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**Production, storage and handling of liquefied natural gas
(LNG)**

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Production, storage and handling of liquefied natural gas (LNG)

1 Scope

This document specifies the technical requirements for the design, construction, operation and maintenance of liquefied natural gas (LNG) plants.

This document is applicable to newly built, expanded and renovated LNG plants on land.

This document does not apply to frozen soil containers, mobile storage tanks installed or used indoors, LNG filling trucks and LNG fuel trucks.

2 Normative references

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

GB/T 150 (all parts), *Pressure vessels*

GB/T 151, *Heat exchangers*

GB 7956.1, *Fire fighting vehicles -- Part 1: General technical specifications*

GB 7956.2, *Fire fighting vehicles -- Part 2: Water tank fire fighting vehicle*

GB 7956.3, *Fire fighting vehicles -- Part 3: Foam fire fighting vehicle*

GB/T 16507 (all parts), *Water-pipe boilers*

GB/T 23258, *Standard practice controlling internal corrosion in steel piping and piping systems*

GB/T 26978 (all parts), *Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of cryogenic liquefied gas*

GB/T 32270, *Pressure piping code -- Power piping*

GB 36894, *Risk criteria for hazardous chemicals production unit and storage installations*

heat or limit surface temperature;

4) Analysis of LNG storage tank materials, design, and construction methods.

5.3.4 If there are no fire protection measures, the concrete outer tank shall be designed to prevent external fire. Conduct thermal analysis to determine temperature distribution and fire action time:

- a) For membrane tank systems, the fire protection design shall include the hydrostatic pressure of the stored liquid at the design level. When designing fire protection for all types of storage tanks, it shall be assumed that the internal gas is at positive pressure;
- b) The design of concrete outer tanks shall consider the following factors:
 - 1) In case of fire, there is a difference in thermal expansion coefficient between prestressed steel bars and tank wall concrete at high temperatures, resulting in a reduction in the effective prestress of the tank wall;
 - 2) As the temperature of the outer concrete tank increases, the strength and elastic modulus of the concrete, steel bars and prestressed steel bars in the outer tank decrease;
 - 3) Due to the softening and relaxation of prestressed steel bars at high temperatures, the effective prestress of the tank wall is reduced.

5.3.5 Multiple tank shut-off valves shall have at least 0.9 m of operating space.

5.3.6 LNG storage tanks larger than 0.5 m³ shall not be built indoors.

5.3.7 Flammable liquid and flammable refrigerant storage tanks shall not be arranged in the LNG storage tank impounding area specified in Chapter 12.

5.4 Vaporizer spacing

5.4.1 In addition to the provisions of 5.4.5, the distance between the vaporizer and the plant fence shall not be less than 30 m.

5.4.2 The distance between adjacent vaporizers shall not be less than 1.5 m.

5.4.3 When a vaporizer using flammable medium as the heat source, the distance between its primary heat source and any ignition source shall not be less than 15 m, except in the following circumstances:

- a) When two or more vaporizers are arranged in the same area, adjacent vaporizers or primary heat sources do not need to be considered as sources of ignition;
- b) When the vaporizer is interlocked with a process heater or other open flame

equipment, the vaporizer cannot be operated due to the interlock when the vaporizer is in operation or its piping system has been cooled or is being cooled, the above-mentioned process heaters or open flame equipment may not be considered as sources of ignition.

5.4.4 The distance between the built-in heated vaporizer and the impounding wall, liquid collection tank and process equipment shall not be less than 15 m.

5.4.5 When the vaporizer is installed and used integrally with a storage tank with a single containment tank capacity less than 265 m³, the distance between the vaporizer and the wall can be determined according to Table 2 based on the tank capacity.

5.4.6 The distance between the vaporizer and other equipment shall be determined according to the closed process equipment in Table 5.2.1 of GB 50183-2004.

5.4.7 The distance between the shut-off valve of the LNG piping at the inlet of the heated vaporizer shall not be less than 15 m. When the heated vaporizer is arranged indoors, the distance between its inlet LNG piping shut-off valve and the building shall not be less than 15 m.

5.4.8 For vaporizers heated by flammable intermediate medium, shut-off valves shall be installed on both the cold and hot sides of the intermediate medium. The distance between the control facilities of the shut-off valves and the vaporizer shall not be less than 15 m.

