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Guideline for Technical Regulation Volume 2

Design of Thermal Power Facilities

Book 7/12

« Liquefied Gas Handling Facility »

Final Draft

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Electric Power Development Co., Ltd.
Shikoku Electric Power Co., Inc.
West Japan Engineering Consultants, Inc.

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Table of Contents

List of Tables

List of Figures

List of Photos

List of Acronyms/Abbreviations

ACI	American Concrete Institute
AFV	Air Fin Vaporizer
AGA	American Gas Association
API	American Petroleum Institute
AS	Australia Standard
ACSE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing
BOG	Boil Off Gas
BS	British Standard
CFR	Code of Federal Regulations
C3-MCR	C3 Main cryogenic Refrigerant
CASCADE	Optimized Cascade LNG Process
DCEN	Direct Current Electrode Negative
DFD	Dual Fuel Diesel
DMS	Di-Methyl Sulfide
DRL	Diesel and Reliquefaction
DTS	Distributed temperature sensor
EN	European Norm
FERC	Federal Energy Regulatory Commission
FBE	Fusion Bonded Epoxy
FPD	Frame Photometric detector
GPTC	Gas Piping Technology Committee
GTI	Gas Technology Institute
GTL	Gas To Liquid
HCD	High Current Density
HC	High Current
HPCC	High Performance Composite Coating
HWV	Hot Water Vaporizer
IBC	International Building Code
IEC	International Electrotechnical Commission
IFV	Intermediate Fluid Vaporizer
IPMS	Integrated Position Monitoring System
ISO	International Organization for Standardization

JIS	Japanese Industrial Standard
JGA	Japan Gas Association
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
3LPE	3-Layer Poly Ethylene
3LPP	3-Layer Poly Propylene
NACE	National Association of Corrosion Engineers
MAOP	Maximum Allowable Operating Pressure
MC	Electromagnetic Control
MCE	Maximum Considered Earthquake
MIG	Metal Inert Gas Welding
MSS	Manufacturers Standardization Society
NFPA	National Fire Protection Association
OBE	Operating Basis Earthquake
ORV	Open Rack Vaporizer
PPI	Plastic Pipe Institute Inc.
SCV	Submerged Combustion Vaporizer
SSE	Safe Shutdown Earthquake
SMAW	Shield Metal Arc Welding
SYMS	Specific Minimum Yield Strength
THT	Tetra Hydro Thiophene
TBM	Tertiary Butyl Mercaptan
TIG	Tungsten Inert Gas welding
RT	Radiographic Testing
USGS	United States Geological Survey
UT	Ultrasonic Testing
WES	Welding Engineering Society
WPS	Welding Procedure Specification

Chapter-1. Comparison between Technical Regulation and Technical Guideline of liquefied gas fuel handling facility

The article number of this guideline is shown in the Table-1 contrasted technical regulation with technical guideline for easy understanding.

Table- 1: Comparison between Technical Regulation and Technical Guideline of liquefied gas facility

Technical Regulation		Technical Guideline	
Article 154.	General Provision of Liquefied Gas Unloading and Transportation Facility	Article 154.	General Provision of Liquefied Gas Unloading and Transportation Facility
1.	General provision	1.	General provision
Article 155.	Classification of Liquefied Gas	Article 155.	Classification of Liquefied Gas
1.	Classification of liquefied gas	1.	Classification of liquefied gas
Article 156.	Unloading Pipeline for Liquefied Gas	Article 156.	Unloading Pipeline for Liquefied Gas
1.	Applicability of loading arm	1.	Applicability of loading arm
2.	Availability of loading arm	2.	Availability of loading arm
3.	Purge mechanism	3.	Purge mechanism
4.	Leakage from sliding portion	4.	Leakage from sliding portion
5.	Alarm system	5.	Alarm system
6.	Shut-off valve	6.	Shut-off valve
Article 157.	Material of Liquefied Gas Unloading and Transportation Facility	Article 157.	Material of Liquefied Gas Unloading and Transportation Facility
1.	Main material	1.	Main material
Article 158.	Construction, etc. Liquefied Gas Unloading and Transportation Facility	Article 158.	Construction, etc. Liquefied Gas Unloading and Transportation Facility
1.	Structure	1.	Structure
2.	Foundation	2.	Foundation
Article 159.	Welding Part of Liquefied Gas Unloading and Transportation Facility	Article 159.	Welding Part of Liquefied Gas Unloading and Transportation Facility
1.	Gas part	1.	Gas part
2.	Liquefied gas and gas part	2.	Liquefied gas and gas part
3.	Welding part	3.	Welding part
Article 160.	Safety Valve for Liquefied Gas Unloading and Transportation Facility	Article 160.	Safety Valve for Liquefied Gas Unloading and Transportation Facility
1.	Safety valve	1.	Safety valve

Technical Regulation		Technical Guideline	
Article 161.	Instrument Device for Liquefied Gas Unloading and Transportation Facility	Article 161.	Instrument Device for Liquefied Gas Unloading and Transportation Facility
1.	Instrument device	1.	Instrument device
Article 162.	Alarm Device for Liquefied Gas Unloading and Transportation Facility	Article 162.	Alarm Device for Liquefied Gas Unloading and Transportation Facility
1.	Alarm device	1.	Alarm device
Article 163.	Fail-safe Control and Interlock for Liquefied Gas Transportation Facility	Article 163.	Fail-safe Control and Interlock for Liquefied Gas Transportation Facility
1.	Fail-safe isolation	1.	Fail-safe isolation
2.	Interlock	2.	Interlock
Article 164.	Back-up Power, etc. for Liquefied Gas Transportation Facility	Article 164.	Back-up Power, etc. for Liquefied Gas Transportation Facility
1.	Back-up power	1.	Back-up power
Article 165.	General Provision for Liquefied Gas Storage Facility	Article 165.	General Provision for Liquefied Gas Storage Facility
1.	General provision	1.	General provision
Article 166.	Material of Liquefied Gas Storage Facility	Article 166.	Material of Liquefied Gas Storage Facility
1.	Main material	1.	Main material
Article 167.	Structure of Liquefied Gas Storage Facility	Article 167.	Structure of Liquefied Gas Storage Facility
1.	Liquefied gas part	1.	Liquefied gas part
2.	Main part of storage tank	2.	Main part of storage tank
3.	Gas tight function	3.	Gas tight function
4.	Stable deformation behavior	4.	Stable deformation behavior
5.	Cold insulation	5.	Cold insulation
6.	Performance of cold insulation material	6.	Performance of cold insulation material
7.	Cold insulation material for bottom	7.	Cold insulation material for bottom
8.	Joint of cold insulation	8.	Joint of cold insulation
Article 168.	Sign for Liquefied Gas Storage Facility	Article 168.	Sign for Liquefied Gas Storage Facility
1.	Sign	1.	Sign
Article 169.	Safety Valve, etc. for Liquefied Gas Storage Facility	Article 169.	Safety Valve, etc. for Liquefied Gas Storage Facility
1.	Safety valve	1.	Safety valve
2.	Quantity of safety valve	2.	Quantity of safety valve

