Second Revision No. 11-NFPA 59A-2022 [Global Comment]

See Word Document for attached changes to standardize the application of flammable fluid, flammable liquid and hazardous fluid throughout the document.

Supplemental Information

File Name	Description	Approved
Hazardous_Fluid_TG_Final.docx	See Word Document for attached changes. FOR STAFF USE	
Hazardous_Fluid_TG.docx	This word document just shows all instances that were reviewed. It includes sections that were not changed. Sections not changed were not included in the final document.	
59A_SR-11_For_Ballot.pdf		

Submitter Information Verification

Committee: LNG-AAA

Submittal Date: Fri Apr 29 16:09:33 EDT 2022

Committee Statement

Committee Statement: NFPA 59A has inconsistent application of flammable fluid, flammable liquid and hazardous fluid. The edit provided corrects those inconsistencies and replaces flammable with ignitable where appropriate and aligns NFPA 59A with definitions and application of these terms in other standards.

Response Message: SR-11-NFPA 59A-2022

Public Comment No. 4-NFPA 59A-2022 [Global Input]

~~**3.3.4 Cargo Tank Vehicle.**~~
~~A tank truck or trailer designed to transport liquid cargo.~~

3.3.5* Container.
A vessel, tank, portable tank *(isotainer)*, or cargo tank used for or capable of holding, storing, or transporting ~~liquid or gas~~fluid.

3.3.7 Cryogenic Fluid.
A fluid with a boiling point lower than –130°F (–90°C) at an absolute pressure of 14.7 psi (101.3 kPa). [**55,** 2023]

3.3.16* Hazardous Fluid.
A liquid or gas that is ~~flammable~~ignitible, toxic, or corrosive.

A.3.3.16 Hazardous Fluid.
LNG is considered to be a hazardous fluid. For corrosive fluids the concern is skin corrosivity rather than material corrosivity.

3.3.17* Ignitible Fluid.
A liquified gas or liquid that has a measurable flashpoint or gas that is flammable.

A.3.3.17 Ignitible Fluid.
LNG is considered to be an ignitible fluid.
Below are some recognized testing standards for measuring flashpoint and gas flammability:

(a) ASTM D92, *Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester*

(b) ASTM D1310, *Standard Test Methods for Flash Point and Fire Point of Liquids by Tag Open Cup Tester*

(c) ASTM E502, *Standard Test Method for Selection and Use of ASTM Standards for the Determination of Flash Point of Chemicals for by Closed Cup Methods*

(d) ASTM D56, *Standard Test Method for Flash Point by Tag Closed Cup Tester*

(e) ASTM D93, *Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester*

(f) ASTM E681-09 2015, *Standard Test Methods for Concentration Limits of Flammability Limit of Chemicals (of Vapors and Gases)*

(g) ASTM E918, *Standard Test Method for Determining Limits of Flammability of Chemicals at Elevated Temperature and Pressure*

3.3.34 Tank Car.
A type of railroad car, tank wagon, or rolling stock designed to transport ~~liquid and gaseous~~fluid commodities.

4.9.1
Each plant shall have a record of materials of construction for components, buildings, foundations, and support systems used for containment of ~~LNG or other hazardous liquids~~hazardous fluids.

4.11.3
Portable electric tools and extension lights capable of igniting ~~LNG or other flammable fluids~~ignitible fluids shall not be permitted within classified areas except where the area has been identified as free of ~~flammable fluids~~ignitible fluids.

5.3.1.1
Provisions shall be made to minimize the potential of discharge of ~~LNG or other~~ hazardous liquids at containers, piping, and other equipment such that a discharge from any of these does not endanger adjoining property or important process equipment, buildings, and structures, or reach waterways.

5.3.1.2
~~LNG containers and hazardous~~Hazardous liquid storage tanks shall be provided with one of the following methods to contain any release:

(1) An impounding area surrounding the container(s) that is formed by a natural barrier, dike, impounding wall, or combination thereof complying with Chapter 13 and Chapter 6

(2) An impounding area formed by a natural barrier, dike, excavation, impounding wall, or combination thereof complying with Chapter 13 and Chapter 6, plus a natural or man-made drainage system surrounding the container(s) that complies with Chapter 13 and Chapter 6

(3) Where the container is constructed below or partially below the surrounding grade, an impounding area formed by excavation complying with Chapter 13 and Chapter 6

(4) Secondary containment as required for double-, full-, or membrane-containment tank systems complying with Chapter 13 and Chapter 6~~.~~

5.3.2.7* ~~Flammable~~Ignitible Gas or Vapor Dispersion.
The siting of the plant shall be such that, in the event of an ~~LNG or other flammable or combustible fluid~~ignitible fluid release as specified in 5.3.2.3, a predicted concentration to the lower flammability limit (LFL) does not extend beyond the property line that can be built upon.

5.3.2.10 Fires.
The siting of the plant shall be such that, in the event of an ~~LNG or other flammable or combustible fluid~~ignitible fluid release as specified in 5.3.2.3, a maximum radiant heat flux from a fire shall not exceed the limits listed in Table 5.3.2.10.

6.3.5
~~Flammable liquid and flammable refrigerant storage tanks~~Ignitible fluid containers shall not be located within an LNG ~~container~~tank impounding area.

6.4.1
Vaporizers using ~~flammable heat transfer fluids~~ignitible fluids for heat transfer~~and~~as their primary heat sources shall be located at least 50 ft (15 m) from any other source of ignition.

6.4.2*
The fired components of an integral heated vaporizer shall be located as follows:

(1) At least 50 ft (15 m) from any ~~impounded LNG, flammable refrigerant, or flammable liquid~~impounding area for ignitible fluids*(see Section 6.3)* or the paths of travel of such fluids between any other source of accidental discharge and the impounding area

(2) At least 50 ft (15 m) from ~~LNG, flammable liquid, flammable refrigerant, or flammable gas~~ignitible fluids storage containers or tanks~~;~~, unfired process equipment containing such fluids~~;~~ or loading and unloading connections used in the transfer of such fluids

(3) At least 50 ft (15 m) from control buildings, offices, shops, and other occupied or important plant structures

(4) At least 100 ft (30 m) from property line that can be built upon *(see 6.4.4)*

6.5.1
Process equipment containing ~~LNG, refrigerants, flammable liquids, or flammable gases~~ignitible fluid shall be located at least 50 ft (15 m) from sources of ignition, a property line that can be built upon, control centers, offices, shops, and other occupied structures.

6.7.2
Buildings not covered by Sections 12.5 through 12.7 shall be located no less than 50 ft (15 m) from tanks, vessels, and gasketed or sealed connections to equipment containing ~~LNG and other hazardous fluids~~ignitible fluids.

7.3.1
Process system equipment containing ~~LNG or other hazardous~~ignitible fluids shall be installed in accordance with one of the following:

(1) Outdoors, for ease of operation, to facilitate manual firefighting, and to facilitate dispersal of accidentally released liquids and gases

(2) Indoors, in enclosing structures that comply with Sections 12.5 through 12.7

7.5 ~~Flammable Refrigerant and Flammable~~Hazardous Liquid Storage.

7.5.1
Storage containers and equipment for hazardous ~~fluids~~liquids other than LNG shall comply with NFPA 30; NFPA 58; NFPA 59; API Std 2510, *Design and Construction of Liquefied Petroleum Gas (LPG) Installations*, as applicable; or Section 5.3 of this standard.

A.8.4.3
…
Another mechanism is when the upper layer experiences preferential boil-off of lighter end fluids (i.e., nitrogen) and the liquid in the upper layer becomes warmer and ~~more dense~~denser compared to the bottom layer until the density difference becomes large enough that the gravitational force causes the upper warmer layer to sink and heat and vaporize the lower colder fluid.
…

9.4.1.1
Where LNG plants are either unattended or vaporizers are installed within a 50 ft (15 m) radius of their heat source or any ~~flammable liquids~~ignitible fluid container, an automatic

shutoff valve shall be installed within 10 ft (3 m) of the vaporizer or vaporizer system in accordance with 16.3.6.

9.4.1.2
Where an LNG plant is attended and vaporizers are installed at least a 50 ft (15 m) radius from their heat source and any ~~flammable liquids~~ignitible fluid container, either an automatic or manual shutoff valve shall be installed at least a 50 ft (15 m) radius from the vaporizer, vaporizer system, or vaporizer building.

9.4.4
Where ~~a flammable intermediate fluid~~an ignitible fluid used as an intermediate fluid is used with a vaporizer, shutoff valves shall be provided on both the hot and the cold lines of the intermediate fluid system with the controls at least a 50 ft (15 m) radius from the vaporizer.

10.3.2.5
A liquid line on a container, cold box, or other insulated equipment external to the outer shell or jacket, whose failure can release a significant quantity of ~~flammable~~hazardous fluid, shall not be made of aluminum, copper or copper alloy, or material with a melting point of less than 2000°F (1093°C).

10.4.2.11
A piping system used for periodic transfer of ~~cold~~cryogenic fluid shall be provided with a means for precooling before transfer.

~~**A.11.3.2**~~
~~Flammable process fluids include natural gas liquids and gas condensates.~~

11.3.2.3
The requirements of 11.3.1.4 shall apply to installations of refrigerants or ~~flammable process fluids~~ignitible liquids.

11.9.3*
Electrically classified areas shall be as specified in Table 11.9.2 and as specified by recognized methods that account for the properties of the fluids potentially released such as highly volatile liquids (HVLs) and the conditions ~~of the fluids~~ such as operating pressure, density, temperature, and volume.

11.9.6*
Each interface between ~~a~~an~~flammable~~ignitible fluid system and an electrical conduit or wiring system, including process instrumentation connections, integral valve operators, foundation heating coils, canned pumps, and blowers, shall be sealed or isolated to prevent the passage of ~~flammable~~ignitible fluids to another portion of the electrical installation in accordance with the requirements in this standard, Article 501.17 of *NFPA 70*, and ISA 12.27.01, *Requirements for Process Sealing Between Electrical Systems and Flammable or Combustible Process Fluids*.

