel Bars for Concrete Reinforcement* (ASTM A15–66)*; *Specifications for Minimum Requirements for the Deformations for Deformed Bars for Concrete Reinforcement* (ASTM A305–66)*; *Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement* (ASTM A82–66)*; *Specifications for Welded Steel Wire Fabric for Concrete Reinforcement* (ASTM A185–64)*; and *Specifications for Deformed Billet-Steel Bars for Concrete Reinforcement with 60,000 psi Minimum Yield Strength* (ASTM A432–66)*.

4235. Nonstructural metallic barriers incorporated in and functioning compositely with prestressed concrete in direct contact with LNG during normal operations may be of any metal classified for either "Primary components" or "Secondary components" in API 620, Appendix Q,* providing that the composite section is prestressed such that no significant tensile stresses are developed under any design loading condition.

4236. Nonstructural metallic barriers incorporated in and functioning compositely with prestressed concrete, serving primarily as moisture barriers for internally insulated tanks, may be of any metal classified for either "primary component" or "secondary component" service in API 620, Appendix Q* or of steel conforming to *Cold-Rolled Carbon Steel Sheets, Commercial Quality* (ASTM A366–68)* providing that the composite section is prestressed such that no significant tensile stresses are developed under any design loading condition.

4237. The use of alternative materials of construction may be approved by the authority having jurisdiction provided they afford an equivalent degree of safety to those specified.

424. Construction, Inspection and Tests

4240. Concrete LNG containers shall be built in accordance with the applicable provisions of Building Code Requirements for Reinforced Concrete (ACI 318–63)*, and ACI Committee Report 344,* Design and Construction of Circular Prestressed Concrete Structures.

*See Appendix B for availability.

4241. Concrete LNG containers shall be inspected in accordance with Recommended Practice for Concrete Inspection (ACI 311–64)* and Section 44.

4242. Metal components shall be constructed and tested in accordance with the applicable provisions set forth in API Standard 620,* Recommended Rules for Design and Construction of Large, Welded, Low-Pressure Storage Tanks, Appendix Q.

4243. Other materials used in the construction of concrete LNG containers shall be subjected to suitable inspection and tests.

43. Marking of LNG Containers

430. Each container shall be identified by the attachment of a nameplate in an accessible place marked with the following information:

(a) Builder's name and date built.

(b) Nominal liquid capacity; barrels, gallons, or cubic meters.

(c) Design pressure in appropriate units for methane gas at top of container.

(d) Maximum permissible density of liquid to be stored.

(e) Maximum level to which container may be filled with stored liquid (see 408).

(f) Maximum level to which container may be filled with water for test, if applicable.

(g) Minimum temperature in degrees Fahrenheit or Celsius for which the container was designed.

431. Storage containers shall have all penetrations marked with the function of the penetration. Consideration shall be given to "frosting" and identification shall not be lost from such effect.

44. Testing of LNG Containers

440. LNG containers shall be leak tested by a method appropriate to the design, construction, and operating pressure of the container and in accordance with the governing construction code or standard. All leaks shall be repaired.

4400. Inspection shall be performed in accordance with the Inspection and Tests section of the applicable construction code. If no specific single code is applicable the equivalent of API 620 should be applied for containers designed for 15 psig (0.103 MN/m^2) and under and of the ASME Code (see Definitions) for containers designed for over 15 psig (0.103 MN/m^2) design pressure.

*See Appendix B for availability.

4401. Shop fabricated and tested LNG containers shall be leak tested to a minimum of the design pressure after installation and prior to filling the container with LNG.

4402. For vacuum insulation, the inner tank, outer jacket and internal lines shall be tested for vacuum leaks by an appropriate procedure.

441. After acceptance tests are completed, there shall be no field welding on the LNG containers except upon saddle plates or brackets provided for the purpose or as otherwise provided for by the code under which the container was fabricated.

45. Container Purging Procedures

450. There are several methods used for purging large vessels into and out of service. This Standard does not restrict constructors or operators to any one technique but cautions that only experienced and qualified personnel be responsible for such activities.

