

Fire-Protection Considerations for the Design and Operation of Liquefied Petroleum Gas (LPG) Storage Facilities

API PUBLICATION 2510A
SECOND EDITION, DECEMBER 1996

REAFFIRMED, DECEMBER 2015



AMERICAN PETROLEUM INSTITUTE

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Downstream Segment

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FOREWORD

This publication covers aspects of the design, operation, and maintenance of liquefied petroleum gas (LPG) storage facilities from the standpoints of prevention and control of releases, fire-protection design, and fire-control measures. The storage facilities covered are LPG installations (storage vessels and associated loading/unloading/transfer systems) at marine and pipeline terminals, natural gas processing plants, refineries, petrochemical plants, and tank farms. This publication provides background, philosophy, methods, and alternatives to achieve good fire protection.

Information on the production or use of liquefied petroleum gas is not included.

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Fire-Protection Considerations for the Design and Operation of Liquefied Petroleum Gas (LPG) Storage Facilities

SECTION 1—GENERAL

1.1 Scope

1.1.1 This publication addresses the design, operation, and maintenance of LPG storage facilities from the standpoints of prevention and control of releases, fire protection design, and fire-control measures. The history of LPG storage facility failure, facility design philosophy, operating and maintenance procedures, and various fire protection and firefighting approaches are presented. This publication, since it supplements [API Standard 2510](#) and provides the basis for many of the requirements stated in that standard, must be used in conjunction with [API Standard 2510](#). In case of conflict, [API Standard 2510](#) shall prevail. Alternate designs are acceptable provided equal safety can be demonstrated.

1.1.2 The storage facilities covered by this publication are LPG installations (storage vessels and associated loading/unloading/transfer systems) at marine and pipeline terminals, natural gas processing plants, refineries, petrochemical plants, and tank farms. The following types of LPG installations are not addressed:

- a. Underground storage, such as buried tanks, storage caverns, salt domes, or wells.
- b. Mounded storage tanks.
- c. Refrigerated storage at pressures below 15 pounds per square inch gauge.
- d. Installations covered by API Standard 2508.
- e. Installations covered by NFPA Standards 58 or 59.
- f. Department of Transportation (DOT) containers.
- g. Those portions of LPG systems covered by NFPA 54 (ASME Z223.1).
- h. Small installations with a single LPG tank of less than 2000-gallon capacity.
- i. Process equipment for LPG manufacture or treatment preceding LPG storage.

1.2 Retroactions

The provisions of this publication pertain to new installations, but may also be used to review and evaluate existing storage facilities. The applicability of some or all of these provisions to facilities and equipment already in place or in the process of construction or installation before the date of this publication will have to be considered on a case-by-case basis.

1.3 Introduction

1.3.1 In developing fire-protection guidelines for an LPG storage facility, the greatest concern is the massive failure of a

vessel with a full inventory of LPG. The probability of this type of failure can be made virtually negligible with properly engineered and operated facilities. The fire-protection principles of this publication are intended to prevent fire-induced vessel failure.

1.3.2 Most LPG fires originate as smaller fires that have the potential to become larger and more hazardous. It is important to note that LPG fires usually occur, not as a result of tank failure, but because of pump seal leaks, piping leaks, or failure to follow safe work procedures. Human failure such as overfills and piping leaks from poor drawoff (water and sample) procedures can lead to LPG release and consequent fire. This publication treats the prevention and control of such incidents and provides various fire extinguishment and containment methods.

1.4 Failure History

1.4.1 The most serious LPG release is a massive failure of a storage vessel. Such failures are rare and seldom occur without exacerbating circumstances such as exposure to fire or external explosion.

1.4.2 To project LPG storage vessel failure frequency, fire-protection professionals have reviewed applicable U.S., British, and German failure statistics for pressure vessels.¹ These statistics reveal that the failure rate for pressure vessels from causes other than pre-existing fires or explosions, has been about 1 failure per 100,000 vessel years. To assume this failure rate for hydrocarbon storage vessels is conservative, since most of the data in these studies are for steam boilers and drums operating under more adverse conditions.

1.4.3 A more likely LPG incident, and in the context of this publication a more relevant one, is leakage from piping or other components attached to or near the vessel followed by ignition, a flash fire or vapor cloud explosion, and a continuing pool fire and pressure (torch) fire. The possibility of a pool fire is greater with lower-vapor-pressure LPG or in cold climates. Should flames impinge on a nearby LPG vessel, a boiling liquid-expanding vapor explosion (BLEVE) involving one or more storage vessels may ensue. Injury to facility or neighboring personnel and damage losses of several million dollars can be incurred in these types of LPG incidents.