A.11.9.6
Examples of other means for preventing the passage of ~~flammable~~ignitible fluids to another portion of the conduit or wiring system can include a physical interruption of the conduit run and of the stranded conductors through the use of an adequately vented junction box containing terminal strip or busbar connections; an exposed section of mineral-insulated (MI) cable using suitable fittings; or an exposed section of single conductors that are incapable of transmitting gases or vapors. See *NFPA 70*, 501.15(e)(2).

11.9.6.2
A primary seal shall be provided between the ~~flammable~~ignitible fluid system and the electrical conduit wiring system.

11.9.6.2.1
If the failure of the primary seal allows the passage of ~~flammable~~ignitible fluids to another portion of the conduit or wiring system, an additional approved seal, barrier, or other means shall be provided to prevent the passage of the ~~flammable~~ignitible fluid beyond the additional device or means if the primary seal fails.

11.9.7
Where primary seals are installed, drains, vents, or other devices shall be provided to detect ~~flammable~~ignitible fluids and leakage.

12.6* Fire and Explosion Control.
Rooms containing ~~LNG and flammable~~ignitible fluids, if located within or attached to buildings in which such fluids are not handled shall be designed for fire and explosion control in accordance with the following:

(1) Deflagration venting shall be provided in accordance with NFPA 68.

(2) Common walls shall have no doors or other communicating openings.

(3) Common walls shall have a fire-resistance rating of at least 1 hour.

A.12.6
Buildings in which ignitible fluids are not handled are buildings such as control centers and shops.

13.4 Enclosed Drainage Channels.
Enclosed drainage channels for ~~LNG or other flammable and combustible liquids~~ignitible fluids shall be prohibited except where they meet one of the following requirements:

(1) Where enclosed drainage channels are approved to be used to rapidly conduct spilled ~~LNG or other flammable and combustible liquids~~ignitible liquids away from critical areas and they are sized for the anticipated liquid flow and vapor formation rates

(2) Where the enclosed drainage channels are inerted or purged with an inert gas and continuously monitored for ~~a flammable liquid leak or flammable gas~~ignitible fluids, and instrumentation and controls are provided to maintain pressures at a safe level within the drainage channel

(3) Where the enclosed drainage channels are provided with deflagration venting in accordance with NFPA 68

(4) Where pipe-in-pipe is installed in accordance with 10.13.3.3, and instrumentation and controls are provided to maintain pressures at a safe level within the drainage channel

13.9.1
Dikes, impounding walls, and drainage channels for ignitible (flammable or combustible) liquid containment shall conform to NFPA 30.

13.12.2
Water removal systems shall be as follows:

(1) Operated as necessary to keep the impounding area as dry as practicable

(2) If designed for automatic operation, have redundant automatic shutdown controls to prevent operation when ~~LNG or other~~ hazardous fluids are present

(3) If water removal systems are designed for manual operation, have a means or procedure to prevent hazardous fluids from escaping through piping or valves

Chapter 15 Transfer Systems for ~~LNG and Other~~ Hazardous Fluids

15.6.2
Tank vehicles not under the jurisdiction of the DOT shall comply with the following standards:

(1) LNG tank vehicles shall comply with CGA 341, *Standard for Insulated Cargo Tank Specification for Cryogenic Liquids*.

(2) LP-Gas tank vehicles shall comply with NFPA 58.

(3) ~~Flammable~~Ignitible (flammable or combustible) liquid tank vehicles shall comply with NFPA 385.

16.1.1
This chapter covers equipment and procedures designed to minimize the consequences from released ~~LNG and other~~ hazardous fluids in facilities constructed and arranged in accordance with this standard.

16.2.2*
The evaluation shall determine the following:

(1) The type, quantity, and location of equipment necessary for the detection and control of fires, leaks, and spills of ~~LNG and other~~ hazardous fluids

(2) The type, quantity, and location of equipment necessary for the detection and control of potential nonprocess and electrical fires

(3) The methods necessary for protection of the equipment and structures from the effects of fire exposure

(4) Requirements for fire protection water systems

(5) *Requirements for fire-extinguishing and other fire control equipment

(6) The equipment and processes to be incorporated within the ESD system, including analysis of subsystems, if any, and the need for depressurizing specific vessels or equipment during a fire emergency or hazardous release

(7) The type and location of sensors necessary to initiate automatic operation of the ESD system or its subsystems

(8) The availability and duties of individual plant personnel and the availability of external response personnel during an emergency

(9) *The personal protective equipment, special training, and qualification needed by individual plant personnel for their respective emergency duties as specified by NFPA 600

(10) Requirements for other hazard protection equipment and systems

16.3.1*
Each LNG facility shall have an ESD system(s) to isolate or shut off a source of ~~LNG and other~~ hazardous fluids, and to shut down equipment whose continued operation could add to or sustain an emergency.

16.3.4
If equipment shutdown will introduce a hazard or result in mechanical damage to equipment, the shutdown of any equipment or its auxiliaries shall be omitted from the ESD system if the effects of the continued release of ~~flammable or combustible~~ignitible fluids are controlled.

16.4.1
Areas, including enclosed buildings and enclosed drainage channels, that can have the presence of ~~LNG or other~~ hazardous fluids during normal operation or following an accidental release shall be monitored as required by the evaluation in 16.2.1.

16.8.3
At LNG plants, there shall be a protective enclosure, including a peripheral fence, wall, building wall, or approved natural barrier enclosing major facility components, including, but not limited to, the following, except where the entire onshore facility is enclosed:

(1) LNG storage containers

(2) Impoundment systems

(3) *~~Flammable refrigerant storage tanks~~Hazardous fluid containers

(4) ~~Hazardous materials storage tanks, including those storing toxic materials~~

(5) ~~Flammable liquid storage tanks~~

(4) Other hazardous materials storage areas

(5) Outdoor process equipment areas

(6) Buildings housing process or control equipment

(7) Onshore loading and unloading facilities

(8) Control rooms and stations

(9) Control systems

(10) Fire control equipment

(11) Security communications systems

(12) Alternative power sources

A.16.8.3(3)
Hazardous fluid containers can be located in multiple areas of the plant and can be segregated by fluid type and 16.8.3 could be applied to each of these areas individually.

17.1.2
This chapter provides an alternative set of requirements for LNG plants that meets all of the following limitations:

(1) LNG storage capacity complies with one of the following:

(a) Individual LNG container water capacity not exceeding 264,000 gal (1000 m^3) water capacity with an aggregate 1,056,000 gal (3997 m^3) water capacity of LNG storage constructed in accordance with the ASME *Boiler and Pressure Vessel Code*

(b) LNG tank systems with an aggregate capacity not exceeding 1,056,000 gal (3997 m^3) water capacity of LNG storage

(2) Aggregate mass of ~~flammable hazardous fluid~~ignitible fluids, excluding methane and LNG, not exceeding 25,000 lb (11,340 kg) and individual tanks with a storage capacity not exceeding 10,000 lb (4536 kg)
(3) Toxic fluids with a 60-minute AEGL-2 of 10,000 ppm or less and an aggregate mass of toxic fluids not exceeding 25,000 lb (11,340 kg) and individual tanks with a storage capacity not exceeding 10,000 lb (4536 kg)
(4) LNG container liquid line penetrations not exceeding 6 in. (15.24 cm) nominal pipe size
(5) LNG container design pressure not exceeding 300 psi (2068 kPa)

17.3.2.1.1
Provisions shall be made to minimize the potential of discharge of ~~LNG or other~~ hazardous liquids at containers, piping, and other equipment such that a discharge from any of these does not endanger adjoining property, occupied buildings, or important process equipment and structures or reach waterways.

17.3.2.1.2
Where there is a possibility for hazardous liquid releases to accumulate and endanger adjoining property, occupied buildings, or important process equipment and structures, or reach waterways, the following areas shall be graded, drained, or provided with impoundment:

(1) Process areas

(2) Vaporization areas

(3) Liquefaction areas

(4) Transfer areas ~~for LNG, flammable refrigerants, and flammable liquids~~

(5) ~~Areas immediately surrounding flammable refrigerant and flammable liquid storage tanks~~Storage areas

17.3.2.1.6
Site preparation shall include provisions for retention of spilled ~~LNG and other~~ hazardous liquids where liquids might accumulate on the ground within the limits of plant property and for surface water drainage.

17.12 Transfer Systems for ~~LNG and Other~~ Hazardous Fluids.
Transfer systems for ~~LNG and other~~ hazardous fluids shall comply with Chapter 15, Transfer Systems for ~~LNG and Other~~ Hazardous Fluids.

17.13 Fire Protection, Safety, and Security.
Fire protection, safety, and security shall comply with Chapter 16, Fire Protection, Safety, and Security.

17.14 Operating, Maintenance, and Personnel Training.
Operating, maintenance, and personnel training shall comply with Chapter 18, Operating, Maintenance, and Personnel Training, with the follow differences:

(1) Positive identification of all persons entering the plant and in the plant shall be required in lieu of requirements in 18.5.1(6).

(2) Vehicle traffic shall be prohibited on the pier or dock within 100 ft (30 m) of the loading and unloading or shorter distances as approved while transfer operations are in progress in lieu of requirements in 18.8.7.4.1.

(3) General cargo, other than ships' stores for the LNG tank vessel, shall not be handled over a pier or dock within 100 ft (30 m) or shorter distances as approved, of the point where connections are made for ~~LNG, and flammable~~ignitible fluids transfer while ~~LNG or flammable~~ignitible fluids are being transferred through piping systems in lieu of requirements in 18.8.7.4.6.

18.3.9
The operating manual shall include procedures for the following:

(1) Maintaining the vaporization rate, temperature, and pressure so that the resultant gas is within the design tolerance of the vaporizer and the downstream piping

(2) Determining the existence of any abnormal conditions and the response to those conditions in the LNG facility

(3) The safe transfer of ~~LNG and~~ hazardous fluids, including prevention of overfilling of containers

(4) Security

18.8.6.9.1
Before ~~LNG or flammable or combustible~~ignitible fluids are loaded into a tank car, tank vehicle, or ISO container that is not in exclusive service for that fluid, a test shall be made to determine the oxygen content in the container.

18.8.7.4.6
General cargo, other than ships' stores for the LNG marine vessel, shall not be handled over a pier or dock within 100 ft (30 m) of the point where connections are made for ~~LNG, and flammable~~ignitible fluids transfer while ~~LNG or flammable~~ignitible fluids are being transferred through piping systems.