NOTE: There are several references covering the purging of large vessels, two of which are American Gas Association's "Gas Engineer's Handbook"* and American Petroleum Institute's "Recommended Practice for Cleaning Petroleum Storage Tanks" (API RP 2015).*

451. Prior to placing an LNG container into service the air must be displaced by an acceptable procedure.

452. Prior to taking a container out of service, the natural gas in the container shall be purged from the container in a safe manner using a proven procedure.

NOTE: Many insulating materials which have had prolonged exposure to natural gas or methane retain appreciable quantities of the gas within their pores or interstitial spaces.

453. During purging operations, the oxygen content of the container shall be determined by the use of an acceptable oxygen analyzer.

46. Cooldown Procedure

460. Cooldown of an LNG container shall be limited to a rate and distribution pattern that will assure thermal stresses are within allowable limits during the cooldown period.

461. During initial cooldown of the tank particular attention shall

*See Appendix B for availability.

be given to tank penetrations to ensure proper performance of expansion bends or joints.

47. Pressure and Vacuum Control

470. Provision shall be made to maintain the internal pressure and vacuum of LNG containers within the limits set by the design specifications by releasing or admitting gas as needed. Factors which shall be considered in sizing such pressure control means shall include:

4701. For Pressure:

(a) Loss of refrigeration
(b) Operational upset, such as failure of a control device
(c) Vapor displacement and flash vaporization during filling
(d) Drop in barometric pressure

4702. For Vacuum:

(a) Withdrawal of liquid at the maximum rate
(b) Withdrawal of vapor at the maximum compressor suction rate
(c) Rise in barometric pressure
(d) Reduction in vapor pressure resulting from the introduction of sub-cooled LNG into the vapor space

471. Provision for admission and release of gas required in 470 may be by any means compatible with the gas handling facilities in the plant.

472. In addition to the pressure control means provided for in 470, LNG containers shall be equipped with adequate direct acting pressure relief valves and vacuum relief valves (vacuum breakers) communicating directly with the atmosphere and having capacities calculated for any likely combination of the factors listed in 4701 and 4702. Pressure relief valves shall also consider discharge which can accompany fire exposure (see Appendix A).

CHAPTER 5. VAPORIZATION FACILITIES

50. Classification of Vaporizers

500. Heated Vaporizers shall be classified as those vaporizers which derive their heat from the combustion of fuel, electric power, or waste heat, such as from boilers or internal combustion engines.

5000. INTEGRAL HEATED VAPORIZERS shall be classified as those heated vaporizers in which the heat source is integral to the actual vaporizing exchanger. This classification includes submerged combustion vaporizers.

5001. REMOTE HEATED VAPORIZERS shall be classified as those heated vaporizers in which the primary heat source is separated from the actual vaporizing exchanger and an intermediate fluid (e.g., water, steam, isopentane, glycol, etc.) is used as the heat transport medium.

501. Ambient Vaporizers shall be classified as those vaporizers which derive their heat from naturally occurring heat sources such as the atmosphere, sea water, or geothermal waters.

NOTE: If the temperature of the naturally occurring heat source exceeds 212 F (100 C) the vaporizer shall be considered to be a Remote Heated Vaporizer.

502. Process Vaporizers shall be classified as those vaporizers which derive their heat from another thermodynamic or chemical process or in such a fashion as to conserve or utilize the refrigeration from the LNG.

51. Design and Materials of Construction

510. Vaporizers shall be designed, fabricated and inspected in accordance with Section VIII, Division 1 of the ASME Code (see Definition). Because these vaporizers operate over a temperature range of minus 260 F to 100 F (minus 162 C to 38 C) the rules of Section 1 of the ASME Code, Part PVG, are not applicable.

52. Vaporizer Piping and Intermediate Fluid Piping and Storage

520. Manifolded vaporizers shall have both inlet and discharge block valves at each vaporizer.

521. The discharge valve of each vaporizer, piping components and relief valves installed upstream of that valve shall be suitable for operation at LNG temperatures (minus 260 F or minus 162 C).

522. Suitable automatic equipment shall be provided to prevent the discharge of either LNG or vaporized gas into a distribution system at a temperature either above or below the design temperatures of the sendout system.