¹Spencer H. Bush, "Pressure Vessel Reliability," *Transactions of the ASME: Journal of Vessel Technology*, February 1975.

1.4.4 An examination of the 100 largest hydrocarbon-chemical accidents over a 30-year period has made it possible to estimate the probability of major accidents (losses of \$12,000,000 or more in 1983 dollars) in LPG storage facilities.² This data and the 1984 disaster near Mexico City³ demonstrate that there were about three major incidents worldwide every 10 years involving pressurized liquid light-hydrocarbon storage facilities. The number of such facilities in operation during the 30-year period examined was between 600 and 1000. Hence, the probability that any one facility will have a major LPG accident in any one year is from less than 1 in 2000 to less than 1 in 3333. Since a typical facility is likely to contain several vessels, the frequency of a major accident at any one facility is probably on the order of 1 per 20,000 vessel years. A consideration of the nine major LPG storage facility incidents studied suggests that many if not most of the incidents would probably not have occurred or would have been much less severe if the practices described in this publication had been observed. Hence, implementation of the recommendations described herein should reduce the frequency of major LPG storage facility fires from 1 per 20,000 vessel years to about 1 per 100,000 vessel years.

1.4.5 Some of the causes for releases that have occurred at facilities that transfer and store pressurized LPG are listed below:

- a. Leakage from an LPG transfer pump seal.
- b. Leakage from valve stem seals and flange gaskets.
- c. Leakage when taking a sample or drawing water.
- d. Leakage from transfer piping because of corrosion, mechanical damage, or from screwed piping connections.
- e. Failure of a transfer pipe flexible joint or cargo hose at the interface between a fixed facility and a tank truck, railroad tank car, or tank ship.
- f. Leakage from a storage vessel because of corrosion.
- g. Tank overfilling, which forces liquid out the pressure safety valves.
- h. Failure of a storage vessel because of direct flame impingement on the unwetted shell.

1.5 Safety Analysis

1.5.1 Where site location, equipment spacing, or limited built-in fire protection increase the risk to the public or the potential for damage to an industrial area, a safety analysis of the LPG facility should be performed. The analysis should include possible but realistic scenarios of accidents that may occur, including LPG release, ignition, and fire. Refer to OSHA 29 CFR 1910.119 for additional information and

guidance for evaluating the safe design, operation, inspection and maintenance of a facility.

1.5.2 The safety analysis should be periodically reviewed to ensure that conditions have not significantly changed and that the current level of fire prevention and fire suppression is still appropriate.

1.5.3 A smaller storage facility that is remotely located, such as at an oil field producing site, should not require as much built-in fire protection as a major facility in an industrial or urban area. An evaluation should be made to establish the value of the facility, the economic impact if it were lost, and the exposure risk to people and neighboring installations. The level of fire protection incorporated in the design should be commensurate with the exposure risk and value of the facility, provided that any reductions in fire protection would not result in unacceptably high risks to people.

1.6 LPG Properties

1.6.1 At normal temperature and atmospheric pressure, LPG is in a gaseous state. It can be liquefied under moderate pressure or by cooling to temperatures below its atmospheric pressure boiling point but will readily vaporize upon release to normal atmospheric conditions. It is this property that permits LPG to be transported and stored in a liquid form but used in the vapor form.

1.6.2 Liquefied petroleum gas consists of light hydrocarbons with a vapor pressure exceeding 40 pounds per square inch absolute at 100°F. Examples include propane, propylene, butane (normal or isobutane), and butylene (including isomers). The most common LPG's are propane and normal butane or a mixture of these, and thus only the properties of these gases will be discussed. The properties of propane and normal butane are shown in Tables 1 and 2.

1.6.3 Concentrated LPG vapors are heavier than air; thus they tend to stay close to the ground, collect in low spots, and disperse less readily than lighter-than-air gases. Undiluted propane vapor is 1½ times more dense than air, and normal butane vapor is twice as dense. However, once LPG is released, it mixes with air to form a flammable mixture, and the density of the mixture becomes essentially the same as air. Natural air currents, diffusion, and dispersion will eventually dilute the mixture to below the lower flammable limit (LFL).