18.10.13.1.1*
All metallic components containing ~~LNG and~~ hazardous fluids ~~(liquid or vapor state)~~ that could have their integrity or reliability adversely affected by external, internal, or atmospheric corrosion during their intended service life shall be protected from corrosion.

18.10.13.8.2
All expanded, significantly modified plants or plants replacing components containing ~~LNG and~~ hazardous fluids ~~(liquid or vapor state)~~ shall meet the requirements for corrosion control in 18.10.13 for expanded, modified, or replaced portions of the plant.

18.11.2
The training plan shall include training of permanent maintenance, operating, and supervisory personnel with respect to the following:

(1) The basic operations carried out at the LNG facility

(2) The characteristics and potential hazards of ~~LNG and other~~ hazardous fluids involved in operating and maintaining the LNG plant, ~~including~~consisting of the serious danger from frostbite that can result from contact with LNG or cold refrigerants, asphyxiants, flammability of mixtures with air, odorless vapors, boiloff characteristics, ~~and~~ reactions with water, skin corrosivity, and exposure to toxic fluids

(3) Methods of carrying out the duties of maintaining and operating the LNG plant as set out in the manual of operating and maintenance procedures referred to in Sections 18.3 and 18.9

(4) Methods of carrying out emergency procedures required by Section 18.4 as they relate to their assigned functions

(5) Personnel safety and general construction industry safety-related training as it relates to the assigned functions

19.5.2.1
The following shall be specified for each ~~LNG and~~ hazardous ~~material~~fluid release scenario, as applicable:

(1) Stream composition

(2) Nominal stream pressure and temperature

(3) Physical state of the fluid

(4) Sectionable inventory

(5) Hole size(s)

(6) Release location(s) and direction(s)

(7) Release duration for successful and unsuccessful isolated inventories

19.5.2.4
The behavior modes that shall be considered include~~, but are not limited to,~~ flashing, aerosol formation, liquid jetting, pool formation and flow, dispersion of vapors, jet fires, flash fires, vapor cloud explosions, fireballs, pool fires, pressure vessel bursts, and ~~boiling liquid expanding vapor explosion (~~BLEVES~~)~~.

Second Revision No. 2-NFPA 59A-2022 [Section No. 1.4.4]

1.4.4

~~This~~ The siting, design, and layout portions of this standard shall not apply to situations where equipment, piping, or components are replaced with in-kind equipment, piping, or components for the purpose of continued maintenance to ensure safety and operability of the facility.

Submitter Information Verification

Committee: LNG-AAA

Submittal Date: Tue Apr 26 14:52:46 EDT 2022

Committee Statement

Committee Statement: Changes were made to revise the intent of the paragraph to not exclude the whole standard for in-kind replacements. Design, siting, and layout are excluded to grandfather previously sited facilities.

Response Message: SR-2-NFPA 59A-2022

Public Comment No. 2-NFPA 59A-2021 [Section No. 1.4.4]

Second Revision No. 9-NFPA 59A-2022 [Sections 2.1, 2.2, 2.3]

2.1* General.

The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications.

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 4, *Standard for Integrated Fire Protection and Life Safety System Testing,* 2021 edition.

NFPA 10, *Standard for Portable Fire Extinguishers,* 2022 edition.

NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam,* 2021 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems,* 2022 edition.

NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems,* 2022 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2022 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 2023 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection,* 2022 edition.

NFPA 17, *Standard for Dry Chemical Extinguishing Systems,* 2021 edition.

NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection,* 2022 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection,* 2023 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances,* 2022 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2023 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* 2021 edition.

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines,* 2021 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work,* 2019 edition.

NFPA 54, *National Fuel Gas Code,* 2021 edition.

NFPA 55, *Compressed Gases and Cryogenic Fluids Code,* 2023 edition.

NFPA 56, *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems,* 2023 edition.

NFPA 58, *Liquefied Petroleum Gas Code,* 2023 edition.

NFPA 59, *Utility LP-Gas Plant Code,* 2021 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting,* 2023 edition.

NFPA 69, *Standard on Explosion Prevention Systems,* 2019 edition.

NFPA 70®, National Electrical Code®, 2023 edition.

NFPA 72®, National Fire Alarm and Signaling Code®, 2022 edition.

NFPA *101®, Life Safety Code®,* 2021 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems,* 2022 edition.

NFPA 274, *Standard Test Method to Evaluate Fire Performance Characteristics of Pipe Insulation,* 2023 edition.

NFPA 385, *Standard for Tank Vehicles for Flammable and Combustible Liquids,* 2022 edition.

NFPA 496, *Standard for Purged and Pressurized Enclosures for Electrical Equipment,* 2021 edition.

NFPA 600, *Standard on Facility Fire Brigades,* 2020 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems,* 2023 edition.

NFPA 770, *Standard on Hybrid (Water and Inert Gas) Fire-Extinguishing Systems,*2021 edition.

NFPA 1221, *Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems,* 2019 edition.

NFPA 1901, *Standard for Automotive Fire Apparatus,* 2016 edition.

NFPA 1961, *Standard on Fire Hose,* 2020 edition.

NFPA 1962, *Standard for the Care, Use, Inspection, Service Testing, and Replacement of Fire Hose, Couplings, Nozzles, and Fire Hose Appliances,* 2018 edition.

NFPA 1963, *Standard for Fire Hose Connections,* 2019 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems,* 2022 edition.

NFPA 5000®, Building Construction and Safety Code®, 2021 edition.

2.3 Other Publications.

2.3.1 ACI Publications.

American Concrete Institute, 38800 Country Club Dr., Farmington Hills, MI 48331-3439.

ACI 304R, *Guide for Measuring, Mixing, Transportation and Placing of Concrete*, 2000, reapproved 2009.

ACI 318, *Building Code Requirements for Structural Concrete and Commentary,* 2019.

ACI 350, *Code Requirements for Environmental Engineering Concrete Structures*, ~~2021~~ 2006 .

ACI 376, *Code Requirements for Design and Construction of Concrete Structures for the Containment of Refrigerated Liquefied Gases,* 2011.

2.3.2 ALPEMA Publications.

Brazed Aluminum Plate-Fin Heat Exchanger Manufacturer's Association, IHS (secretariat), 321 Inverness Drive South, Englewood, CO 80112.

Standards of the Brazed Aluminum Plate-Fin Heat Exchanger Manufacturer's Association, 3rd ~~Edition~~ edition , 2012.

2.3.3 API Publications.

American Petroleum Institute, 200 Massachusetts Avenue NW, Suite 1100, Washington, DC 20001-5571.

API 510, *Pressure Vessel Inspection Code: In-service Inspection, Rating, Repair, and Alteration, 10th edition*, 2014, with addendum 1 2017.

API RP 576, *Inspection of Pressure-Relieving Devices*, 4th edition, 2017.

API Spec 6D, *Specification for Pipeline and Piping Valves,*~~24th~~ 25th edition, ~~with errata 1-8 and addendums 1–2, 2016~~ 2021 .

API Std 620, *Design and Construction of Large, Welded, Low-Pressure Storage Tanks,* 12th edition, with addendum ~~2~~ 3 , ~~2018~~ 2021 .

API Std 625, *Tank Systems for Refrigerated Liquefied Gas Storage,* with addendums 1–~~3~~ 4 , ~~2018~~ 2021 .

API Std 650, *Welded Tanks for Oil Storage,* 13th edition, 2021.

API Std 2510, *Design and Construction of Liquefied Petroleum Gas (LPG) Installations,* 9th edition, 2020.

2.3.4 ASCE Publications.

American Society of Civil Engineers, 1801 Alexander Bell Drive, Reston, VA 20191-4400.

ASCE 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures,*~~2016~~ 2022 ~~including Supplement No. 1, Errata dated 7/9/2018, 2/13/2019, and 1/16/2020~~ .

2.3.5 ASME Publications.

American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016-5990.

ASME B31.1, *Power Plant Piping*, 2020.

ASME B31.3, *Process Piping,* 2020.

ASME B31.4, *Pipeline Transportation Systems for Liquids and Slurries*, 2019.

ASME B31.5, *Refrigeration Piping and Heat Transfer Components,* 2019.

ASME B31.8, *Gas Transmission and Distribution Piping Systems,*~~2018~~ 2020 .

Boiler and Pressure Vessel Code, 2021.

2.3.6 ASTM Publications.

ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 2021 Rev. 21A .

ASTM E136, *Standard Test Method for Assessing Combustibility of Materials in a Vertical Tube Furnace at 750°C,* 2019.

ASTM E2652, *Standard Test Method for Assessing Combustibility of Materials in a Tube Furnace with a Cone-shaped Airflow Stabilizer, at 750°C,* 2018.

2.3.7 CGA Publications.

Compressed Gas Association, 14501 George Carter Way, Suite 103, Chantilly, VA 20151-1788.

CGA 341, *Standard for Insulated Cargo Tank Specification for Cryogenic Liquids,* 2017.

CGA S-1.3, *Pressure Relief Device Standards — Part 3 — Stationary Storage Containers for Compressed Gases,* 2020.

2.3.8 CSA Group Publications.

CSA Group, 178 Rexdale Blvd. Toronto, ON M9W 1R3, Canada.

CSA B51, *Boiler, Pressure Vessel and Pressure Piping Code,* 2019.

CSA C22.1, *Canadian Electrical Code,* 2021.

2.3.9 IEEE Publications.

IEEE, 3 Park Avenue, 17th Floor, New York, NY 10016-5997.

IEEE/ASTM SI 10, *American National Standard for Metric Practice,* 2016.

2.3.10 ISA Publications.

International Society of Automation, 67 T.W. Alexander Drive, PO Box 12277, Research Triangle Park, NC 27709.

ISA 12.27.01, ~~*American National Standard for Metric Practice*~~ *Requirements for Process Sealing Between Electrical Systems and Flammable or Combustible Process Fluids* , 2016.

2.3.11 NACE Publications.

NACE International, 15835 Park Ten Place, Houston, TX 77084-4906.