5220. Isolation of an idle manifolded vaporizer to prevent leakage of LNG into that vaporizer shall be accomplished with two inlet valves, and a safe means shall be provided to dispose of the LNG or gas which may accumulate between the valves. Ambient vaporizers having inlets 2 inches in size or less, need not comply with this provision.

523. Each *heated vaporizer* shall be provided with a means to shut off the heat source from a location at least 50 feet (15 meters) distant from the vaporizer. The device shall also be operable at its installed location.

524. A shutoff valve shall be installed on the LNG line to a vaporizer at least 50 feet (15 meters) from the vaporizer except when the vaporizer is closer than 50 feet (15 meters) to the container from which it is supplied (See 2143), in which case the provisions of 525 apply. If the vaporizer is installed in a building the shutoff valve shall be installed at least 50 feet (15 meters) from the building. This may be the valve provided for in 6221.

5240. This shutoff valve shall be operable either at its installed location or from a remote location, and the valve shall be protected from becoming inoperable due to external icing conditions.

525. An *Ambient* or *Remote Heated Vaporizer*, which is installed within 50 feet (15 meters) of an LNG container (see 2142) shall be equipped with an automatic shutoff valve in the liquid line which will close on loss of pressure (excess flow), on abnormal high temperature (fire), or low temperature. At attended facilities, remote operation of this valve from a point at least 50 feet (15 meters) from the vaporizer is acceptable.

526. If a flammable intermediate fluid is used with a *Remote Heated Vaporizer*, shutoff valves shall be provided on both the hot and cold lines of the intermediate fluid system. The controls for these valves shall be located at least 50 feet (15 meters) from the vaporizer.

53. Relief Devices on Vaporizers

530. Each vaporizer shall be provided with a safety relief valve providing an effective rate of discharge. The minimum required rate of discharge shall be determined so as to prevent pressures exceeding those allowed by the governing code giving proper consideration to fire exposure.

531. For exposure to external fire the relief valve capacity shall be calculated as follows:

5310. Obtain the total wetted surface area in the vaporizer, A, by adding the area of the shell in direct contact with the LNG, and the area of heat exchange surface in direct contact with the LNG.

5311. Obtain the discharge rate in cubic feet of air per minute at 60 F (15.6 C) and 14.7 psia (0.101 MN/m^2) by substituting the area, A, in the applicable equation given in Appendix A. Equation (1) can be used for vaporizers with external insulation and Equation (2) for uninsulated vaporizers.

532. Relief valves on heated vaporizers shall be so located that they are not subjected to temperature exceeding 140 F (60 C) during normal operation unless designed to withstand higher temperatures.

54. Combustion Air Supply

540. Combustion air required for the operation of integral heated vaporizers or the primary heat source for remote heated vaporizers shall be taken outside a completely enclosed structure or building.

55. Products of Combustion

550. When integral heated vaporizers or the primary heat source for remote heated vaporizers are installed in buildings, consideration shall be given to the prevention of an accumulation of hazardous products of combustion.

CHAPTER 6. PIPING SYSTEMS AND COMPONENTS

60. General

600. The design and fabrication of piping systems shall be in accordance with American National Standard (ANSI) B31.3,* "Petroleum Refinery Piping", 1966, except as modified by the provisions of this Chapter.

61. Component Materials

610. General

6100. Materials, such as gaskets or thread compounds, shall be suitable for use with the fluids handled throughout the range of temperatures to which they will be subjected.

611. Piping

6110. Spiral weld, furnace lap-weld, and furnace butt-welded pipe shall not be used. Seamless pipe should be used for process and transfer piping handling LNG, flammable refrigerants, flammable liquids or flammable gases, but, if welded pipe is used, the weld and heat affected zone shall comply with ANSI B31.3,* Subsection 323.2.2.

6111. Threaded pipe shall be at least Schedule 80.

6112. A liquid line on a storage container, coldbox or other major item of insulated equipment external to the outer shell or jacket, whose failure can release a significant quantity of flammable fluid, shall not be made of aluminum, copper or copper alloy unless protected against a two-hour fire exposure. This does not apply to loading arms and hoses. Transition joints may be used.