Technical Regulation		Technical Guideline	
Article 170.	Prevention Vacuum in Liquefied Gas Storage Tank	Article 170.	Prevention Vacuum in Liquefied Gas Storage Tank
1.	Vacuum condition	1.	Vacuum condition
Article 171.	Instrument Device for Liquefied Gas Storage Tank	Article 171.	Instrument Device for Liquefied Gas Storage Tank
1.	Instrument device	1.	Instrument device
Article 172.	Alarm Device for Liquefied Gas Storage Tank	Article 172.	Alarm Device for Liquefied Gas Storage Tank
1.	Alarm device	1.	Alarm device
Article 173.	Shut-off Device of Liquefied Gas Storage Tank	Article 173.	Shut-off Device of Liquefied Gas Storage Tank
1.	Shut-off device	1.	Shut-off device
Article 174.	Heat Insulation Measure for Liquefied Gas Storage Tank	Article 174.	Heat Insulation Measure for Liquefied Gas Storage Tank
1.	Heat insulation	1.	Heat insulation
Article 175.	Dike for Liquefied Gas Storage Tank	Article 175.	Dike for Liquefied Gas Storage Tank
1.	Protection dike	1.	Protection dike
2.	Installation of equipment in the dike	2.	Installation of equipment in the dike
Article 176.	Anti-corrosion Measure of Liquefied Gas Storage Tank	Article 176.	Anti-corrosion Measure of Liquefied Gas Storage Tank
1.	Corrosion measure of buried part	1.	Corrosion measure of buried part
Article 177.	General Provision of Pump, Compressor and Blower for Liquefied Gas Storage Tank	Article 177.	General Provision of Pump, Compressor and Blower for Liquefied Gas Storage Tank
1.	Fuel for LNG carrier	1.	Fuel for LNG carrier
2.	Fuel for LPG carrier	2.	Fuel for LPG carrier
3.	Unloading of LNG	3.	Unloading of LNG
Article 178.	Pump for Liquefied Gas	Article 178.	Pump for Liquefied Gas
1.	Operation condition	1.	Operation condition
2.	Heat effect	2.	Heat effect
3.	Gas accumulation	3.	Gas accumulation
4.	Discharge rate	4.	Discharge rate
5.	Protection for moving part	5.	Protection for moving part
6.	Maintenanceability	6.	Maintenanceability
7.	Gas purge	7.	Gas purge

Technical Regulation		Technical Guideline	
Article 179.	Blower for Return Gas	Article 179.	Blower for Return Gas
1.	Operation condition	1.	Operation condition
2.	Minimum flow operation	2.	Minimum flow operation
3.	Alarm system	3.	Alarm system
Article 180.	Compressor, Blower	Article 180.	Compressor, Blower
1.	Structure	1.	Structure
2.	Discharge rate	2.	Discharge rate
3.	Protection for moving part	3.	Protection for moving part
4.	Maintenanceability	4.	Maintenanceability
5.	Gas purge	5.	Gas purge
Article 181.	General Provision of Liquefied Gas Vaporization Facility	Article 181.	General Provision of Liquefied Gas Vaporization Facility
1.	General provision	1.	General provision
Article 182.	Off Limit, etc. to Liquefied Gas Vaporization Facility	Article 182.	Off Limit, etc. to Liquefied Gas Vaporization Facility
1.	Off limit	1.	Off limit
Article 183.	Security Communication Facility for Liquefied Gas Vaporization Facility	Article 183.	Security Communication Facility for Liquefied Gas Vaporization Facility
1.	Security communication equipment	1.	Security communication equipment
Article 184.	Off-set Distance for Liquefied Gas Vaporization Facility	Article 184.	Off-set Distance for Liquefied Gas Vaporization Facility
1.	Security distance	1.	Security distance
Article 185.	Security Compartment for Liquefied Gas Vaporization Facility	Article 185.	Security Compartment for Liquefied Gas Vaporization Facility
1.	Security compartment	1.	Security compartment
Article 186.	Firefighting Facility for Liquefied Gas Vaporization Facility	Article 186.	Firefighting Facility for Liquefied Gas Vaporization Facility
1.	Firefighting facility	1.	Firefighting facility
Article 187.	Prevention of Gas Accumulation of Liquefied Gas Vaporization Facility	Article 187.	Prevention of Gas Accumulation of Liquefied Gas Vaporization Facility
1.	Indoor gas accumulation	1.	Indoor gas accumulation
2.	Leakage detector and alarm device	2.	Leakage detector and alarm device
Article 188.	Explosionproof Structure of Electric Facility for Liquefied Gas Vaporization Facility	Article 188.	Explosionproof Structure of Electric Facility for Liquefied Gas Vaporization Facility
1.	Explosionproof electric facility	1.	Explosionproof electric facility

Technical Regulation		Technical Guideline	
Article 189.	Distance from Flammable Facility of Liquefied Gas Vaporization Facility	Article 189.	Distance from Flammable Facility of Liquefied Gas Vaporization Facility
1.	Distance from flammable facility	1.	Distance from flammable facility
Article 190.	Static Electric Removal for Liquefied Gas Vaporization Facility	Article 190.	Static Electric Removal for Liquefied Gas Vaporization Facility
1.	Static electricity removal	1.	Static electricity removal
Article 191.	Gas Displacement of Liquefied Gas Vaporization Facility	Article 191.	Gas Displacement of Liquefied Gas Vaporization Facility
1.	Gas displacement	1.	Gas displacement
2.	Vent-stack	2.	Vent-stack
3.	Heat radiation from friar-stack	3.	Heat radiation from friar-stack
Article 192.	Material of Liquefied Gas Vaporization Facility	Article 192.	Material of Liquefied Gas Vaporization Facility
1.	Material	1.	Material
Article 193.	Structure of Liquefied Gas Vaporization Facility	Article 193.	Structure of Liquefied Gas Vaporization Facility
1.	Direct fire	1.	Direct fire
2.	Thermal expansion	2.	Thermal expansion
3.	Heat exchanger tube	3.	Heat exchanger tube
4.	Sea water part	4.	Sea water part
5.	Freezing	5.	Freezing
6.	Leakage of liquefied gas	6.	Leakage of liquefied gas
Article 194.	Welding Parts of Liquefied Gas Vaporization Facility	Article 194.	Welding Parts of Liquefied Gas Vaporization Facility
1.	Liquid gas part	1.	Liquid gas part
2.	Liquid gas and gas part	2.	Liquid gas and gas part
3.	Appropriate welding standard	3.	Appropriate welding standard
Article 195.	Safety Valve for Liquefied Gas Vaporization Facility	Article 195.	Safety Valve for Liquefied Gas Vaporization Facility
1.	Safety valve	1.	Safety valve
Article 196.	Instruments Device, etc. for Liquefied Gas Vaporization Facility	Article 196.	Instruments Device, etc. for Liquefied Gas Vaporization Facility
1.	Instrument device	1.	Instrument device
Article 197.	Alarm Device for Liquefied Gas Vaporization Facility	Article 197.	Alarm Device for Liquefied Gas Vaporization Facility
1.	Warning device	1.	Warning device