1.6.4 Since LPG is stored under pressure and vaporizes readily when released, it is difficult to control leaks once they occur. The vapor cloud from a leak tends to stay close to the ground and drift downwind toward low areas. This property makes it essential that leaks be prevented, ignition sources kept at a safe distance, and vapor from leaks be dispersed before it is ignited. Wind significantly reduces the dispersion distance, that is, the size of the flammable vapor cloud, for any given leak rate.

² "One Hundred Largest Losses: A Thirty-Year Review of Property Damage Losses in the Hydrocarbon-Chemical Industries," Marsh & McLennan Protection Consultants, 1986.

³ "Analysis of the LPG Incident in San Juan Ixhuatpec, Mexico City, November 19, 1984," TNO, Netherlands, May 6, 1985.

Table 1—Properties of Two Common LPG's

Property	Propane	<i>n</i> -Butane
Specific gravity of gas (air = 1.0)	1.5	2.0
Vapor pressure at 60°F, psia ^a	105	26
Vapor pressure at 60°F, psia ^a	190	52
Boiling point, °F	-44	+31
Cubic feet of gas/gallon of LPG at 60°F	36.4	31.8
Lower flammable limit (LFL), percent in air	2.0	1.5
Upper flammable limit (UFL), percent in air	9.5	9.0
Gross Btu/ft ^{3b} of gas at 60°F	2516	3262

Note: *n* = normal.

^apsia = pounds per square inch absolute.

^bBtu/ft³ = British thermal units per cubic foot.

Table 2—Tank Pressures for Two Common LPG's

Liquid Temperature (Degrees Fahrenheit)	Tank Pressure ^a (Pounds per square inch gauge)	
	Propane	<i>n</i> -Butane
31	50	0
60	90	11
100	175	37
130	250	65
140	290	80

Note: *n* = normal

^aVapor pressure at the listed temperature. Actual tank pressure can exceed these values if the vessel contains noncondensable gases such as nitrogen.

1.6.5 Both propane and normal butane have low boiling points. Since the boiling point of liquid propane is far below temperatures typically found in nature, propane generally does not form a liquid pool when spilled. However, liquid normal butane is more likely to remain liquid if accidentally released at low ambient or storage temperatures, due to its 31°F atmospheric pressure boiling point.

1.6.6 Other characteristics of LPG include the following:

- LPG exerts a chilling effect from vaporization when released or vented to a lower pressure. This effect is known as auto-refrigeration; the liquid temperature approaches its boiling temperature at atmospheric pressure (see boiling point in Table 1).
- The density of the liquid is approximately half that of water, and thus water will settle to the bottom in LPG.
- Small quantities of liquid will yield large quantities of vapor as shown in Table 3.
- High rates of vaporization and strong turbulence will result when LPG is spilled on water or water streams are added to an LPG spill.

e. Liquefied petroleum gas, when vaporized, leaves no residue.

f. Pure LPG is noncorrosive to steel and generally noncorrosive to copper alloys. However, when sulfur compounds and other impurities are present in the LPG, corrosion can be a serious problem.

g. Liquefied petroleum gas has no lubricating properties, and this fact must be taken into account when specifying LPG-handling pumps, compressors, and so forth.

h. Liquefied petroleum gas is colorless. However, when the liquid evaporates, the cooling effect on the surrounding air causes condensation of water vapor in the air, which usually makes it possible to see an escape of LPG. This may not occur in the case of a vapor release if the vapor is near ambient temperature and its pressure is relatively low.

i. Pure LPG is practically odorless. For safety purposes, it is required that an odorizing agent (such as ethyl mercaptan) be added to commercial grades of LPG to make them detectable by smell.

1.7 Definitions

Terms used in this publication are defined in 1.7.1 through 1.7.19.

1.7.1 adiabatic: A closed thermodynamic system in which changes take place with no net gain or loss of energy.

1.7.2 autorefriegeration: The chilling effect from vaporization of LPG when it is released or vented to a lower pressure.

1.7.3 boiling liquid-expanding vapor explosion (BLEVE): A phenomenon that occurs when an LPG vessel fails catastrophically releasing its contents. The most common cause of a BLEVE of a LPG vessel is prolonged, direct exposure to a fire with flame contact above the liquid level. A BLEVE can occur when a vessel containing a liquid fails with the liquid at a temperature above the boiling point of its components at atmospheric pressure.