612. Fittings

6120. Threaded nipples shall be at least Schedule 80.

6121. Malleable iron or cast-iron fittings shall not be used in LNG, flammable refrigerant, flammable liquid, or flammable gas piping systems. Malleable iron fittings are permitted in auxiliary systems for oil, water, air, etc.

6122. Bends are permitted provided impact properties are not impaired by the bending operations.

6123. Solid plugs or bull plugs made of at least Schedule 80 seamless pipe shall be used for threaded plugs.

*See Appendix B for availability.

6124. Compression-type couplings shall not be used where they will be subjected to service temperatures below minus 20 F (minus 28.9 C) unless such couplings are proven by testing at design conditions.

613. Valves

6130. In addition to complying with ANSI B31.3,* Section 307, valves shall comply with ANSI B31.5* or B31.8* or API Standard 6D* if design conditions fall within their scope.

6131. Extended bonnet valves, with or without bellows seals, should be used for service temperatures below minus 50 F (minus 45.6 C).

62. Installation

620. Bolted Connections

6200. Care should be taken to ensure the tightness of all bolted connections. Spring washers or other such devices designed to compensate for the contraction and expansion of bolted connections during normal operating cycles shall be used where required.

621. Piping Joints

6210. Pipe joints of 2½ inches nominal diameter and larger shall be welded or flanged. Pipe joints 2 inches nominal diameter or less may be threaded, welded, or flanged (see 6213).

6211. The number of threaded or flanged joints shall be kept to a minimum and used only where necessary, such as at material transitions, instrument connections, or where required for maintenance.

6212. Metals may be joined for cryogenic service by silver brazing. Silver brazing may be used in joining copper to itself, to copper alloys, and to stainless steel. Dissimilar metals may be joined by flanges or transition joint techniques which have been proven by test.

6213. Threaded pipe should be avoided for service temperatures below minus 20 F (minus 28.9 C). If threaded joints are unavoidable, they shall be seal welded or sealed by other means proven by test.

622. Valves

6220. Extended bonnet valves shall not be installed with stems positioned below the horizontal. Valves installed with their stems

*See Appendix B for availability.

positioned horizontally shall be proven by test that the packings will not freeze and produce ice build-up causing the valve to become inoperable.

6221. Shutoff valves shall be provided on all LNG, flammable refrigerant, flammable liquid and flammable gas containers, tank and vessel connections, except those for relief valves (as permitted by Section VIII, Division 1, of the ASME Code, Paragraphs UG-125(e) and Appendix M, UA-354, and UA-355), those for liquid level gaging devices (except as provided in 7001) and those that are blank or plugged. Shutoff valves shall be located as close as practicable to such containers, tanks, and vessels.

6222. The design and installation of an internal valve shall be such that any failure of the penetrating nozzle resulting from external pipe strain will be beyond the shutoff seats of the internal valve itself.

6223. The number of shutoff valves installed shall be kept to the minimum required for efficient and safe operation.

6224. In the design of the piping system, consideration shall be given to the installation of shutoff or block valves as a means of limiting the volume of LNG, flammable refrigerant, flammable liquid or flammable gas that could be discharged in the vicinity of important structures or in the event of a piping system failure. The following valving shall be provided:

(a) Sufficient valves, which can be operated both at the installed location and from a remote location, shall be provided to permit shutting down the process and transfer systems by systems, areas, or totally in the event of an emergency.

(b) LNG, flammable refrigerant, flammable liquid and flammable gas container connections larger than one (1) inch in size and through which liquid can escape shall be equipped with at least one of the following:

(1) A valve which closes automatically in the event of fire exposing the valve.

(2) A remotely controlled, quick-closing valve which shall remain closed except during the operating period.

(3) A check valve on filling connections.

6225. Consideration shall be given to icing conditions which may cause control devices to become inoperable.

6226. Powered operators shall be provided on emergency shutoff valves 8 inches and larger in size. Means for manual operation shall be provided.

623. Welding

6230. Qualification and performance of welders shall be in accordance with ANSI B31.3,* Subsection 327.5, and 6231.

6231. When welding impact-tested materials, qualified welding procedures shall be selected to minimize degradation of the low temperature properties of the pipe material.