Technical Regulation		Technical Guideline	
Article 198.	Shut-off device for Liquefied Gas Vaporization Facility	Article 198.	Shut-off device for Liquefied Gas Vaporization Facility
1.	Shut-off device	1.	Shut-off device
Article 199.	Back-up Power, etc. for Liquefied Gas Vaporization Facility	Article 199.	Back-up Power, etc. for Liquefied Gas Vaporization Facility
1.	Back-up power	1.	Back-up power
Article 200.	Odor Measurement for Liquefied Gas Vaporization Facility	Article 200.	Odor Measurement for Liquefied Gas Vaporization Facility
1.	Odorization facility	1.	Odorization facility
Article 201.	Control Room for Liquefied Gas Vaporization Facility	Article 201.	Control Room for Liquefied Gas Vaporization Facility
1.	Control room	1.	Control room

Article 154. General provision of liquefied gas unloading and transportation facility

Article 154-1. General provision

1. Liquefied natural gas

(1) Generally, natural gas refers to a hydrocarbon that is naturally occurring fossil fuels. In the broader sense, they are the general gas jet to the surface from underground. These gases contain not only fossil gas (flammable gas) but also non-flammable gas such as nitrogen, oxygen, carbon dioxide, hydrogen sulfide gas, sulfur oxide gas, sulfurous acid gas. Many of these non-flammable gases are volcanic gases. Liquefied natural gas was cooled to liquid the natural gas as a gas to below -162°C. Volume of LNG is only 1/600 of the gas. Natural gas is liquefied for the purpose of transportation and storage. There is a difference in the composition of hydrocarbons by the produce of natural gas, although natural gas contains gases such as ethane, propane and butane in addition to methane, which is the main component, and are liquefied at the same time these gases in the process of liquefaction to LNG. LNG would be harmless for the human body, since impurities such as carbon dioxide which make a hydrate and cause blockage to pipe and sulfur oxides to cause corrosion of plant is removed. Four methods of “C3-MCR”, “TEALARC”, “PRICO” and “CASCADE” to liquefaction. Pure ingredients of methane, ethane and propane are used as a refrigerant in CASCADE individually in three stages, a mixture of nitrogen, methane; ethane and propane are used in other three methods. C3-MCR method is often used in the liquefaction plant.

(2) The method to transport natural gas is roughly divided into two. One is to transport by pipeline, it has been made in the United States since the 1930s, and now it has been used to transport natural gas from Russia to Eastern Europe and from North Africa to southern Europe. Another one is to transport liquefied natural gas by LNG tanker, and is frequently used to transport from Middle East or Southeast Asia to Japan. Accident of LNG carrier is extremely low, and large-scale environmental destruction accident including gas explosion and gas leakage has not occurred even once. In addition, it is under development to transport as methane hydrate. It can be reduced the volume even at high temperature compared to LNG and improved transportation efficiency can be expected. In addition, the method to transport methanol converted to liquid by GTL method in the origin country is in the stage of commercialization.

(3) In order to use the LNG, it is necessary to a range of facilities, called “LNG chain” such as gas well, pipeline, LNG plant, LNG tanker, receiving facility and vaporizing facilities.

2. Liquefied propane gas

(1) LPG mainly composed by butane and propane, which is a type of gas fuel (gaseous fuel) which can be liquefied easily at room temperature. Generally, it is called propane gas (also called German: Propan-gas). Other than petroleum derived gas such as the natural gas derived account about half in

the world, although it is easy to be misinterpreted as “perfect petroleum products”. Usually, propane and butane, which is heavier than ethane, is separated from wet natural gas contains a lot of these, though the main component of natural gas is methane. Or it is separated in the process of refining of petroleum. It has a large amount of heating value compared with natural gas.

(2) Impurities in the gas from oil well, natural gas well, oil refinery is removed and liquefied in a simple compressor and cooling container. Compression pressure is 0.21MPa (about 2.1atm) for butane at 20^{o}C, 0.86MPa (about 8.5atm) at 20^{o}C, can be liquefied easily and the volume can be reduced 1/250 at the time of vaporized gas having excellent portability. At this time, the gas itself is colorless, odorless. It is possible to storage and transport in low pressure tank. In addition, it is supplied to final customer after odorizing by melcaptan, etc. (it is often expressed as an rotten onion smell)in order to perceive when the gas leaked, since it is dangerous due to the gas explosion when gas leaking and gas is accumulated under that specific gravity heavier than air. The dedicated carrier (LPG ship) or tank lorry will be used for mass transportation.

3. Properties of the gas

(1) Comparison of various gas fuels are shown in Table-2.

Table- 2: Composition, heating value, etc. of gas fuel

Gas fuel		Composition (%)										Heating value (kJ/m^3_N)	
		H_2	CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_5H_{12}	CO_2	CO	O_2	N_2	Higher	Lower
Natural gas	Alaska (Kenai)	—	99.8	0.1	0.0	0.0	0.0	—	—	—	0.1	39,780	35,800
	Brunei (Lumut)	—	88.6	5.2	3.6	1.6	0.0	—	—	—	0.0	44,800	40,610
	Abu Dhabi (Das)	—	80.4	17.5	2.0	0.0	0.0	—	—	—	0.1	46,060	41,870
	Indonesia (Badack)	—	89.6	5.7	3.3	1.4	0.0	—	—	—	0.0	44,380	41,030
	Indonesia (Arum)	—	86.1	8.8	4.1	1.0	0.0	—	—	—	0.0	45,220	41,450
	Malaysia (Sarawak)	—	91.6	4.1	2.7	1.5	—	—	—	—	0.1	44,170	39,820
	Australia (Karratah)	—	89.0	7.4	2.5	1.1	0.0	—	—	—	0.0	44,380	40,190
	Japan (Niigata)	—	96.4	2.4	0.4	0.3	0.1	0.4	—	—	—	40,950	36,930
Blast furnace gas (BFG)		2.8	—	—	—	—	—	21.9	21.9	—	53.4	3,100	3,060
Converter gas (LDG)		1.1	—	—	—	—	—	13.1	76	—	9.8	9,760	9,710
Coke-oven gas (COG)		55.2	28.1	C_mH_n=3.1				2.7	8.0	0.3	2.6	21,350	18,840
Producer gas		12.1	3.6	C_mH_n=0.4				4.8	25.5	0.2	53.4	6,490	6,070