1.7.4 excess flow valve: A device designed to close when the flow rate of the liquid or vapor passing through it exceeds a prescribed value as determined by pressure drop.

1.7.5 fireproofing: A fire-resistant insulating material applied to steel to minimize the effects of fire exposure by flame impingement, to reduce the steel's rate of temperature rise, and to delay structural failure.

1.7.6 inert substance: A substance that is chemically unreactive (usually a gas when referred to in this publication).

1.7.7 lower flammable limit (LFL): The lowest concentration of vapor in air that can be ignited. For normal butane, it is 1.5 percent; for propane, it is 2.0 percent.

Table 3—Vapor Volumes Obtained for Two Common LPG's

Liquid	Quantity (Gallons)	Vapor Volume		Volume of Gas/Air Mixture at LFL (Cubic Feet)
		Gallons	Cubic Feet	
Propane	1	270	36	1680
<i>n</i> -Butane	1	230	32	1630

Note: *n* = normal.

1.7.8 may: Indicates provisions that are optional.

1.7.9 minimum pressurizing temperature: The lowest temperature at which a pressure greater than 40 percent of the maximum allowable working pressure should be applied to the vessel.

1.7.10 must: Indicates provisions that are mandatory.

1.7.11 net positive suction head (NPSH): The net positive pressure in feet of liquid at the inlet to a pump.

1.7.12 pressure safety valve (PSV): Used to limit pressure to a predetermined safe maximum.

1.7.13 remote location: A location that is 4000 feet or more from populated or industrial areas. Locations without this clear zone may also be considered remote through a safety analysis.

1.7.14 root valve: The valve located at the vessel or equipment for the connection of a pipe. It is the starting point or “root” of the piping connection and is used to isolate the piping from its source.

1.7.15 sample container: A small hand-held pressure container used to collect LPG samples for transport to a laboratory.

1.7.16 shall: Indicates provisions taken from [API Standard 2510](#) that are mandatory.

1.7.17 should: Indicates supplemental provisions that are recommended but not mandatory.

1.7.18 upper flammable limit (UFL): The highest concentration of vapor in air that can be ignited. For normal butane, it is 9.0 percent; for propane, it is 9.5 percent.

1.7.19 weep hole: A drain hole at the low point of a pressure safety valve atmospheric vent stack.

1.8 Referenced Publications

The following standards, codes, publications, and recommended practices are cited in this publication:

API

[RP 500](#) *Classification of Locations for Electrical Installations at Petroleum Facilities*

[RP 510](#) *Pressure Vessel Inspection Code*

[RP 520](#) *Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries*

[RP 521](#) *Guide for Pressure-Relieving and Depressurizing Systems*

[RP 576](#) *Inspection of Pressure Relieving Devices*

[Publ 920](#) *Prevention of Brittle Fracture of Pressure Vessels*

[RP 2003](#) *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents*

[Publ 2009](#) *Safe Welding and Cutting Practices in Refineries, Gasoline Plants, and Petrochemical Plants*

[Publ 2015](#) *Cleaning Petroleum Storage Tanks*

[Publ 2030](#) *Guidelines for Application of Water Spray Systems for Fire Protection in the Petroleum Industry*

[Publ 2214](#) *Spark Ignition Properties of Hand Tools*

[Publ 2217](#) *Guidelines for Confined Space Work in the Petroleum Industry*

[Publ 2218](#) *Fireproofing Practices in Petroleum and Petrochemical Processing Plants*

[Std 2508](#) *Design and Construction of Ethane and Ethylene Installations at Marine and Pipeline Terminals, Natural Gas Processing Plants, Refineries, Petrochemical Plants, and Tank Farms*

[Std 2510](#) *Design and Construction of Liquefied Petroleum Gas (LPG) Installations*

Manual of Petroleum Measurement Standards

Validation of Heavy Gas Dispersion Models With Experimental Results of the Thorney Island Trial (Volume I—text; Volume II—appendix)

AICE⁴

Guidelines for Hazard Evaluation Procedures

ASME⁵

Boiler and Pressure Vessel Code, Section II, “Material Specification,” Section VIII, “Pressure Vessels”

B31.3 Chemical Plant and Petroleum Refinery Piping

OSHA⁶

29 CFR 1910.110 *Storage and Handling of Liquefied Petroleum Gases*

29 CFR 1910.119 *Process Safety Management of Highly Hazardous Chemicals*

⁴ American Institute of Chemical Engineers, 345 East 47th Street, New York, New York 10017.