NACE SP0169, *Control of External Corrosion of Underground or Submerged Metallic Piping Systems,* 2013.

NACE SP0198, *Control of Corrosion Under Insulation and Fireproofing Materials — A Systems Approach*, ~~2016~~ 2017 .

2.3.12 UL Publications.

Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062–2096.

UL 723, *Test for Surface Burning Characteristics of Building Materials*, 2018.

2.3.13 Other Publications.

ANSI/NB-23, *National Board Inspection Code, Part 2, Inspection,* Section 2, The National Board of Boiler and Pressure Vessel Inspectors, Columbus, OH, ~~2017~~ 2021 .

ASNT SNT-TC-1A, *Personnel Qualification and Certification in Nondestructive Testing,* 2020.

BS EN 14620, *Design and manufacture of site built, vertical, cylindrical, flat-bottomed, steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0°C and −165°C*, Parts 1–5, 2006.

CEB Bulletin 187, *Concrete Structures Under Impact and Impulsive Loading — Synthesis Report*, International Federation for Structural Concrete, Switzerland, 1988.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

Supplemental Information

File Name	Description	Approved
59A-2019_Chapter_2.docx	Cleaner version of the updated standards	

Submitter Information Verification

Committee: LNG-AAA

Submittal Date: Wed Apr 27 16:28:24 EDT 2022

Committee Statement

Committee Statement: Standards are being revised to their relevant edition year. ACI 350 is reverting to 2006 edition as that is the last edition where Annex G is referenced.

Response Message: SR-9-NFPA 59A-2022

Public Comment No. 3-NFPA 59A-2021 [Section No. 2.3.6]

Second Revision No. 1-NFPA 59A-2022 [Section No. 2.4]

2.4 References for Extracts in Mandatory Sections.

NFPA 52, *Vehicular Natural Gas Fuel Systems Code,* ~~2019~~ 2023 edition.

NFPA 54, *National Fuel Gas Code,* 2021 edition.

Submitter Information Verification

Committee: LNG-AAA

Submittal Date: Thu Mar 03 11:54:52 EST 2022

Committee Statement

Committee Statement: Updating extracted standards to the latest revision year.

Response Message: SR-1-NFPA 59A-2022

Second Revision No. 5-NFPA 59A-2022 [Section No. 10.1]

10.1* Scope.

This chapter presents the design, construction, installation, examination, and inspection requirements for process piping systems and components.

A.10.1

Refer to 8.4.2 and Section ~~17.13~~ 17.8 for piping that is part of an LNG tank

Submitter Information Verification

Committee: LNG-AAA

Submittal Date: Tue Apr 26 16:38:04 EDT 2022

Committee Statement

Committee Statement: Cross reference is being corrected

Response Message: SR-5-NFPA 59A-2022

Second Revision No. 4-NFPA 59A-2022 [Section No. 11.9.2]

11.9.2*

Fixed electrical equipment and wiring installed within the classified areas specified in Table 11.9.2 shall comply with Table 11.9.2 and Figure 11.9.2(a) through Figure 11.9.2(e) and shall be installed in accordance with *NFPA 70*.

Table 11.9.2 Electrical Area Classification

Part	Location	Group D, Division[a]	Extent of Classified Area
A	**LNG storage containers with vacuum breakers**		
	Inside containers	2	Entire container interior, except where 11.9.5 applies
B	**LNG storage container area**		
	Indoors	1	Entire room
	Outdoor aboveground containers (other than small containers)[b]	1	Open area between a high-type dike and the container wall where dike wall height exceeds distance between dike and container walls *[see Figure 11.9.2(b)]*
		2	Within 15 ft (4.5 m) 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 11.9.2(a)]*
	Outdoor belowground containers	1	Within any open space between container walls and surrounding grade or dike *[see Figure 11.9.2(c)~~.~~]*
		2	Within 15 ft (4.5 m) in all directions from roof and sides *[see Figure 11.9.2(c)~~.~~]*
C	**Tank car, tank vehicle, and container loading and unloading**		
	Indoors with adequate ventilation[c]	1	Within 5 ft (1.5 m) in all directions from connections regularly made or disconnected for product transfer
		2	Beyond 5 ft (1.5 m) and entire room and 15 ft (4.5 m) beyond any wall or roof ventilation discharge vent or louver
	Outdoors in open air at or above grade	1	Within 5 ft (1.5 m) in all directions from connections regularly made or disconnected for product transfer
		2	Beyond 5 ft (1.5 m) but within 15 ft (4.5 m) 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
D	**Electrical seals and vents specified in ~~10.7.5~~ 11.9.6 through ~~10.7.7~~ 11.9.8**	2	Within 15 ft (4.5 m) in all directions from the equipment and within the cylindrical volume between the horizontal equator of the sphere and grade
E	**Marine terminal loading and unloading areas***[see Figure 11.9.2(e)~~.~~]*	2	Within 15 ft (4.5 m) in all directions, above the deck, from the open sump

[a]See Article 500 in *NFPA 70* for definitions of classes, groups, and divisions. Article 505 can be used as an alternate to Article 500 for classification of hazardous areas using an equivalent zone classification to the division classifications specified in Table 11.9.2. Most of the flammable vapors and gases found within the facilities covered by NFPA 59A are classified as Group D. Ethylene is classified as Group C. Much of the available electrical equipment for hazardous locations is suitable for both groups.

[b]Small containers are portable and of less than 200 gal (760 L) capacity.

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

Figure 11.9.2(a) Dike Height Less Than Distance from Container to Dike (*H* < *x*).

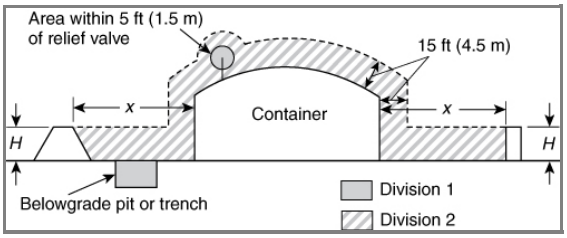


Figure 11.9.2(b) Dike Height Greater Than Distance from Container to Dike (*H* > *x*).

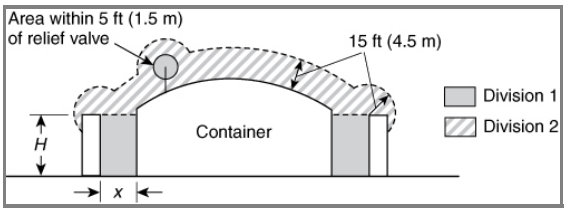


Figure 11.9.2(c) Container with Liquid Level Below Grade or Below Top of Dike.

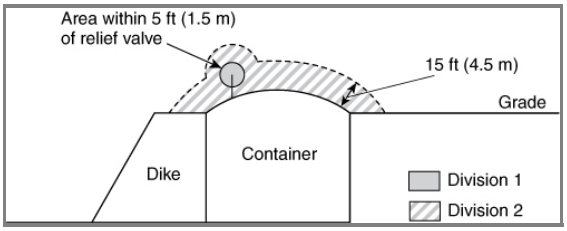


Figure 11.9.2(d) Full and Membrane-Containment Tank Systems.

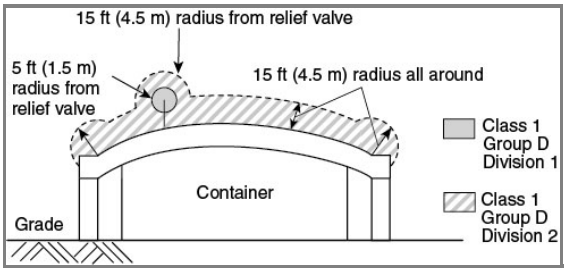
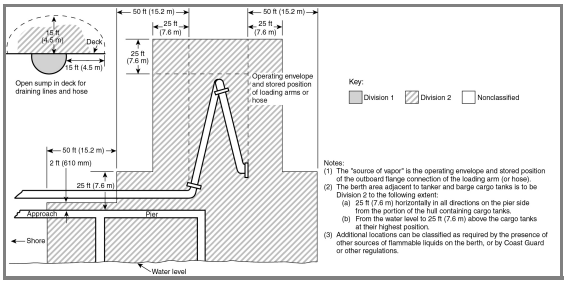


Figure 11.9.2(e) Classification of a Marine Terminal Handling LNG.



Submitter Information Verification

Committee: LNG-AAA
Submittal Date: Tue Apr 26 16:24:23 EDT 2022

Committee Statement

Committee Statement: Cross referenced sections are being corrected.
Response Message: SR-4-NFPA 59A-2022

Second Revision No. 3-NFPA 59A-2022 [Section No. 14.1]

14.1 Temporary Service Use.

Where mobile and temporary LNG equipment is used for temporary use, for service maintenance during gas systems repair or alteration, or for other short-term applications, the following requirements shall be met:

(1) Mobile and temporary LNG equipment shall not remain in service more than 180 days at the mobile and temporary equipment installation.

(2) Mobile and temporary installations in service more than 180 days shall meet one of the following:

  (a) Approval by the AHJ to remain for a period exceeding 180 days

  (b) Compliance with all the applicable requirements of Chapter 17 for stationary applications using ASME containers and with the security requirements in Section 16.8

(3) LNG transport vehicles complying with US Department of Transportation (DOT) requirements shall be used as the supply container.

(4) All mobile and temporary LNG equipment shall be operated by at least one person qualified by experience and training in the safe operation of these systems in accordance with the requirements in 18.11.3 and 18.11.4, based on the written training plan requirements in 18.11.1 and 18.11.2.

(5) All other operating personnel, at a minimum, shall be qualified by training in accordance with the requirements in 18.11.3 and 18.11.4, based on the written training plan requirements in 18.11.1 and 18.11.2.

(6) All personnel requiring training in Section 14.1(3) and 14.1(4) shall receive refresher training in accordance with requirements in 18.11.6.1.

(7) All personnel training shall be documented in accordance with records requirements in 18.12.4.

(8) Each operator shall provide and implement a written plan of initial training in accordance with the requirements in 18.11.1 and 18.11.2 to instruct all designated operating and supervisory personnel.

(9) Provisions shall be made to minimize the possibility of accidental discharge of LNG at containers endangering adjoining property or important process equipment and structures or reaching surface water drainage.