5.5 Process equipment spacing

5.5.1 The distance between process equipment containing LNG, refrigerants, flammable liquids and combustible gases and sources of ignition, centralized control rooms, instrument control rooms, offices, factories and other manned buildings and structures shall not be less than 15 m.

5.5.2 If there is a control room in the combustible gas compressor room, the building structure shall comply with the provisions of 9.5.

5.5.3 The distance from open flame equipment and other sources of ignition to any impounding area or container open discharge system shall not be less than 15 m.

5.6 Loading-unloading equipment spacing

5.6.1 Piers or berths used for piping transportation of LNG shall be such that any vessel being loaded or unloaded shall be no less than 30 m from any bridge spanning a navigable waterway.

5.6.2 The distance between the loading and unloading manifold and the bridge spanning the channel shall not be less than 61 m.

- a) Welding and brazing of process equipment shall comply with the requirements of equipment design and manufacturing in 6.1.5~6.1.8;
- b) All welding and brazing operations shall comply with TSG 21 and GB/T 150 (all parts).

6.1.3 Dangerous goods storage containers and equipment other than LNG shall comply with the provisions of Annex A.

6.1.4 Process equipment shall be marked with the maximum allowable working pressure.

6.1.5 The design and manufacture of boilers shall comply with the regulations of GB/T 16507 (all parts), GB/T 16508 and TSG G0001.

6.1.6 The design and manufacture of pressure vessels shall comply with the regulations of GB150/T (all parts) and TSG 21.

6.1.7 The design and manufacture of shell and pipe heat exchangers shall comply with the regulations of GB/T 151 and TSG 21.

6.1.8 The design and manufacture of aluminum plate-fin heat exchangers shall comply with the regulations of TSG 21 and NB/T 47006.

6.1.9 Torches used for emergency pressure relief of the system or other process purposes shall comply with the provisions of SH 3009.

6.1.10 A boil-off gas treatment system independent of the tank safety valve shall be set up to safely handle the boil-off gas generated in process equipment and LNG storage tanks.

6.1.11 Evaporative gas shall be discharged to a closed system or an atmospherically safe location to avoid harm to personnel, equipment or surrounding facilities.

6.1.12 Process equipment, piping, cold boxes or other equipment that may form a vacuum shall be designed to withstand vacuum conditions or take measures to prevent vacuum. If air supplementary measures are used, the formation of flammable mixtures in the system shall be prevented.

6.2 Pumps and compressors

6.2.1 The material selection of pumps and compressors shall comply with the design temperature and design pressure regulations.

6.2.2 Valves shall be provided so that each pump or compressor can be isolated for maintenance.

6.2.3 For pumps or centrifugal compressors operating in parallel, each outlet pipeline shall be equipped with a check valve.

6.2.4 When the design pressure of the pump and compressor shell, downstream piping and equipment is lower than the maximum discharge pressure of the pump and compressor, pressure relief facilities shall be provided at the outlets of the pump and compressor, so as to prevent the shell, downstream pipeline and equipment from exceeding the design pressure.

6.2.5 Each pump shall be provided with a vent and/or safety valve to prevent overpressure in the pump casing when cooling at maximum speed.

6.2.6 Combustible gas compressors shall be equipped with vents at various points where gas normally escapes. The vent shall be piped to a safe discharge point.

6.3 Vaporization facilities

6.3.1 If the temperature of the natural heat source of an ambient heat source vaporizer exceeds 100°C, the vaporizer shall be considered a remote heated vaporizer.

6.3.2 If the natural heat source of an ambient heat source vaporizer is separated from the actual vaporizer, and a controlled heat transfer medium circulation is used between the heat source and the vaporizer, the vaporizer shall be considered a remote heated vaporizer and shall comply with the regulations for the heated vaporizer.

6.3.3 The design, construction and inspection of vaporizers that meet the definition of pressure vessels shall comply with the requirements of TSG 21.

6.3.4 The vaporizer design pressure shall not be less than the maximum outlet pressure of the LNG pump or the maximum design pressure of the pressurized storage system supplying the vaporizer.