Gas fuel		Composition (%)				Heating value (kJ/m^3_N)	
		C_2H_6	C_3H_8	C_4H_{10}	C_5H_{12}	Higher	Lower
Liquefied petroleum gas (LPG)							
	JIS type-2 No.1 standard product	2.0	96	2.0	—	100,440	93,580
	JIS type-2 No.4 standard product	—	3.0	95.0	2.0	133,390	123,010

Reference: Handbook for thermal and nuclear power engineerings/2008 6-13 "Composition, Heating Value, etc. of Gas Fuel (Example)"

Reference: P-51 of Journal (No.611: Aug. /2007): TENPES

4. Concept of liquefied gas handling facilities

The system configuration for handling facility for liquefied gas fuel is shown Fig-3 and 4. In case of

LNG, drilled natural gas is liquefied to LNG in the liquefaction plant onshore or in the liquefaction ship as shown Photo-3. The LNG is loaded to LNG vessel by pipeline or corrugated marine hose as shown in Photo-4. After transportation by dedicated liquefied gas vessel, liquefied gas will be unloaded at the LNG or LPG base as shown in Photo-1 and 2.

Liquefied gas is unloaded by loading arm, stored in the gas storage tank and supplied to power plant after vaporization as shown in Fig-1. The generated gas (BOG: boil-off gas) caused due to natural heat absorption from tank, piping and compressor will be sent to the gas vaporizing line after pressurizing. Its operation is performed by means of maintaining the inner pressure of tank constant by pressure control unit for main BOG piping as shown in Fig-1. Also BOG is re-liquefied by LNG/BOG re-liquefaction system applied LNG cold energy as shown Fig-2.

Photo- 1: LNG incoming piping

http://www.shimbun.denki.or.jp/news/special/20110928_01.

Photo- 2: LNG incoming piping

http://www.oitalng.co.jp/business/acceptance.shtml

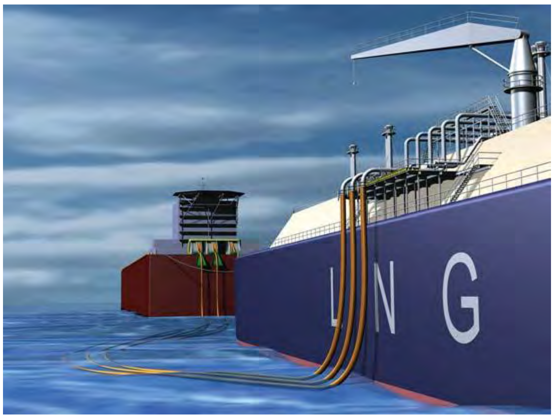


Photo- 3: LNG corrugated marine hose

http://www.acusim.com/html/apps/corrugPipe.html

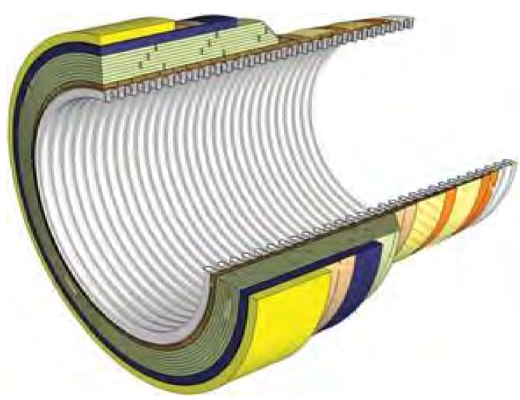


Photo- 4: LNG corrugated flexible pipe

http://www.acusim.com/html/apps/corrugPipe.html

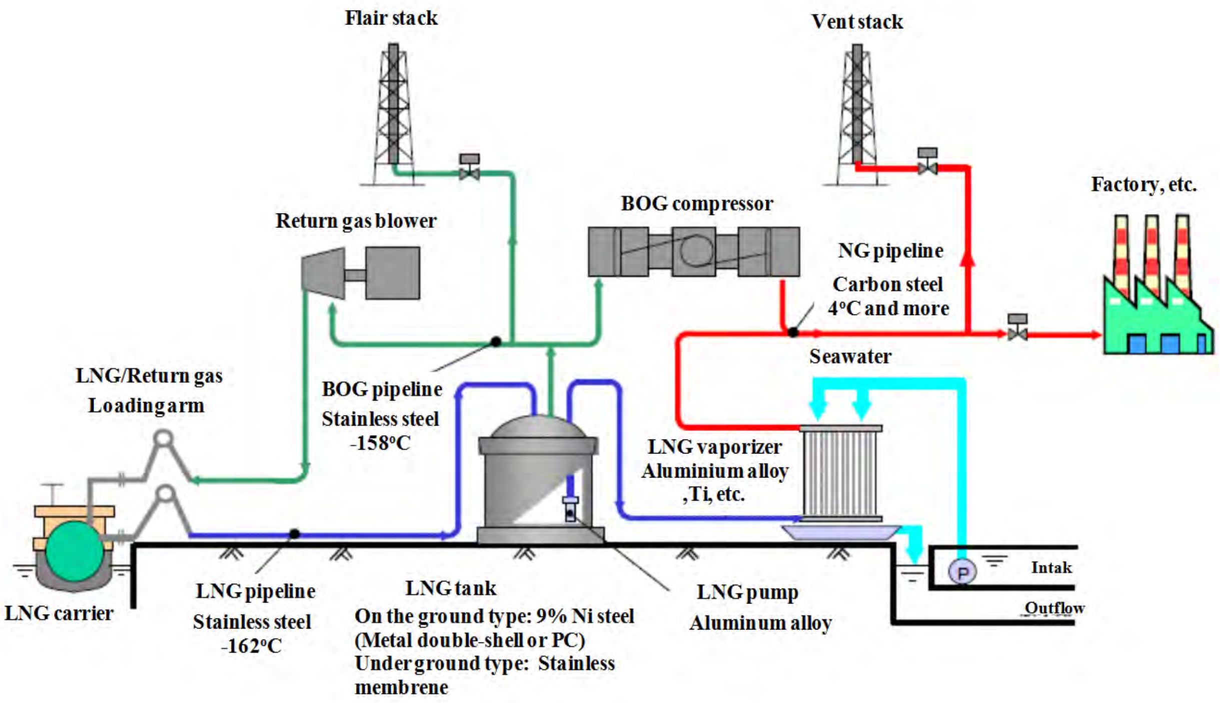


Fig- 1: System configuration of the LNG receiving terminal

Reference: P-2 of "Concept for inspection of LNG receiving terminal facility" (High pressure Gas LNG Association: Jan. /2003)