⁵ American Society of Mechanical Engineers, East 345 47th Street, New York, New York 10017.

⁶ Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.

NFPA⁷54 *National Fuel Gas Code* (ASME Z223.1)58 *Storage & Handling of Liquefied Petroleum Gases*59 *Storage & Handling of Liquefied Petroleum Gases at Utility Gas Plants*25 *Water-Based Fire Protection Systems*600 *Industrial Fire Brigades*

SECTION 2—FACILITY DESIGN PHILOSOPHY

2.1 Introduction

Adherence to the design considerations and requirements of this section will significantly reduce fire risk at LPG facilities and will limit the spread of fire and extent of damage should a fire occur. This section is intended to be used as a supplement to [API Standard 2510](#).

2.2 Site Selection

2.2.1 Liquefied petroleum gas storage facilities should be located to minimize the exposure risk to adjacent facilities, properties, or population. The location, layout, and arrangement of a storage facility should be based primarily on the requirement for safe and efficient operation in normal use. Recognition of safety requirements in plant layout and equipment spacing is essential in the early design of new facilities and has a direct impact on both the risk and the potential magnitude of loss. Typical considerations are listed in 3.1 of [API Standard 2510](#).

2.2.2 For remotely located storage facilities, such as those in producing areas or at facilities where the quantity of stored LPG is limited, the amount of built-in fire protection warranted may be less than that needed for larger facilities located in populated or developed industrial areas. Thus, the remoteness of the location is a major factor in determining the degree of fire protection to be included in the design. A safety analysis, discussed in 1.5, can help to establish a realistic exposure risk to aid in deciding on the amount of protection necessary.

2.2.3 Risk assessment and dispersion modeling can be useful tools in estimating setback distances to limit exposure to adjacent facilities.⁸ For additional information, see the API report *Validation of Heavy Gas Dispersion Models with Experimental Results of the Thorney Island Trials* June 1986, Volumes I and II.

2.3 Layout and Spacing

2.3.1 GENERAL

2.3.1.1 Spacing and design of LPG facilities are interdependent and must be considered together. Spacing require-

ments used shall be in accordance with 3.1 of [API Standard 2510](#).

2.3.1.2 Spacing should be sufficient to minimize both the potential for small leak ignition and the exposure risk to adjacent vessels, equipment, or installations should ignition occur. Prudent spacing will not necessarily protect against a major accident, but it may prevent a minor incident from escalating into a major one. The remaining design features of this document and [API Standard 2510](#) are intended to prevent a major incident from occurring.

2.3.2 MINIMUM DISTANCE REQUIREMENTS FOR ABOVEGROUND LPG VESSELS

2.3.2.1 The spacing of aboveground LPG vessels shall be as given in 3.1.2 of [API Standard 2510](#).

2.3.2.2 Good engineering judgment should be used in selecting spacing distances. Many factors should be considered. For example, when three or more horizontal vessels are in a group, an increase in shell-to-shell spacing to 10 feet will result in a repositioning of the drainage from an area immediately adjoining each vessel to a low point midway between adjacent vessels. This arrangement will minimize flame contact between adjacent vessels in a fire except under some wind conditions, since the drainage channel will be centered between the vessels. Further increases in spacing are normally not justified, since other requirements of this publication minimize the risk of a major unconfined leak and fire. There may be value in spacing greater than 10 feet for vessels larger than 10 feet in diameter, since larger vessels tend to stand higher and would have greater surface area exposed to potential flame impingement from a spill fire in the drainage path. These comments apply to 3.1.2.2, Item b, in [API Standard 2510](#). Similar engineering judgment should be exercised as appropriate for other design features.

2.3.3 SITING OF ABOVEGROUND PRESSURIZED LPG VESSELS

The site selection for aboveground LPG vessels shall be as given in 3.1.3 of [API Standard 2510](#). The emphasis should be on limiting exposure of the vessels to fire, explosion, or mechanical damage from adjacent facilities or properties, and on protecting those facilities or properties from an incident involving the storage vessels.

⁷ National Fire Protection Association, 1 Batterymarch Park, Quincy, Massachusetts 02269.

⁸ "Canvey Summary of an Investigation of Potential Hazards from Operations in the Canvey Island/Thurrock Area," *Health and Safety Executive*, England, 1978.