(10) Mobile and temporary containment means shall be permitted to be used.

(11) Vaporizers and controls shall comply with Section 9.3, 9.4.1(1), 9.4.1(2), and Section 9.5.

(12) Each heated vaporizer shall be provided with a means to shut off the fuel source remotely and at the installed location.

(13) Equipment and process design, including piping, piping components, instrumentation and electrical systems, and transfer systems, shall comply with Sections 4.2 and 4.9; 7.4.3, 7.4.5, 7.4.6, 7.4.7, 7.6.1, 7.6.2, 7.6.6.1, 7.6.6.2, 10.2.1, 10.2.1.2, 10.2.1.3, 10.3.1.1, 10.3.1.2(3), 10.3.2.1 through 10.3.2.4, 10.3.3, and 10.3.4; Sections 10.4 through 10.10; and if utilized, cryogenic pipe-in-pipe systems shall comply with Section 10.13, 11.9.1, 11.9.2, 11.9.6, Section 11.10, 15.4.1, 15.6.1, 15.6.2, 15.8.1, 15.8.2, 15.8.3, 15.8.6, 15.9.1, 15.9.2, and 16.2.1.

(14) The LNG facility spacing specified in Table 6.3.1 shall be maintained except where necessary to provide temporary service on a public right-of-way or on property where clearances specified in Table 6.3.1 are not feasible and where the following additional requirements are met:

  (a) Traffic barriers shall be erected on all sides of the facility subject to passing vehicular traffic.

  (b) The operation shall be continuously attended to monitor the operation whenever LNG is present at the facility.

  (c) If the facility or the operation causes any restriction to the normal flow of vehicular

traffic, in addition to the monitoring of personnel required in Section 14.1(11), flag persons shall be continuously on duty to direct such traffic.

(15) Provisions shall be made to minimize the possibility of accidental ignition in the event of a leak.

(16) Fire protection systems shall comply with 16.2.1, Section 16.3, 16.4.1, 16.4.2.2, 16.6.1, 16.7.1, 16.8.1, and 16.8.2.

(17) Portable or wheeled fire extinguishers recommended by their manufacturer for gas fires shall be available at strategic locations and shall be provided and maintained in accordance with NFPA 10.

(18) Operating and maintenance activities shall comply with~~16.4.2 and~~ Sections 18.1 through 18.4; 18.8.1, 18.8.2, 18.8.4, 18.8.5, 18.8.6.5 through 18.8.6.8, 18.8.6.8.3, 18.8.6.8.4, 18.8.6.8.5; Section 18.9; and 18.10.1, 18.10.2, 18.10.6, 18.10.8, 18.10.9, 18.10.10.1, 18.10.10.2, 18.10.10.3, 18.10.10.7, 18.10.13.1, 18.10.13.6, and 18.10.13.7.

(19) The site shall be continuously attended, and provisions shall be made to restrict public access to the site whenever LNG is present.

Submitter Information Verification

Committee: LNG-AAA

Submittal Date: Tue Apr 26 15:30:32 EDT 2022

Committee Statement

Committee Statement: The section being deleted is a fire protection requirement which are already called out in a previous list item (14.1(13)).

Response Message: SR-3-NFPA 59A-2022

Public Comment No. 1-NFPA 59A-2021 [Section No. 14.1]

Second Revision No. 6-NFPA 59A-2022 [Section No. 17.3.2.1.1.1]

17.3.2.1.1.1*

An analysis shall be performed that determines the practical limits of unimpounded liquid spills.

A.17.3.2.1.1.1

Spill limit analysis should include the rate of the spill; the net amount of liquid anticipated available for the spill; the flashing, atomizing and vaporization of rainout that is required to cool the substrate under the spill; and the transient nature of the above parameters.

Submitter Information Verification

Committee: LNG-AAA

Submittal Date: Tue Apr 26 16:41:28 EDT 2022

Committee Statement

Committee Statement: There are numerous means or methods to determining the limit spills and the committee did not want to show preference to one or the other.

Response Message: SR-6-NFPA 59A-2022

Second Revision No. 12-NFPA 59A-2022 [Section No. 19.6]

19.6 Release Probabilities and Conditional Probabilities.

19.6.1*

The annual probability of ~~LNG and other hazardous material~~ hazardous fluid releases from various equipment for scenarios identified in Section 19.5 shall be based on ~~Table 19.6.1~~ failure rates specified as follows or as approved by the AHJ: ~~.~~

(1) For storage tanks and tank systems, use Table 19.6.1(a).

(2) For transfer devices including arms and hoses, use Table 19.6.1(b).

(3) For process equipment, use Table 19.6.1(c), where failures rates are presented for five nominal hole size ranges and the largest applied hole size is limited by the maximum piping diameter of the piping in the portion of the process being evaluated:

(a) Very small, 0.04–0.1 in. (0.001–0.003 m) holes

(b) Small, 0.1–0.4 in. (0.003–0.01 m) holes

(c) Medium, 0.4–2 in. (0.01–0.05 m) holes

(d) Large, 2–6 in. (0.05–0.15 m) holes

(e) Extra large, 6 in. (0.15 m) and larger holes, represented by a hole equivalent to the pipe diameter

~~Table 19.6.1 Failure Rate Database~~

~~Type of Failure~~	~~Failure Rate Per Year of Operation~~
~~**Single-Containment Atmospheric Storage Tank System**~~	
~~Catastrophic failure~~	~~1E-6 per tank system*~~
~~Catastrophic failure of tank system roof (steel roof only)~~	~~1E-4 per tank system~~
~~**Double-Containment Atmospheric Storage Tank System**~~	
~~Catastrophic failure~~	~~1.25 E-8 per tank system*~~
~~Catastrophic failure of tank system roof (steel roof only)~~	~~1E-4 per tank system~~
~~**Full-Containment and Membrane Atmospheric Storage Tanks System (Concrete Outer Container)**~~	
~~Catastrophic failure~~	~~1E-8 per tank system*~~
~~Catastrophic failure of tank system roof (steel roof only)~~	~~4E-5 per tank system~~
~~**Membrane-Containment Atmospheric Storage Tanks System (Concrete Outer Container)**~~	
~~Catastrophic failure~~	~~1E-8 per tank system*~~
~~Catastrophic failure of tank system roof (steel roof only)~~	~~4E-5 per tank system~~
~~**Other Atmospheric Storage Tanks**~~	
~~Catastrophic failure~~	~~3E-6 per tank~~
~~Product release from a hole with effective diameter of 12 in. (300 mm)~~	~~2.5E-3 per tank~~
~~Product release from a hole with effective diameter of 36 in. (1000 mm)~~	~~1E-4 per tank~~
~~Catastrophic failure of tank roof~~	~~2E-3 per tank~~
~~**Pressurized Storage Vessels**~~	
~~Catastrophic failure (i.e., rupture)~~	~~5E-7 per vessel~~
~~Catastrophic failure of vessel fabricated according to 8.5.1.5~~	~~1E-8* per vessel~~
~~Release from a hole with effective diameter of 0.4 in. (10 mm)~~	~~1E-5 per vessel~~

Type of Failure	Failure Rate Per Year of Operation
Process Vessels, Distillation Columns, Heat Exchangers, and Condensers	
Catastrophic failure (i.e., rupture)	5E-6 per vessel
Release from a hole with effective diameter of 0.4 in. (10 mm)	1E-4 per vessel
Truck Transfer	
Rupture of transfer arm	3E-4 per transfer arm
Release from a hole in transfer arm with effective diameter of 10% of the transfer arm diameter with maximum of 2 in. (50 mm)	3E-3 per transfer arm
Rupture of transfer hose	4E-2 per transfer hose
Release from a hole in transfer hose with effective diameter of 10% of the transfer hose diameter with maximum of 2 in. (50 mm)	4E-1 per transfer hose
Ship Transfer	
Rupture of transfer arm	2E-5 per transfer arm
Release from a hole in transfer arm with effective diameter of 10% of the transfer arm diameter with maximum of 2 in. (50 mm)	2E-4 per transfer arm
Piping (General)†	
Rupture at valve	9E-6 per valve
Rupture at expansion joint	4E-3 per expansion joint
Failure of gasket	3E-2 per gasket
Piping: d < 2 in. (50 mm)	
Catastrophic rupture	1E-6 per meter of piping
Release from a hole with effective diameter of 1 in. (25 mm)	5E-6 per meter of piping
Piping: 2 in. (50 mm) ≤ d < 6 in. (150 mm)	
Catastrophic rupture	5E-7 per meter of piping
Release from a hole with effective diameter of 1 in. (25 mm)	2E-6 per meter of piping
Piping: 6 in. (150 mm) ≤ d < 12 in. (300 mm)	
Catastrophic rupture	2E-7 per meter of piping
Release from a hole equivalent to ¼ of the pipe diameter	4E-7 per meter of piping
Release from a hole with effective diameter of 1 in. (25 mm)	7E-7 per meter of piping
Piping: 12 in. (300 mm) ≤ d < 20 in. (500 mm)	
Catastrophic rupture	7E-8 per meter of piping
Release from a hole equivalent to ¼ of the pipe diameter	2E-7 per meter of piping
Release from a hole equivalent to 10% of the pipe diameter, up to 2 in. (50 mm)	4E-7 per meter of piping
Release from a hole with effective diameter of 1 in. (25 mm)	5E-7 per meter of piping
Piping: 20 in. (500 mm) ≤ d < 40 in. (1000 mm)	

Type of Failure	Failure Rate Per Year of Operation
Catastrophic rupture	2E-8 per meter of piping
Release from a hole equivalent to ⅓ of the pipe diameter	1E-7 per meter of piping
Release from a hole equivalent to 10% of the pipe diameter, up to 2 in. (50 mm)	2E-7 per meter of piping
Release from a hole with effective diameter of 1 in. (25 mm)	4E-7 per meter of piping

*Consider effects due to external hazards when determining failure frequency.

†Consider distribution of hole sizes using total failure frequency in table.