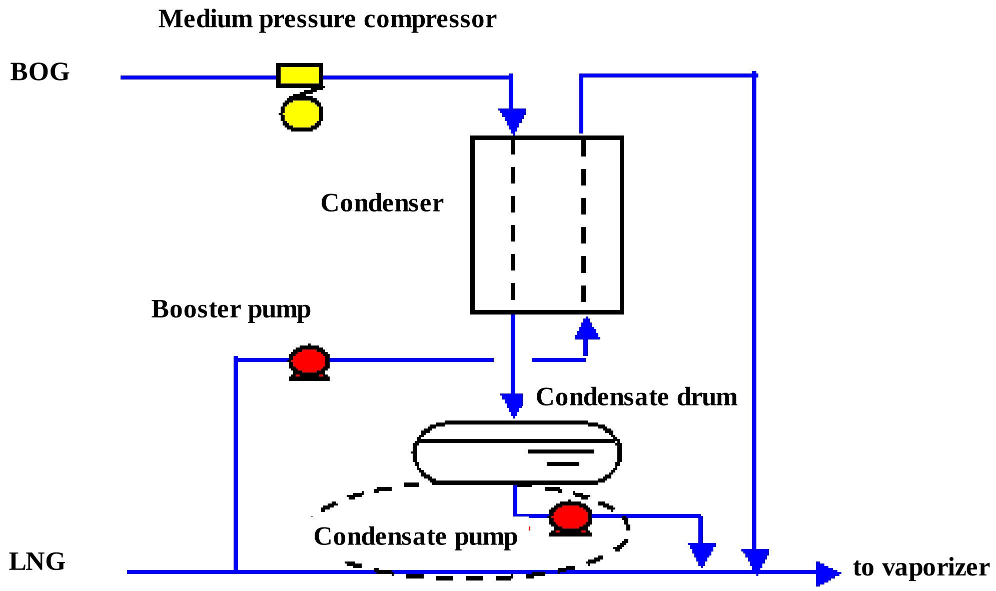


Fig- 2: LNG/BOG re-liquefaction system

Reference: http://www.netdecheck.com/emerging_technologies/LNG_PUMP/page1.htm

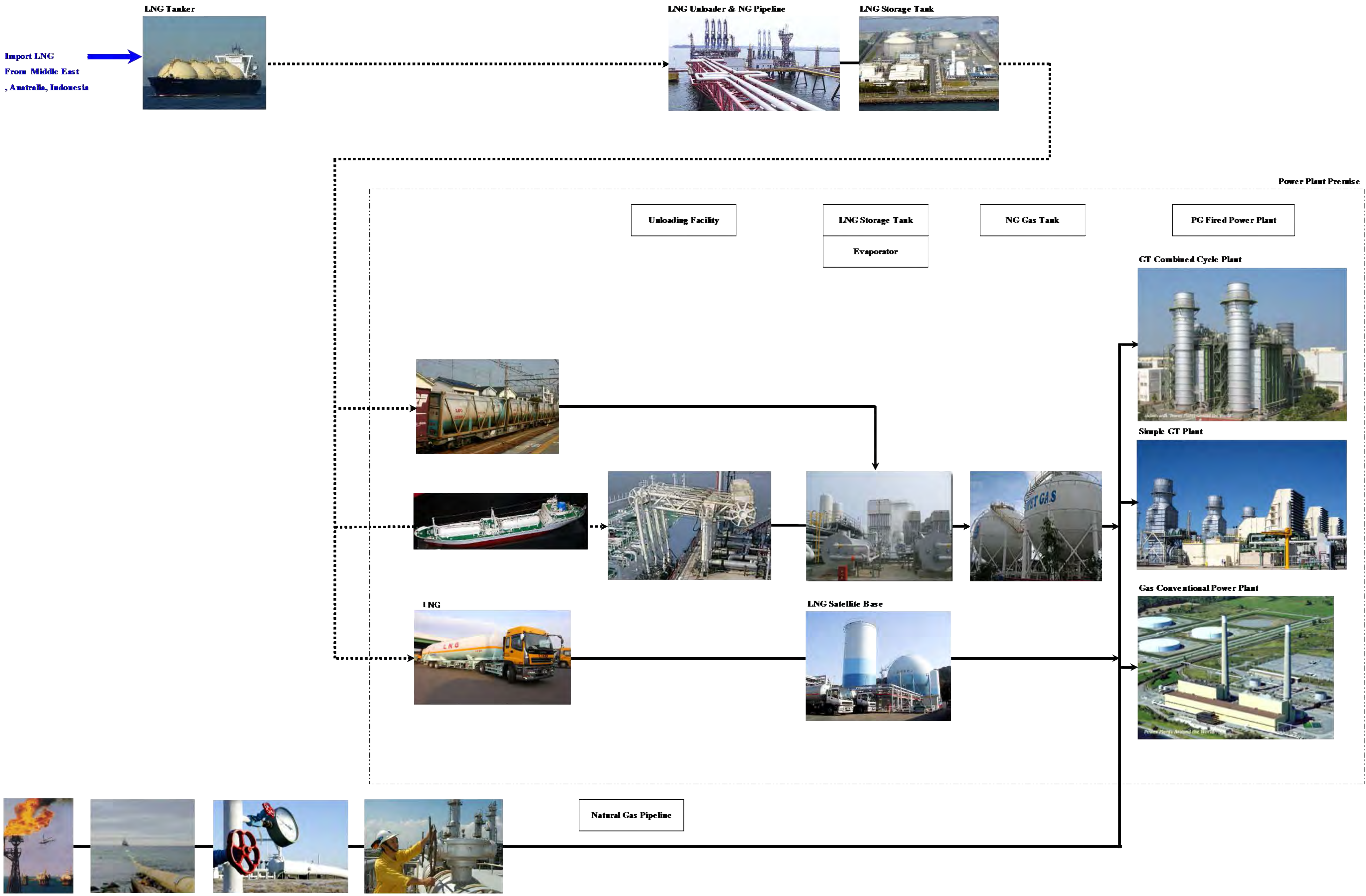


Fig- 3: Constitution concept of fuel for gas thermal power plant (LNG)