6.3.5 The outlet valve of each vaporizer and the pipe fittings between the outlet valve and the vaporizer (including the safety valve installed upstream of the vaporizer outlet valve) shall be designed according to the operating temperature of the vaporizer.

6.3.6 The LNG inlet to the vaporizer or vaporizer system shall be provided with at least one manual or automatic shut-off valve. It shall be shut down in any of the following situations.

- a) When the piping loses pressure (i.e., the flow rate is too large);
- b) When a fire occurs near a vaporizer or shut-off valve;
- c) When the temperature of the vaporizer and outlet pipe exceeds the design temperature range.

and structures or entering surface drainage systems;

- b) Mobile and temporary containers can be used;
- c) The vaporizer and control facilities shall comply with the provisions of 6.3.3~6.3.5, 6.3.6 a), 6.3.6 b) and 6.3.12~6.3.14;
- d) Heated vaporizers shall be equipped with fuel remote cut-off facilities and can be operated locally;
- e) The design of equipment and process piping, piping components, instrumentation, electrical and transmission systems shall comply with 6.1.4~6.1.8, 6.2.2~6.2.5, 8.1.1.1, 8.1.1.2, 8.1.4.1, 8.1.4.2 c), the provisions of 8.2.1.1~8.2.1.4, 8.2.2 and 8.2.3. If a cryogenic pipe-in-pipe system is used, it shall comply with the provisions of 8.11, 10.1, 10.2, 10.4, 10.5, 11.2, 13.1 and 13.2;
- f) The spacing between LNG facilities shall comply with the provisions of Table 2 and Table 3;
- g) Measures shall be taken to minimize accidental fires caused by leaks;
- h) The fire protection system shall comply with the provisions of 11.1.7, 11.1.8.1, 11.1.8.2c), 13.3.1, 13.4.1, 13.5.1.1 and 13.5.1.2;
- i) Portable or trolley-type gas fire extinguishers that comply with GB 50140 shall be installed at key locations;
- j) Operation and maintenance shall comply with the provisions of 11.1.8.2, 17.1, 17.2, 17.5.1, 17.5.2.3 ~17.5.2.6, 17.6, 17.7.1, 17.7.3.1 and 17.7.3.2

6.4.2 When temporary facilities need to be odorized, if the flammable odorant in the facility does not exceed 76 L, the equipment spacing does not need to apply to the provisions of Table 2 and Table 3.

7 Liquefied natural gas storage tanks

7.1 General requirements

7.1.1 LNG membrane tanks, LNG metal storage tanks and LNG concrete storage tanks shall comply with the provisions of 7.4.

7.1.2 The material selection, design, installation, inspection and testing of the metal diaphragm, pressure-bearing insulation layer and outer tank moisture-proof layer of the membrane tank shall comply with the regulations of GB/T 26978 (all parts) and 7.4.

7.1.3 LNG pressure storage tanks shall comply with the regulations of GB/T 150 (all

parts), TSG 21 and 7.5. The use of pressure vessels shall comply with the regulations of TSG 21.

7.2 Design requirements

7.2.1 All materials in the LNG storage tank system that come into contact with LNG or low-temperature LNG vapor (temperature below -20°C) shall be adapted to their corresponding operating temperatures.

7.2.2 The outer surface of the LNG storage tank, where it may come into contact with LNG or low-temperature boil-off gas at flanges, valves, seals or other non-welded joints, shall be able to adapt to low temperatures or take measures to protect them from the effects of low temperatures.

7.2.3 The density of LNG is the actual mass per unit volume of liquid at the lowest storage temperature. The design value of liquid density shall be no less than 470 kg/m^3 .

7.2.4 The wind load and snow load used in the design of LNG storage tanks shall be based on the 100-year return value in GB 50009.

7.2.5 The marking settings of LNG storage tanks and LNG pressure storage tanks shall comply with the following regulations.

- a) LNG storage tanks shall be equipped with corrosion-resistant nameplates in easily accessible places;
- b) LNG pressure storage tanks shall be equipped with corrosion-resistant nameplates. The nameplate shall comply with the regulations of TSG 21 and GB/T 150 (all parts);
- c) All openings in LNG storage tanks and LNG pressure storage tanks shall be marked with their purpose;
- d) When LNG storage tanks and LNG pressure storage tanks are frosted, the opening markings shall be clearly visible.