Table 19.6.1(a) Failure Rates for Storage Tanks

Storage Tank Type	Type of Failure	Failure Rate Per Year of Operation Per Tank or Tank System
Single-containment LNG storage tank system	Catastrophic failure	1.00E-6*
	Catastrophic failure of tank system roof (steel roof only)	1.00E-04
Double-containment LNG storage tank system	Catastrophic failure	1.25 E-8*
	Catastrophic failure of tank system roof (steel roof only)	1.00E-04
Full-containment and membrane LNG storage tank system (concrete outer containment)	Catastrophic failure	1.00E-8*
	Catastrophic failure of tank system roof (steel roof only)	4.00E-05
Atmospheric storage tanks	Catastrophic failure	3.00E-06
	Product release from a hole with effective diameter of 12 in. (0.3 m)	2.50E-03
	Product release from a hole with effective diameter of 36 in. (1 m)	1.00E-04
	Catastrophic failure of tank roof	2.00E-03
Pressurized product or refrigerant storage	Catastrophic failure	4.70E-07
	Product release from a hole with effective diameter of 4 in. (0.1 m)	4.30E-06
	Product release from a hole with effective diameter of 1 in. (0.025 m)	7.10E-06
	Product release from a hole with effective diameter of 0.20 in. (0.05 m)	2.30E-05

*Consider effects due to external hazards when determining failure frequency.

Table 19.6.1(b) Failure Rates for Transfer Devices

Transfer Type	Type of Failure	Failure Rate Per Hour of Operation Per Arm or Hose

Transfer Type	Type of Failure	Failure Rate Per Hour of Operation Per Arm or Hose
Truck transfer	Rupture of transfer arm	3.00E-08
	Release from a hole in transfer arm with effective diameter of 10% of the transfer arm diameter with maximum of 2 in. (0.05 m)	3.00E-07
	Rupture of transfer hose	4.00E-06
	Release from a hole in transfer hose with effective diameter of 10% of the transfer hose diameter with maximum of 2 in. (0.05 m)	4.00E-05
Ship transfer	Rupture of transfer arm	2.00E-9*
	Release from a hole in transfer arm with effective diameter of 10% of the transfer arm diameter with maximum of 2 in. (0.05 m)	2.00E-8*

* Assumes ESD system with powered emergency release coupling (PERC) installed

Table 19.6.1(c) Failure Rates for Process Equipment

Equipment Type	Nominal Equipment Diameter (in.)	Failure Rate Per Year of Operation for Hole Size [in.] Category					
		0.04 - 0.1	0.1 - 0.4	0.4 - 2	2 – 6*	> 6*	Total Failure Rate
Steel process pipe, failure rate per meter	Up to 2	1.49E-05	6.40E-06	2.79E-06	1.02E-06		2.51E-05
	3	1.36E-05	5.77E-06	2.47E-06	8.80E-07		2.27E-05
	4	1.23E-05	5.14E-06	2.17E-06	7.54E-07		2.03E-05
	6	9.54E-06	3.89E-06	1.60E-06	3.24E-07	2.05E-07	1.56E-05
	8	8.62E-06	3.64E-06	1.56E-06	3.30E-07	2.27E-07	1.44E-05
	10	8.65E-06	3.91E-06	1.81E-06	4.17E-07	3.27E-07	1.51E-05
	12	8.62E-06	4.16E-06	2.08E-06	5.22E-07	4.63E-07	1.58E-05
	14	8.51E-06	4.39E-06	2.37E-06	6.49E-07	6.49E-07	1.66E-05
	16	8.32E-06	4.59E-06	2.69E-06	7.98E-07	9.04E-07	1.73E-05
	18	8.05E-06	4.75E-06	3.01E-06	9.71E-07	1.25E-06	1.80E-05
	>20	7.69E-06	4.85E-06	3.33E-06	1.17E-06	1.74E-06	1.88E-05
Flexible piping, failure rate per meter	Up to 2	5.81E-04	3.04E-04	1.67E-04	9.16E-05		1.14E-03
	3	4.41E-04	2.45E-04	1.44E-04	9.01E-05		9.21E-04
	4	3.13E-04	1.84E-04	1.16E-04	8.34E-05		6.98E-04
	6	9.65E-05	6.38E-05	4.63E-05	1.72E-05	2.77E-05	2.52E-04
	8	3.06E-05	2.16E-05	1.70E-05	6.86E-06	1.31E-05	8.93E-05
	10	2.46E-05	1.81E-05	1.49E-05	6.30E-06	1.35E-05	7.74E-05
	12	1.91E-05	1.46E-05	1.26E-05	5.60E-06	1.36E-05	6.56E-05
	14	1.42E-05	1.13E-05	1.02E-05	4.76E-06	1.33E-05	5.37E-05
	16	9.88E-06	8.17E-06	7.76E-06	3.79E-06	1.23E-05	4.19E-05
	18	6.20E-06	5.34E-06	5.32E-06	2.72E-06	1.05E-05	3.00E-05
	>20	3.20E-06	2.86E-06	2.99E-06	1.61E-06	7.53E-06	1.82E-05
Flanged joints†	Up to 2	4.39E-06	1.97E-06	9.06E-07	3.79E-07		7.64E-06

Equipment Type	Nominal Equipment Diameter (in.)	Failure Rate Per Year of Operation for Hole Size [in.] Category					
		0.04 - 0.1	0.1 - 0.4	0.4 - 2	2 – 6*	> 6*	Total Failure Rate
	3	5.05E-06	2.26E-06	1.04E-06	5.08E-07		8.85E-06
	4	5.71E-06	2.55E-06	1.17E-06	6.36E-07		1.01E-05
	6	7.03E-06	3.13E-06	1.42E-06	3.22E-07	5.67E-07	1.25E-05
	8	8.67E-06	3.75E-06	1.64E-06	3.58E-07	7.92E-07	1.52E-05
	10	1.06E-05	4.36E-06	1.81E-06	3.71E-07	1.03E-06	1.82E-05
	12	1.26E-05	4.95E-06	1.94E-06	3.73E-07	1.27E-06	2.12E-05
	14	1.47E-05	5.50E-06	2.03E-06	3.68E-07	1.50E-06	2.41E-05
	16	1.69E-05	6.01E-06	2.10E-06	3.58E-07	1.73E-06	2.71E-05
	18	1.91E-05	6.49E-06	2.14E-06	3.43E-07	1.96E-06	3.01E-05
	>20	2.14E-05	6.93E-06	2.16E-06	3.25E-07	2.19E-06	3.31E-05
Manual valves	Up to 2	1.50E-05	8.05E-06	4.58E-06	2.66E-06		3.03E-05
	3	1.55E-05	8.06E-06	4.39E-06	2.36E-06		3.03E-05
	4	1.61E-05	8.05E-06	4.19E-06	2.08E-06		3.04E-05
	6	1.71E-05	7.97E-06	3.81E-06	9.15E-07	7.16E-07	3.06E-05
	8	2.09E-05	9.85E-06	4.78E-06	1.16E-06	9.81E-07	3.77E-05
	10	2.53E-05	1.24E-05	6.31E-06	1.62E-06	1.51E-06	4.71E-05
	12	2.93E-05	1.50E-05	7.99E-06	2.16E-06	2.18E-06	5.65E-05
	14	3.29E-05	1.75E-05	9.80E-06	2.78E-06	3.03E-06	6.60E-05
	16	3.60E-05	2.00E-05	1.17E-05	3.51E-06	4.11E-06	7.54E-05
	18	3.88E-05	2.24E-05	1.38E-05	4.34E-06	5.49E-06	8.48E-05
	>20	4.11E-05	2.47E-05	1.60E-05	5.29E-06	7.23E-06	9.42E-05
Actuated valves	Up to 2	1.45E-04	5.77E-05	2.30E-05	7.28E-06		2.33E-04
	3	1.27E-04	5.28E-05	2.21E-05	7.59E-06		2.10E-04
	4	1.11E-04	4.77E-05	2.09E-05	7.81E-06		1.87E-04
	6	7.87E-05	3.68E-05	1.77E-05	4.26E-06	3.61E-06	1.41E-04
	8	6.89E-05	3.25E-05	1.58E-05	3.87E-06	3.37E-06	1.25E-04
	10	7.19E-05	3.28E-05	1.54E-05	3.60E-06	2.95E-06	1.27E-04
	12	7.48E-05	3.31E-05	1.49E-05	3.34E-06	2.57E-06	1.29E-04
	14	7.78E-05	3.32E-05	1.44E-05	3.10E-06	2.24E-06	1.31E-04
	16	8.08E-05	3.34E-05	1.39E-05	2.87E-06	1.93E-06	1.33E-04
	18	8.37E-05	3.35E-05	1.34E-05	2.65E-06	1.66E-06	1.35E-04
	>20	8.67E-05	3.35E-05	1.29E-05	2.45E-06	1.42E-06	1.37E-04
Instrument connections	All	1.20E-04	5.00E-05	2.70E-05			1.97E-04
Process (pressure) vessels	Inlets < 2	3.30E-04	1.70E-04	1.40E-04			6.42E-04
	2 ≤ Inlets < 6	3.30E-04	1.70E-04	9.30E-05	4.90E-05		6.42E-04
	Inlets ≥ 6	3.30E-04	1.70E-04	9.30E-05	2.50E-05	2.40E-05	6.42E-04
Centrifugal pumps	Inlets < 2	2.70E-03	6.40E-04	1.60E-04			3.50E-03
	2 ≤ Inlets < 6	2.70E-03	6.40E-04	1.40E-04	1.80E-05		3.50E-03