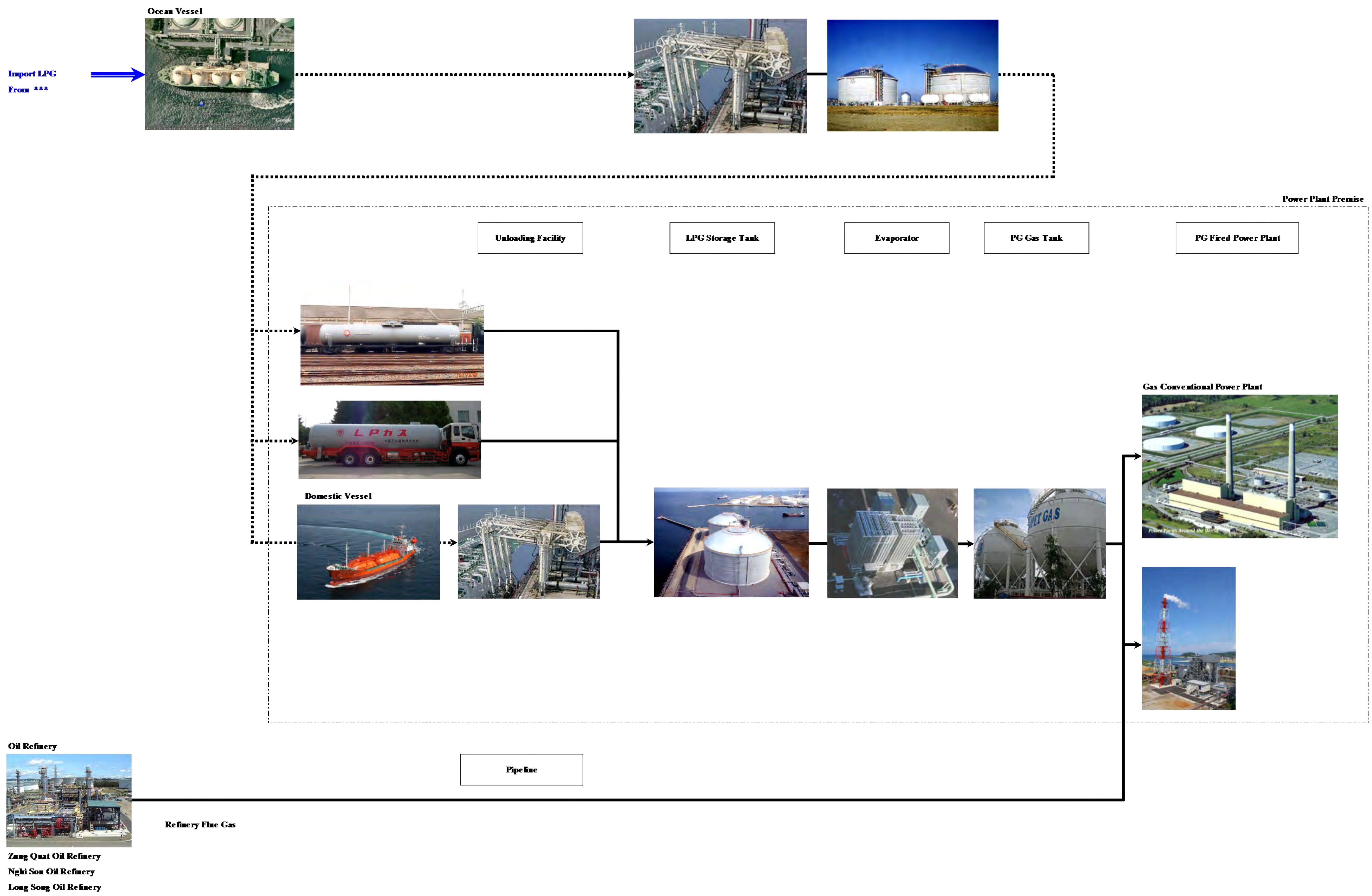


Fig- 4: Constitution concept of fuel for gas thermal power plant (LPG)

Article 155. Classification of liquefied gas

Article 155-1. Classification of liquefied gas

1. LPG and LNG which are the most typical liquefied gas as the fuel for power plant are classified as shown is Table-3 depending on the type and storage condition.

Table- 3: Classification of liquefied gas

Classification		Storage specification				
LPG	Butane Rich	-0.5 °C at ata		0.21MPpa (abs) at 20°C		
	Propane Rich	-42 °C at ata		0.86MPpa (abs) at 20°C		
LNG	Methane Rich	-160 °C at ata		—		
Type of gas	Under normal termp. and pressure (gas state) (0°C, 1 atm)			Under pressure and normal temp. (liquid state)		
	Gas volume from 1kg liquid (ℓ)	Gas volume from 1ℓ Liquid (ℓ)	Specific gravity of gas —	Specific gravity of liquid (at 0°C)	Boiling point (°C at 1 atm)	Vapor pressure (MPa (abs) at 20°C)
Butane	387	232	2.00	0.60	- 0.5	0.21
Propane	509	274	1.52	0.53	- 42.0	0.86
Methane			0.554	0.425	-161.5	—

Article 156. Unloading pipeline for liquefied gas

Article 156-1. Applicability of loading arm

1. Liquefied gas such as LNG and IPG are carried by the dedicated vessel (tanker) as shown in Photo-5, 7, 8, 10, 11 and Fig-5. The tank of LNG tanker is provided inner membrane and heat insulation to prevent evaporation during transportation as shown in Photo-6 and 9.

Photo- 5: Large LNG vessel

http://www.yenra.com/wiki/Q-Max_LNG_carrier

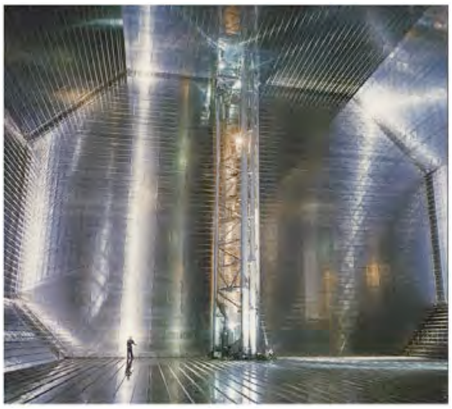


Photo- 6: LNG tank of vessel

http://gcaptain.com/q-max-lng-tankers?4690

Photo- 7: Small LNG vessel

http://ja.wikipedia.org/wiki/%E3%83%95%E3%82%A1%E3%82%A4%E3%83%AB:Pascal_LNG_carrier_model.jpg