7.2.6 Semi-underground LNG storage tanks and underground LNG storage tanks shall be equipped with heating systems to ensure that the temperature at any location around the storage tank is not lower than 0°C . When a heating belt or heating piping fails, the backup piping of the heating system can still meet this requirement.

7.2.7 Heating elements and temperature sensors installed on the heating system shall be easily replaceable.

7.2.8 Buried or semi-buried parts in contact with corrosive soil shall be made of corrosion-resistant materials or protected by cathodic protection and anti-corrosion coatings.

- b) The cracking of the bottom load-bearing insulation layer under the combined action of thermal stress and mechanical stress shall not affect the integrity of the LNG storage tank;
- c) The combustion performance of materials that are in long-term contact with LNG or low-temperature LNG vapor under the design pressure and temperature shall comply with the provisions of this document;
- d) The insulation materials shall be able to be purged with low-temperature LNG steam in the construction and installation environment. The small amount of low-temperature LNG vapor remaining after purging shall not increase the flammability of the insulation material;
- e) Thermal insulation materials shall be non-combustible materials in the construction and installation environment;
- f) The following protective measures shall be taken during construction and shutdown maintenance of the thermal insulation system:
 - 1) In addition to the fact that the insulation materials shall be properly protected from fire sources, after the insulation materials are constructed or out of service for maintenance, hot work that may cause them to burn shall not be carried out near them;
 - 2) Fail-safe temperature controls shall be implemented when tools or equipment used during construction or repair of an insulation system may introduce heat into combustible insulation components.

7.4.3 Bleed device

7.4.3.1 Storage tanks shall be equipped with safety valves and vacuum safety valves.

7.4.3.2 The pressure and vacuum relief devices shall be directly connected to the atmosphere when in use.

7.4.3.3 When the storage tank may experience negative pressure and exceed its design pressure, a vacuum relief device shall be installed.

7.4.3.4 The safety valve and vacuum safety valve of the storage tank shall be able to be isolated from the storage tank using a manual full-open shut-off valve. They shall meet the following requirements:

- a) Shut-off valves shall be locked or sealed in the fully open position;
- b) When any valve is isolated, the capacity of the remaining valves can still meet the relief requirements;
- c) If only one relief device is required, a fully open three-way valve shall be installed

to connect the relief valve and its spare parts to the storage tank, or two independent relief valves with valves shall be installed;

- d) More than one shut-off valve shall not be closed at the same time;
- e) The safety valve discharge pipe or vent pipe of the storage tank shall be vertically upward and prevent the accumulation of water, ice, snow or other foreign matter.

7.4.3.5 The performance of the pressure relief device shall comply with the following requirements:

- a) When determining the pressure relief capacity of a pressure relief device, consideration shall be given to fire, operating disorders (such as control device failure), equipment failure and other situations caused by mis-operation, evaporation gas displaced during filling, flash evaporation due to filling or mixing of different components of products during filling, and refrigeration failure, heat brought in by pump circulation, atmospheric pressure reduction and tumbling and other factors;
- b) The pressure relief device shall be able to relieve the maximum emission amount under a single operating condition, or the emission amount produced by any reasonable and possible combination of operating conditions;
- c) The minimum pressure relief capacity of the pressure relief device (unit: kg/h) shall comply with the requirement that the discharge within 24 h shall not be less than 3% of the full tank capacity.

7.4.3.6 The performance of the vacuum relief device shall comply with the following requirements:

- a) When determining the relief capacity of the vacuum relief device, factors such as the maximum rate of liquid or gas discharge, the increase in atmospheric pressure, and the decrease in gas phase space pressure caused by the entry of supercooled liquid shall be considered;
- b) The vacuum relief device shall be able to relieve the maximum vacuum under a single working condition, or the vacuum generated by any reasonable and possible combination of working conditions. It shall subtract the vaporization amount generated by the minimum normal heat absorption of the material in the tank;
- c) The capacity of the vacuum relief device shall not be offset by the use of gas re-pressurization systems and air make-up systems.

7.4.3.7 External fire calculations shall comply with the following provisions:

- a) The pressure relief capacity required for external fire calculations shall be calculated according to formula (1):

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