**Documents**

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2.4 Drainage and Spill Containment

2.4.1 Proper design of drainage and spill containment systems is important in LPG storage facilities. For spill containment requirements refer to 3.2 through 3.5 in [API Standard 2510](#). The pronounced volatility of LPG generally allows impoundment areas to be reduced and in some cases, such as for smaller propane vessels in warm climates, containment may not be warranted. Even though high-vapor-pressure LPG may not form a pool when released, the principles of good drainage should nevertheless be considered. The provisions that follow are intended to accomplish the following objectives:

- a. To prevent the accumulation of liquid under LPG storage vessels.
- b. To minimize as much as practical the chance of flame impingement on a vessel from a burning spill.
- c. To provide a location for accumulating liquid that will, to the greatest extent, minimize the risk to critical facilities, piping, and equipment if the pool of liquid ignites.
- d. To confine a spill to the smallest area practical in order to reduce the vaporization rate of the liquid that collects, thus reducing the size of the resultant vapor cloud.

2.4.2 Grading at a minimum 1-percent slope shall be provided under each vessel to rapidly carry a spill to an impoundment (spill containment) area. The drainage path to the impoundment area should not come closer than 5 feet to the edge of any other storage vessel, or exposed piping, or other hydrocarbon-containing equipment. The low point of drainage from between adjacent vessels should be centered between the vessels. This may result in the drainage path being closer than 5 feet from the shell of adjacent vessels spaced less than 10 feet shell-to-shell.

2.4.3 The surface under each vessel, the impoundment area, and drainage paths between the two locations should be stabilized to prevent erosion. The surface of the drainage path and impounding area should not be constructed of loose material such as gravel or rock. The surface should be resistant to LPG liquid retention.

2.4.4 Diking or impounding shall be as required in 3.4 and 3.5 of [API Standard 2510](#) where liquid spills may endanger or expose other important facilities, nearby properties, or public areas.

2.4.5 Impoundment areas may be either inside or outside of a dike surrounding the vessel storage area and should have the following features:

- a. The liquid capacity shall be as required in 3.2.3.4 or 3.2.4.3 of [API Standard 2510](#).
- b. Liquid that pools in the impoundment area should expose a vessel on one side only.

- c. The impoundment area, where practical, should be located to minimize the chance of flame impingement on a storage vessel. The distance necessary to accomplish this depends primarily on the size and shape of both the pool and the vessels, and the wind conditions. The distance required for a specific case should be determined by an engineering analysis. The chance of flame contact on a storage vessel from a fire in the impoundment area is reduced significantly by increased spacing up to about 100 feet, beyond which there is little risk under most conditions (see Figure 1). Shown in Figure 1 is a line that indicates the maximum distance for flame contact on a vessel shell at a point 20 feet above grade.

- d. The impoundment area should be designed to keep the surface area of the contained liquid as small as practical in order to minimize the vaporization rate. A slope at the bottom of the impoundment area may help reduce the vaporization rate in case of a partial spill.

- e. Drains shall be provided to remove water from the diked and impoundment areas. An accessible valve outside the enclosure shall be provided and it normally shall be closed.

- f. When an impoundment area serves multiple LPG storage vessels in a common diked area, drainage must be arranged from each vessel so that it goes to the impoundment area without passing under other storage vessels or piping. Suitable intermediate dikes may be appropriate.

- g. When dikes are used for impoundment, they should not exceed an average of 6 feet in height above the interior grade to control risk of vapor accumulation due to lack of ventilation, and to assure safe emergency access and egress for personnel. When dikes must be higher than 6 feet, see 3.5.5 in [API Standard 2510](#).

- h. The extent of vaporization can be reduced by judicious arrangement of drainage paths, including the use of shallow ditches or trenches when applicable, and by the use of special substrates such as insulating concrete.

- i. The effects of thermal shock associated with spilling LPG (shock resulting from the autorefrigeration temperature) should be considered in selecting the materials for all components of a spill containment facility.

- j. The impoundment area should be at least 200 feet from furnaces and other fixed ignition sources.

2.5 Ignition Source Control

2.5.1 Ignition source control is an essential consideration in the safe design and operation of LPG storage facilities. All ignition sources must be recognized, identified, and restricted to safe (nonhazardous) areas or contained safe enclosures (see [API Recommended Practice 500](#)).

2.5.2 Case histories of accidental ignition indicate that fires have been caused by improper hot work procedures, unauthorized use of motor vehicles, smoking/matches in restricted areas, and improperly maintained or designed electrical