Fig- 5: Small LNG vessel

http://small-lng.com/

Photo- 8: Large LNG vessel

http://de.wikipedia.org/wiki/Datei:LNG-carrier.Galea.wmt.jpg

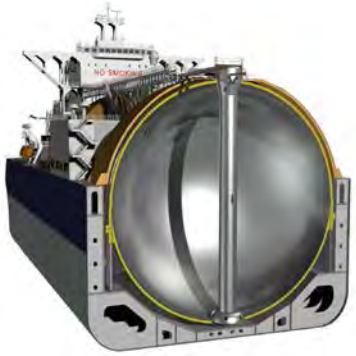


Photo- 9: LNG tank of vessel

http://www.aukevisser.nl/supertankers/gas/id390.htm

Photo- 10: Large LPG vessel

http://www.pixstel.com/lpg-tanker-kendal-_urlt950.php?id=

Photo- 11: Small LPG vessel

http://www.motorship.com/news101/major-lpg-tanker-equipment-order-from-brazil

Photo- 12: LNG unloading arm

http://www.egyptianlng.com/ELNG/Project/MarineFacilities/

Photo- 13: LNG unloading arm

http://www.rivieramm.com/article/SVT-records-a-year-to-remember-7917

Article 156-2. Availability of unloading arm

1. Following ship berthing and cool-down of the unloading arms, LNG is transferred to the onshore LNG tanks by the ship pumps. The unloading facility is often designed to accommodate a wide range of tanker sizes from 87,000 m^3 to 145,000 m^3. The liquid unloading rate from the ship is usually 10~12,000m^3/hr carried out by eight pumps with two pumps located in each of four cargo tanks onboard a typical ship. It takes approximately 12~14 hours to unload one 135,000m^3 ship. From the ship the LNG flows through the unloading arms and the unloading lines into the storage tanks. The loading lines can be two parallel pipes or a single larger pipe. The typical unloaders are shown in Photo-14, 15, 16, 17, 18 and 19.
2. During ship unloading some of the vapor generated in the storage tank is returned to the ship's cargo tanks via the vapor return line and arm, in order to maintain a positive pressure in the ship. Due to the low pressure difference between the storage tank and the ship, vapor return blowers are sometimes needed. However, for full containment storage tanks where the design pressure is approximately 290 mbarg, enough pressure is often available to return vapor without using vapor return blowers.
3. It is customary to have three unloading arms for LNG and one arm for return vapor, but there is cost-saving potential in reducing the number of LNG arms to two if hydraulics permit and the ultimate unloading duration have some flexibility. Phased installation of arms could also be considered. Eliminating the vapor return to the ship is another cost savings measure that is worth exploring but has yet to be incorporated. New LNG ships could be designed to generate enough vapor to make up for liquid displacement, and strictly speaking would not need a vapor return line. LNG ships already include vaporizers to enable the cargo to be used as fuel when gas is less costly than Bunker C and this system could be extended to provide displacement gas. It would however be necessary to stipulate the use of customized ships that could be at a premium. The drawback of eliminating the vapor return line is that in the event the ship boil-off vapors build up to the point of

venting before unloading begins, the vapors will exit via the ship vent and become a safety issue. With a vapor return line any excess ship boil-off is vented to the receiving terminal vapor handling system.

Photo- 14: LNG unloading arm

http://www.niigata-ls.co.jp/en/topics/2006_before/200608_cpc_tangguh.html

Photo- 15: LNG unloading arm

http://picasaweb.google.com/lh/photo/Pu-fSNPmZvCGgpnSBBJ9AQ

Photo- 16: LNG unloading arm coupler

http://www.niigata-ls.co.jp/en/topics/2008/200811_shanghai.html

Photo- 17: LNG unloading arm

http://www.nwsssc.com.au/fleet_tech-info.aspx

Photo- 18: LNG unloading arm

http://www.tokyo-gas.co.jp/techno/stp/e_txt/37e.htm

Photo- 19: LPG unloading arm

http://www.candnpetro.com/lpg_loading_arm.html

Article 156-3. Purge mechanism

1. During normal operation, boil-off vapor is produced in the tanks and liquid-filled lines by heat transfer from the surroundings. This vapor is collected in the boil-off header that ties into the boil-off compressor suction drum. An in-line de-superheater, located upstream of the drum will inject LNG into the gas stream if the temperature rises above minus 80°C (LNG temperature is approximately minus 162°C). Boil-off vapors generated during normal operation (not unloading) by heat leak into the storage tank and piping are compressed and liquefied in a recondenser.
2. During ship unloading, the quantity of vapor in the tank outlet increases significantly. These additional vapors are a combination of volume displaced in the tanks by the incoming LNG, vapor resulting from the release of energy input by the ships pumps, flash vapor due to the pressure difference between the ship and the storage tanks and vaporization from heat leak through the unloading arms and transfer lines. Boil-off gas compressor vendors are addressing the need to allow operation with warm inlet gas and thus avoid the need for LNG injection and hence the requirement for a compressor suction drum.
3. From the compressor suction drum, vapor can be routed to the boil-off gas blowers for vapor return to the ship or to the boil-off gas compressors. The vapor that is not returned to the ship is compressed and directed to the recondenser. The amount of vapor that can be re-condensed depends on the amount of LNG send-out. If there is not enough LNG send-out to absorb the boil-off vapor then the vapor must be compressed to pipeline pressure, or flared or vented. Thus the priority for handling vapor is in the following order of preference:

Article 156-4. Leakage from sliding portion

1. Packings for swivel joint of unloading arm ensure that fluid does not leak. They come in a variety of materials depending on the physical and chemical characteristics of the product being handled. Specially designed low torque packing is used to enable the swivel joint to easily moved connecting to or disconnecting from a vessel.

Article 156-5. Alarm system

1. It is somewhat difficult for Marine loading arm operation to appraise the risks associated to the drift of a ship with regard to the mechanical integrity of an arm connected to the tanker. This mainly due to the fact that visualization of a working envelope is not easy particularly when a range of ships will off-loaded at the same time. The existing solution to this problem is to install proximity limit switches on the loading arms which warn the operator when the limit of the working envelop is reached. At installations at exposed locations with intermittent or constant movement of the ship when dangerous products such as LNG, LPG and the like are being off-loaded, the "Integrated Position Monitoring System (IPMS) is recommended with three alarm sequence as shown in Fig-6 and 7;

    1) Pre-alarm (Warning)

       A visual and audible signal warns the operator to tighten the mooring lines. However, must the ship continue to drift then the:

    2) First step alarm (Action)

       An intermittent visible and audible sign warns the operator that the first boundary of the envelope has been reached that will automatically start the hydraulic pump of loading arm, send a signal to the central control room to stop the product pumps and after delay (specified by the operator), the closing of the ball valve is initiated. The arm is now ready to be disconnected. Should the ship continue to drift then, the:

    3) Second step alarm (Action)

       A continuous visible and audible signal warns the operator that automatically the Powered Emergency Coupler (PERC) will be opened and loading arm hydraulically blocked.