Equipment Type	Nominal Equipment Diameter (in.)	Failure Rate Per Year of Operation for Hole Size [in.] Category					
		0.04 - 0.1	0.1 - 0.4	0.4 - 2	2 – 6*	> 6*	Total Failure Rate
	Inlets ≥ 6	2.70E-03	6.40E-04	1.40E-04	1.40E-05	4.00E-06	3.50E-03
Reciprocating pumps	Inlets < 2	8.10E-04	5.50E-04	8.60E-04			2.22E-03
	2 ≤ Inlets < 6	8.10E-04	5.50E-04	4.20E-04	4.40E-04		2.22E-03
	Inlets ≥ 6	8.10E-04	5.50E-04	4.20E-04	1.60E-04	2.80E-04	2.22E-03
Centrifugal compressors	Inlets < 2	3.40E-03	1.50E-03	9.20E-04			5.82E-03
	2 ≤ Inlets < 6	3.40E-03	1.50E-03	6.70E-04	2.50E-04		5.82E-03
	Inlets ≥ 6	3.40E-03	1.50E-03	6.70E-04	1.50E-04	1.10E-04	5.83E-03
Reciprocating compressors	Inlets < 2	6.80E-03	3.10E-03	2.00E-03			1.19E-02
	2 ≤ Inlets < 6	6.80E-03	3.10E-03	1.40E-03	5.60E-04		1.19E-02
	Inlets ≥ 6	6.80E-03	3.10E-03	1.40E-03	3.20E-04	2.40E-04	1.19E-02
Shell & tube heat exchangers; Shell side HC	Inlets < 2	9.00E-04	4.30E-04	3.10E-04			1.64E-03
	2 ≤ Inlets < 6	9.00E-04	4.30E-04	2.10E-04	9.70E-05		1.64E-03
	Inlets ≥ 6	9.00E-04	4.30E-04	2.10E-04	5.30E-05	4.40E-05	1.64E-03
Shell & tube heat exchangers; Tube side HC	Inlets < 2	3.90E-04	2.30E-04	2.60E-04			8.80E-04
	2 ≤ Inlets < 6	3.90E-04	2.30E-04	1.50E-04	1.10E-04		8.80E-04
	Inlets ≥ 6	3.90E-04	2.30E-04	1.50E-04	4.90E-05	6.20E-05	8.81E-04
Plate heat exchangers	Inlets < 2	5.60E-03	2.00E-03	8.50E-04			8.45E-03
	2 ≤ Inlets < 6	5.60E-03	2.00E-03	6.80E-04	1.70E-04		8.45E-03
	Inlets ≥ 6	5.60E-03	2.00E-03	6.80E-04	1.10E-04	5.80E-05	8.45E-03
Air-cooled heat exchangers	Inlets < 2	8.90E-04	3.10E-04	1.40E-04			1.34E-03
	2 ≤ Inlets < 6	8.90E-04	3.10E-04	1.10E-04	2.80E-05		1.34E-03
	Inlets ≥ 6	8.90E-04	3.10E-04	1.10E-04	1.80E-05	9.30E-06	1.34E-03
Filters	Inlets < 2	1.20E-03	4.40E-04	1.90E-04			1.83E-03
	2 ≤ Inlets < 6	1.20E-03	4.40E-04	1.50E-04	3.90E-05		1.83E-03
	Inlets ≥ 6	1.20E-03	4.40E-04	1.50E-04	2.60E-05	1.30E-05	1.83E-03
Pig traps	Inlets < 2	1.40E-03	7.40E-04	6.30E-04			2.77E-03
	2 ≤ Inlets < 6	1.40E-03	7.40E-04	4.10E-04	2.20E-04		2.77E-03
	Inlets ≥ 6	1.40E-03	7.40E-04	4.10E-04	1.10E-04	1.10E-04	2.77E-03
Degassers	Inlets < 2	8.70E-04	5.50E-04	7.20E-04			2.14E-03
	2 ≤ Inlets < 6	8.70E-04	5.50E-04	3.80E-04	3.40E-04		2.14E-03
	Inlets ≥ 6	8.70E-04	5.50E-04	3.80E-04	1.40E-04	2.00E-04	2.14E-03
Expanders	Inlets < 2	2.30E-03	1.00E-03	6.20E-04			3.92E-03
	2 ≤ Inlets < 6	2.30E-03	1.00E-03	4.50E-04	1.70E-04		3.92E-03
	Inlets ≥ 6	2.30E-03	1.00E-03	4.50E-04	9.90E-05	7.00E-05	3.92E-03
Turbines	Inlets < 2	6.90E-03	2.40E-03	1.10E-03			1.04E-02
	2 ≤ Inlets < 6	6.90E-03	2.40E-03	7.90E-04	3.40E-04		1.04E-02
	Inlets ≥ 6	6.90E-03	2.40E-03	7.90E-04	1.30E-04	2.10E-04	1.04E-02

For SI units, 1 in. = 0.025 m.

* If the upper bound of the hole size range exceeds pipe diameter, use the pipe diameter as the representative hole size for consequence modeling purposes.

† These failure rates do not necessarily represent gasket failures at LNG facilities. For all systems, piping that includes flanged joints shall consider releases due to gasket failures. See A.19.6.1 for publications that provide guidance for failure rates.

A.19.6.1

~~Additional references~~ References for failure rate data of equipment items ~~are~~ include the following:

~~CCPS Process Equipment Reliability Database. The database is open only to CCPS members, but some data are available in the book, *Guidelines for Process Equipment Reliability Data,* CCPS, 1989.~~

~~*Failure Mode / Mechanism Distribution,* Reliability Analysis Center, Rome, NY, 1997.~~

~~Johnson, E. M. and J. R. Welker, "Development of an Improved LNG Plant Failure Rate Data Base," GRI-80/0093, Gas Research Institute, Chicago, IL, 1980.~~

~~*Nonelectronic Parts Reliability Data* , Reliability Analysis Center, Rome, NY, 1995.~~

~~*OREDA, Offshore Reliability Data Handbook* , 4th Edition, SINTEF, 2002. Contains data for use in reliability, availability, and maintainability studies; failure rates; failure mode distribution; and repair times for equipment.~~

~~*Reliability Data for Control and Safety Systems* , SINTEF Industrial Management, Trondheim, Norway, 1998.~~

~~*Guidelines for Quantitative Risk Assessment — Purple Book* , CPR 18E, National Institute of Public Health and the Environment, The Netherlands, 2005.~~

(1) "Process Release Frequencies" Report 434-01, International Association of Oil and Gas Producers (OGP), 2019.

(2) *Failure Rate and Event Data for Use within Risk Assessment*, UK Health and Safety Executive, 2012.

(3) "Storage Incident Frequencies," Report 434-3, International Association of Oil and Gas Producers (OGP), 2010.

(4) RIVM (2009). Reference Manual Bevi Risk Assessments, Version 3.2. National Institute of Public Health and the Environment (RIVM) Centre for External Safety, P.O. Box 1, 3720 BA Bilthoven, The Netherlands. January 7, 2009.

(5) Guidelines for Quantitative Risk Assessment — Purple Book, CPR 18E, National Institute of Public Health and the Environment, The Netherlands, 2005.

(6) "Handbook Failure Frequencies," Flemish Government, LNE Department, The Netherlands, 2009.

(7) GTI, Statistical Review and Gap Analysis of LNG Failure Rate Table, GTRI Project Number 21873, DOT Contract Number DTPH56-15-T-00008, 2017.

(8) Kohout, A.J., U.S. Regulatory Framework and Guidance for Siting Liquefied Natural Gas Facilities – A Lifecycle Approach, Mary Kay O'Connor Process Safety Center, 15th Annual International Symposium, October 23-25, 2012.

~~One reference for leak frequency data is the Hydrocarbon Releases (HCR) System database from the United Kingdom Health and Safety Executive (HSE) (https://www.hse.gov.uk/hcr3), as well as the following associated documents:~~

~~*Guidelines for Quantitative Risk Assessment — Purple Book* , CPR 18E, National Institute of Public Health and the Environment, The Netherlands, 2005.~~

~~Lees, F. P., *Loss Prevention in the Process Industry* , 2nd edition, BBS Publishing, 1996.~~

~~"Offshore Hydrocarbon Releases Statistics and Analysis, 2002," Hazardous Installations Directorate (HID) statistics report, HSR 2002 002, UK Health and Safety Executive, February 2003.~~

~~Quantitative Risk Assessment Data Directory, E&P Forum Report No. 11.8/250, October 1996.~~

~~"Revised Guidance on Reporting of Offshore Hydrocarbon Releases," OTO 96 956, UK Health and Safety Executive, November 1996.~~

~~"Supplementary Guidance for Reporting Hydrocarbon Releases," UK Offshore Operators Association, September 2002.~~

Failure rates for storage tanks and transfer devices [as shown in Table 19.6.1(a) and Table 19.6.1(b)] were developed from multiple sources, including the Bevi manual, the OGP publications, and the LNE handbook.

The failure rates presented in Table 19.6.1(c) are derived from the OGP's "Process Release Frequencies" (Report 434-01, 2019). This publication presents failure rates calculated by application of correlations for each equipment type that describe the distribution of hole sizes between 0.04 in. and full rupture of the associated pipe diameter, based on loss of containment failures recorded in the UK HSE's Hydrocarbon Releases Database for 2006 through 2015. The equations and correlations in this reference can be used to calculate failure rates with more granularity than is presented in Table 19.6.1(c). The data presented is from offshore-based facilities, and conditions may be different than those found at LNG facilities.

The hole size ranges for the five nominal release sizes in 19.6.1(c) are based on the OGP 434-01 publication. While the OGP recommends using the geometric mean of the range-bounding values, other representative hole sizes for each range may be justified. Because the hole size ranges applied to Table 19.6.1(c) are necessarily fewer in number than the potential pipe sizes, there exist pipe diameters whose largest possible hole size (a pipe rupture) would be smaller than the representative hole size for a given range. In these cases, the hole size associated with that category should be modeled as a pipe rupture. For example, a system with 3 in. diameter pipe would be represented by the selected hole size in the very small, small, and medium release sizes. For the large (2–6 in.) range, a 3 in. diameter hole would be used. For the > 6 in. range, nothing would be modeled.

Gasket releases are included as a requirement in 19.6.2, with the failure frequency left to the QRA practitioner. The above references provide some guidance on this topic. In LNG facilities, frequent flange leaks due to cooldown operations are expected and should be properly represented in the QRA.

19.6.2

Piping in all systems that includes flanged joints shall consider releases due to gasket failures.

19.6.3*

Conditional probabilities applied to the analysis shall be justified and documented.