(a) When welding attachments to unusually thin pipe, procedures and techniques shall be selected to minimize the danger of burn-throughs.

6232. Oxygen-fuel gas welding shall not be permitted on piping for service temperatures below minus 20 F (minus 28.9 C). Electric arc or inert gas-shielded welding is permissible.

624. Weld Identification

6240. Weld identification markings for pipe which will be subject to service temperatures below minus 20 F (minus 28.9 C) shall comply with 6241 and 6242.

6241. Marking shall be made with a material compatible with the basic material or with a round-bottom, low-stress die, except that materials less than ¼ inch (6.35 mm) in thickness shall not be die-stamped.

6242. Under some conditions marking materials containing carbon or heavy material compounds can cause corrosion of aluminum. Chalk, wax-base crayons, or marking inks with organic coloring are satisfactory.

63. Pipe Supports

630. Pipe supports whose stability is essential to plant safety shall be protected against a 2-hour fire exposure or escaping cold liquid, or both.

631. Pipe supports for cold lines shall be designed to prevent excessive heat transfer which can result in piping restraints caused by ice formations or embrittlement of supporting steel. Design of supporting elements shall conform to ANSI B31.3,* Section 321.

64. Piping Identification

640. Process, fuel, high pressure steam, fire protection and other critical piping shall be identified by color-coding, painting, or labeling. *Scheme for the Identification of Piping Systems* ANSI A13.1 — 1956,* may be used as a guide.

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*See Appendix B for availability.

6400. Any existing company color code scheme for the identification of piping systems may be used.

65. Testing of Piping

650. Pressure tests shall be conducted in accordance with ANSI B31.3,* Chapter 6, Section 337.

651. Records of pressure, test medium temperature, and ambient temperature shall be maintained for the duration of each test and these records are to be maintained for the life of the facility or until such time as a retest is conducted.

66. Purging of Piping Systems

660. Systems should be purged of air or gas in a safe manner. ANSI B31.8, Section 841.285, Purging Pipelines and Mains, may be used as a guide.

661. Blow-down and purge connections shall be provided to facilitate purging of all process and flammable gas piping.

67. Safety and Relief Valves

670. Safety and relief devices shall be so arranged that the possibility of damage to piping or appurtenance is reduced to a minimum. The means for adjusting relief valves set pressure shall be sealed.

671. A thermal expansion relief valve shall be installed as required to prevent overpressure in any section of a liquid pipeline which can be isolated by valves.

6710. Thermal expansion relief valves shall be set to discharge above the maximum pressure normally expected in the line but less than the rated test pressure of the line it protects.

6711. Discharge from such valves shall be directed as to minimize hazard to personnel and other equipment.

*See Appendix B for availability.

CHAPTER 7.

INSTRUMENTATION AND ELECTRICAL SERVICES

70. Liquid Level Gaging

700. LNG Containers

7000. Each LNG container shall be equipped with an adequate liquid level gaging device. Density variations shall be considered in the selection of the gaging device. Consideration shall be given to a secondary or backup gage. At least one of these gages shall be replaceable without taking the tank out of operation.

7001. When container filling rate is greater than one percent per day, the container shall be provided with a high-liquid-level alarm which shall be separate from the liquid level gaging device. The alarm should be set so that the operator will have sufficient time to stop the flow without exceeding the maximum permissible filling height, and shall be located so that it is audible to personnel controlling the filling. A high-liquid-level flow cutoff device, if used, shall not be considered as a substitute for the alarm.

7002. Containers with a capacity of 70,000 gallons (265 kiloliters) or less, if attended during the filling operation, may be equipped with liquid trycocks in lieu of the high-liquid-level alarm.

701. Tanks for Refrigerants and/or Flammable Process Fluids

7010. Each storage tank shall be equipped with a liquid level gaging device. If it is possible to overfill the tank, as when the refrigerant or intermediate fluids system is a part of the liquefaction system, a high-liquid-level alarm shall be provided in accordance with 7001.

7011. Paragraph 7002 shall apply to such installations.

71. Pressure Gage

710. LNG Containers

7100. Each container shall be equipped with a pressure gage connected to the container at a point above the maximum intended liquid level.

711. Liquefaction Systems

7110. Consideration shall be given to placing pressure gages or taps upstream and downstream of process equipment where trace contaminants in the feed stream may deposit, as an aid to the scheduling of deriming operations.

72. Vacuum Gage

720. Vacuum-Jacketed Equipment

7200. Vacuum-jacketed equipment shall be equipped with instruments or connections for checking the absolute pressure in the annular space.

73. Temperature Indicators

730. LNG Containers

7300. Consideration shall be given to the provision of temperature monitoring devices in field erected containers to assist in controlling temperatures when placing the container into service or as a method of checking and calibrating liquid level gages.

731. Vaporizers

7310. Vaporizers shall be provided with indicators to monitor inlet and outlet temperatures of LNG, vaporized gas, and heating medium fluids, to assure effectiveness of the heat transfer surface.

732. Liquefaction Systems

7320. Consideration shall be given to locating temperature indicators upstream and downstream of process equipment where trace contaminants in the feed stream may deposit, as an aid to the scheduling of deriming operations.

733. Heated Foundations of Cryogenic Containers and Equipment

7330. Temperature monitoring systems shall be provided where foundations supporting cryogenic containers and equipment could be adversely affected by freezing or frost heaving of the ground.

74. Emergency Shutdown

740. General Failsafe Requirement

7400. To the extent possible, instrumentation for liquefaction, storage and vaporization facilities should be designed so that in the event power or instrument air failure occurs, the system will go into a failsafe condition that can be maintained until the operators can take appropriate action either to reactivate or to secure the system.

741. Emergency Shutdown

7410. Provision shall be made for the shutdown of major items of equipment (such as the compressors for a liquefaction facility, liquid send-out pumps and the vaporizers) from a location remote from the equipment and accessible in an emergency.

75. Electrical Equipment

750. Electrical equipment and wiring shall be of the type specified by and shall be installed in accordance with the National Electrical Code, NFPA No. 70.

751. Fixed electrical equipment and wiring installed within the classified areas specified in Table 7–1 shall comply with Table 7–1 and shall be installed in accordance with the National Electrical Code, NFPA No. 70, for hazardous locations.

76. Electrical Grounding and Bonding

760. General

7600. Electrical grounding and bonding shall be provided as required by 540 and 6130 of NFPA No. 77, Static Electricity, and NFPA No. 70, National Electrical Code.

761. Bonding

7610. Static protection is not required when tank cars, tank vehicles, or marine equipment are loaded or unloaded by conductive or nonconductive hose, flexible metallic tubing, or pipe connections through or from tight (top or bottom) outlets where both halves of metallic couplings are in contact.

762. Stray Currents

7620. If stray currents may be present, or if impressed currents are used on loading and unloading systems (such as for cathodic protection), protective measures to prevent ignition should be taken in accordance with "Protection Against Ignitions Arising Out of Static, Lightning and Stray Currents," American Petroleum Institute (API) RP 2003 (1967).* Particular attention shall be given to:

(a) Protection of underground lines and structures from accelerated corrosion;

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*See Appendix B for availability.

(b) Use of insulating flanges to prevent currents, or use of bonding cables to prevent potential difference, as appropriate, at pipe and equipment interfaces (see 6211).

(c) Bonding of the rail to fill piping to protect against a potential differential between railcar and pipe.

763. Lightning Protection

7630. Although metallic storage containers and tanks do not require lightning protection, ground rods shall be provided for tanks supported on nonconductive foundations for personnel and foundation protection. (See NFPA No. 78 and API RP 2003* for additional information on lightning protection.)

*See Appendix B for availability.