A.19.6.3

Conditional probabilities include one of many possible probabilities that can be included in risk calculations, including, but not limited to, the following:

(1) Probability of release direction

(2) Probability of environmental conditions

(3) Probability of ignition relative to time and vapor cloud dispersion

(4) Probability and availability ~~for~~ of failures on demand of safety equipment, including safety instrumented systems (SIS), pressure relief valves (PRV), fire and gas detection systems (FGS), and so on

(5) Probability of presence of people

(6) Probability of human actions/errors

(7) Probability of the system being active (fraction of time it contains hazardous materials at the modeled conditions), often with a complementary scenario for the system being inactive

There are a number of methods ~~in calculating~~ to calculate each conditional probability and each can have an influence on each other with unequal distributions or enable certain conditions to exist that would not otherwise be of concern. For example, incident history indicates that many of the largest incidents occur during the night due to an increase in the probability ~~for~~ of certain human errors as a result of fatigue, lower staffing/supervisory personnel, and potential for less visibility. This could suggest an increase in the probability ~~for~~ of releases occurring at night when environmental conditions are less favorable and result in an unequal distribution that ~~affect~~ affects QRA results. The American Institute of Chemical Engineers, Center for Chemical Process Safety has publications that might be useful, including *Guidelines for Enabling Conditions and Conditional Modifiers in Layers of Protection Analysis* and *Guidelines for Determining the Probability of Ignition of a Released Flammable Mass*.

Supplemental Information

File Name	Description	Approved
Tables_19.6.1a_c.docx	See Word Document for Table 19.6.1a through Table 19.6.1c	
19.6_Rev_Clean.docx	Clean version of the changes.	
19.6_Rev_Final.docx	See Word Document for revisions to Section 19.6; FOR STAFF USE	

Submitter Information Verification

Committee: LNG-AAA

Submittal Date: Fri Apr 29 16:46:29 EDT 2022

Committee Statement

Committee Statement: Failure rates have been revised to reflect new data for failure rates from off-shore data that is more conservative than what is expected at LNG Facilities. Failure rates are now more reflective of specific hole sizes. Additionally more types of equipment have been added to the tables. Note some of the failure rates and type categories have remained the same but are being reorganized into new tables and will display as new.

Response Message: SR-12-NFPA 59A-2022

Second Revision No. 8-NFPA 59A-2022 [Section No. A.8.3.2.2]

A.8.3.2.2

Ten-thousand (10,000) year wind maps can be found in ~~ICC 500, *Standard and Commentary: ICC/NSSA Standard for the Design and Construction of Storm Shelters*~~ ASCE 7 , for tornadoes and hurricanes.

Submitter Information Verification

Committee: LNG-AAA
Submittal Date: Wed Apr 27 15:31:21 EDT 2022

Committee Statement

Committee Statement: ASCE 7 has updated 10,000 year wind maps and is being referenced here.
Response Message: SR-8-NFPA 59A-2022

Second Revision No. 7-NFPA 59A-2022 [Sections A.18.6.5.3, A.18.6.5.6.5]

A.18.6.5.3

AGA ~~XK0101~~ XK1801 , *Purging ~~Principles and Practice~~ Manual* , can be used as a guide. NFPA 56, while not mandatory for LNG facilities, contains additional guidance for purging activities.

A.18.6.5.6.5

Many insulating materials that have had prolonged exposure to natural gas or methane retain appreciable quantities of the gas within their pores or interstitial spaces and can require prolonged purging time or utilization of diffusion-type purging activities. Refer to AGA ~~XK0101~~ XK1801 , *Purging ~~Principles and Practice~~ Manual* .

Submitter Information Verification

Committee: LNG-AAA
Submittal Date: Wed Apr 27 15:26:53 EDT 2022

Committee Statement

Committee Statement: The referenced document is being updated to the latest document.
Response Message: SR-7-NFPA 59A-2022

Second Revision No. 10-NFPA 59A-2022 [Sections C.1, C.2]

C.1 Referenced Publications.

The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

C.1.1 NFPA Publications.

National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, ~~2020~~ 2023 edition.

NFPA 52, *Vehicular Natural Gas Fuel Systems Code*, 2023 edition.

NFPA 56, *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*, 2023 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2023 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2019 edition.

NFPA 70®, *National Electrical Code®*, 2023 edition.

NFPA 70B, *Recommended Practice for Electrical Equipment Maintenance*, 2022 edition.

NFPA 72®, *National Fire Alarm and Signaling Code®*, 2022 edition.

NFPA 77, *Recommended Practice on Static Electricity*, 2019 edition.

NFPA 85, *Boiler and Combustion Systems Hazards Code*, 2023 edition

NFPA 274, *Standard Test Method to Evaluate Fire Performance Characteristics of Pipe Insulation*, 2023 edition.

NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, 2021 edition

NFPA 600, *Standard on Facility Fire Brigades*, 2020 edition.

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2023 edition.

NFPA 850, *Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations*, 2020 edition.

NFPA 2112, *Standard on Flame-Resistant Clothing for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire,* 2023 edition.

NFPA 2113, *Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Short-Duration Thermal Exposures from Fire*, 2020 edition.

C.1.2 Other Publications.

C.1.2.1 ACI Publications.

American Concrete Institute, 38800 Country Club Drive, Farmington Hills, MI 48331-3439.

ACI 376, *Code Requirements for Design and Construction of Concrete Structures for the Containment of Refrigerated Liquefied Gases,* 2011.

C.1.2.2 AGA Publications.

American Gas Association, 400 North Capitol Street, NW, Washington, DC 20001.

AGA ~~XK0101~~ XK1801 , *Purging ~~Principles and Practice~~ Manual* , ~~2001~~ 2018 .

AGA XL 1001, *Classification of Locations for Electrical Installations in Gas Utility Areas*, 2010, with errata 1 and 2, 2011.

AGA XO8614, *Introduction to LNG for Personnel Safety,* 1986.

C.1.2.3 AIChE Publications.

American Institute of Chemical Engineers, 120 Wall Street, FL 23, New York, NY 10005-4020.

Guidelines for Chemical Process Quantitative Risk Analysis, 2000.

Guidelines for Determining the Probability of Ignition of a Released Flammable Mass, 2014.

Guidelines for Enabling Conditions and Conditional Modifiers in Layers of Protection Analysis, 2013.

Guidelines for the Management of Change for Process Safety, March 2008.

Guidelines for Writing Effective Operating and Maintenance Procedures, 1996.

C.1.2.4 API Publications.

American Petroleum Institute, 200 Massachusetts Avenue NW, Suite 1100, Washington DC 20001-5571.

API Publ 770, *A Manager's Guide to Reducing Human Errors*, 1st edition, 2001.

API Publ 2510A, *Fire Protection Considerations for the Design and Operation of LPG Storage Facilities*, 2nd edition, 1996, revised 2015.

API RP 500, *Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division I and Division 2*, 3rd edition, 2008, revised 2012.

API RP 540, *Electrical Installations in Petroleum Processing Plants*, 1999.

API RP 551, *Process Measurement*, 2nd edition, 2016.

API RP 552, *Transmission Systems*, 1st edition, 1994.

API RP 553, *Refinery Valves and Accessories for Control and Safety Instrumented Systems*, 2nd edition, 2012.

API RP 554, *Process Control Systems, Part 1,* 2021.

API RP 554, *Process Control Systems*, *Part 2*, 2008.

API RP 554, *Process Control Systems*, *Part 3*, 2021.

API RP 556, *Instrumentation, Control, and Protective Systems for Gas Fired Heaters*, 2nd edition, 2011.

API RP 580, *Risk-Based Inspection*, 3rd edition, 2016.

API RP 581, *Risk-Based Inspection Methodology*, 3rd edition, 2016.

API RP 583, *Corrosion Under Insulation and Fireproofing*, 2nd edition, 2021.

API RP 752, *Management of Hazards Associated with Location of Process Plant Permanent Buildings,* 2009, revised 2020 .

API RP 753, *Management of Hazards Associated with Location of Process Plant Portable Buildings,* 2007 , reaffirmed ~~2012~~ 2020 .

API RP 754, *Process Safety Performance Indicators for the Refining and Petrochemical Industries*, ~~2nd~~ 3rd edition, ~~2016, errata 1 2017~~ 2021 .

API RP 755, *Fatigue Management Systems for Personnel in the Refining and Petrochemical Industries*, 2nd edition, 2019.

API RP 2001, *Fire Protection in Refineries*, 9th edition, 2019.

API RP 2003, *Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents,* 2015.

API RP 2030, *Application of Water Spray Systems for Fire Protection in the Petrochemical Industry*, 4th edition, 2014.

API RP 2218, *Fireproofing Practices in Petroleum and Petrochemical Processing Plants*, 3rd edition, 2013.

API Spec 6FA, *Fire Test for Valves*, 1999, reaffirmed 2011.

API Spec 6FB, *Fire Test for End Connections*, ~~3rd~~ 4th edition, ~~revised 2011~~ 2019 .

API Spec 6FD, *Specification for Fire Test for Check Valves*, 1st edition, revised 2013.

API Spec 12D, *Specification for Field Welded Tanks for Storage of Production Liquids*, 12th edition, 2017.

API Spec 12F, *Specification for Shop Welded Tanks for Storage of Production Liquids*, 13th edition, 2019.

API Spec 12K, *Specification for Indirect Type Oilfield Heaters*, 2008.

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

Part 1, Sizing and Selection, 10th edition, 2020.

API Std 520, *Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries — Part 2, Installation*, 7th edition, 2020.

API Std 521, *Pressure-relieving and Depressuring Systems*, 7th edition, 2020.

API Std 527, *Seat Tightness of Safety Relief Valves*, 5th edition, 2020.

API Std 537, *Flare Details for Petroleum, Petrochemical, and Natural Gas Industries*, 3rd edition, 2017.

API Std 541, *Form-Wound Squirrel Cage Induction Motors — 500 Horsepower and Larger*, 5th edition, 2014.

API Std 546, *Brushless Synchronous Motors — 500 Horsepower and Larger*, 3rd edition, 2008.

API Std 560, *Fired Heaters for General Refinery Service*, 5th edition, 2016.

API Std 598, *Valve Inspection and Testing*, 10th edition, 2016.

API Std 607, *Fire Test for Quarter-turn Valves and Valves Equipped with Nonmetallic Seats*, 2016.

API Std 610, *Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries*, 12th edition, 2021.

API Std 611, *General Purpose Steam Turbines for Petroleum, Chemical, and Gas Industry Services*, 5th edition, 2008, errata 2019 .

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