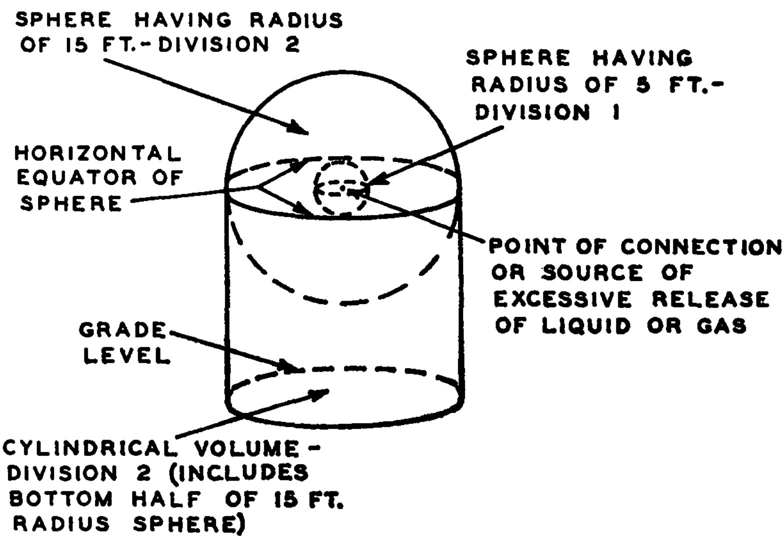

Figure 7-1

(See Table 7-1)

Table 7-1

Part	Location	Equipment Shall Be Suitable for NEC (NFPA No. 70) Class I, Group D, Division[1]	Extent of Classified Area[2]
A	**LNG Storage Container Area** Indoors	1	Entire room.
	Outdoor aboveground containers. (Other than small containers)[5]	1	Open area between a high type dike and container wall where dike wall height exceeds distance between dike and container walls. (See Figure 7-3)
		2	Within 15 feet in all directions from container walls and roof, plus area inside a low-type diked or impounding area up to the height of the dike impoundment wall. (See Figure 7-2)
	Outdoor belowground containers.	1	Within any open space between container walls and surrounding grade or dike. (See Figure 7-4)
		2	Within 15 feet in all directions from roof and sides. (See Figure 7-4)
B	**Nonfired LNG Process Areas Containing Pumps, Compressors, Heat Exchangers, Pipelines, Connections, Small Containers, etc.**		

	Indoors with adequate ventilation.[8]	2	Entire room and any adjacent room not separated by a gastight partition, and 15 feet beyond any wall or roof ventilation discharge vent or louver.
	Outdoors in open air at or above grade.	2	Within 15 feet in all directions from this equipment, and within the cylindrical volume between the horizontal equator of the sphere and grade. (See Figure 7-1)
C	**Pits, Trenches or Sumps Located in or Adjacent to Division 1 or 2 Areas**	1	Entire pit, trench or sump.
D	**Discharge from Relief Valves**	1	Within direct path of relief valve discharge.
E	**Operational Bleeds, Drips, Vents or Drains**		
	Indoors with adequate ventilation.[8]	1	Within 5 feet in all directions from point of discharge.
		2	Beyond 5 feet and entire room and 15 feet beyond any wall or roof ventilation discharge vent or louver.
	Outdoors in open air at or above grade	1	Within 5 feet in all directions from point of discharge.
		2	Beyond 5 feet but within 15 feet in all directions from point of discharge.

F	**Tank Car, Tank Vehicle, and Container Loading and Unloading**[4]		
	Indoors with adequate ventilation.[3]	1	Within 5 feet in all directions from connections regularly made or disconnected for product transfer.
		2	Beyond 5 feet and entire room and 15 feet beyond any wall or roof ventilation discharge vent or louver.
	Outdoors in open air at or above grade.	1	Within 5 feet in all directions from connections regularly made or disconnected for product transfer.
		2	Beyond 5 feet but within 15 feet in all directions from a point where connections are regularly made or disconnected, and within the cylindrical volume between the horizontal equator of the sphere and grade. (See Figure 7-1)

[1] See Article 500 — "Hazardous Locations" in NFPA No. 70 (USA Standard Cl) for definitions of Classes, Groups, and Divisions. Most of the flammable vapors and gases found within the facilities covered by this Standard are classified as Group D. Ethylene is Group C. Much available electrical equipment for hazardous locations is suitable for both Groups.

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

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

[4] When classifying extent of hazardous area, consideration shall be given to possible variations in the spotting of tank cars and tank vehicles at the unloading points and the effect these variations of actual spotting point may have on the point of connection.

[5] Small containers are those that are portable and of less than 200 gallon capacity.