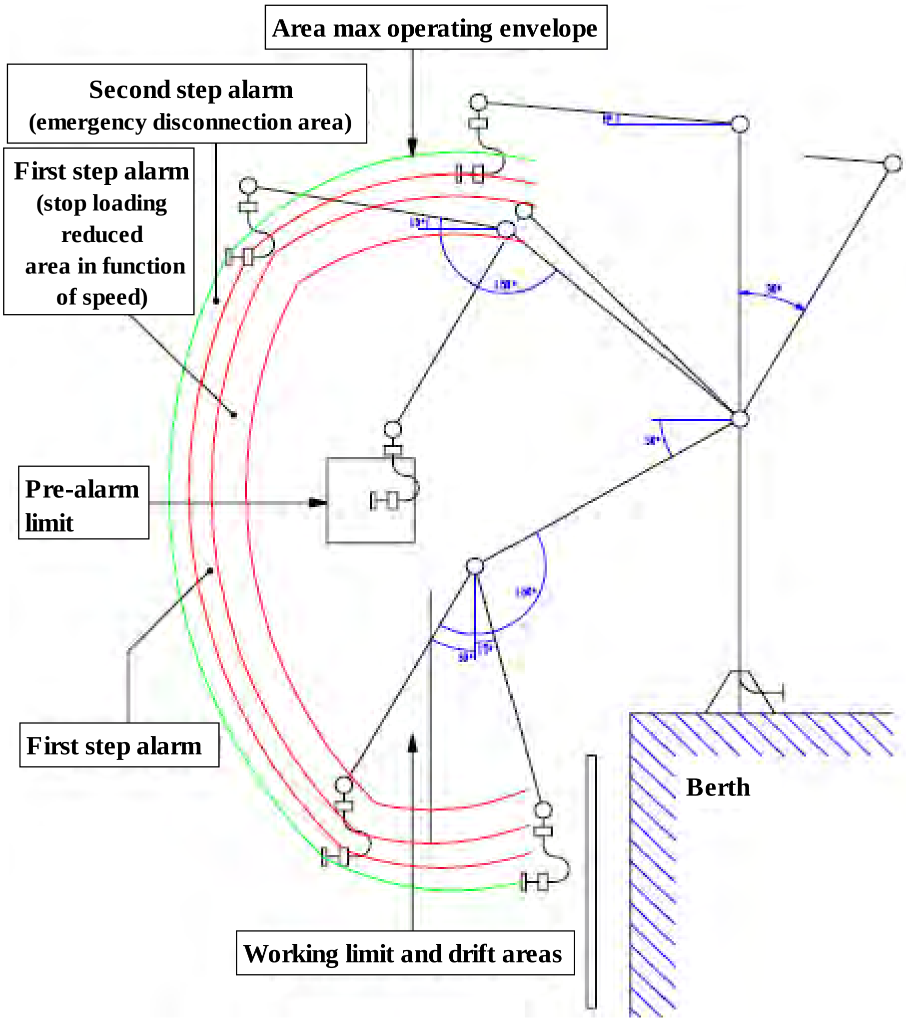


Fig- 6: Side view of alarm area of loading arm

Reference: "presentation of a loading arm installation" of FMC Energy Systems

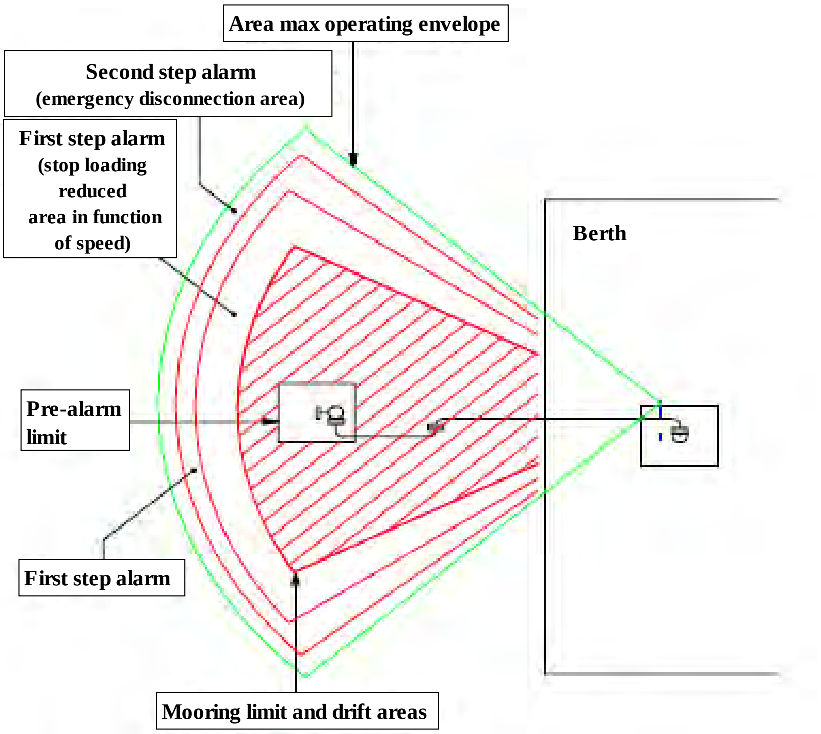


Fig- 7: Top view of alarm area of loading arm

Reference: "presentation of a loading arm installation" of FMC Energy Systems

Article 156-6. Shut-off valve

1. The LNG is unloaded through the pipeline shutoff valves to tanks. Shut down the Primary LNG pumps, send-out pumps and BOG compressors; Isolation of the terminal from the pipeline by closure ESD valves; Isolation of the high pressure part of the terminal by closure ESD valves at send-out pump suction, primary pump discharge, compressor discharge, and depressurization of the vaporizers. Typical shutoff valves are shown in Photo-20, 21, 22, 23.

Photo- 20: LNG shutoff valve

http://www.amrivalves.com/danais.html

Photo- 21: LNG shutoff valve

http://www.amrivalves.com/danais.html

Photo- 22: LNG shutoff valve

http://www.hhc-lewis.co.uk/emerson-expands-cryogenic-valve-testing-to-meet-growing-demand-for-lng-applications/

Photo- 23: LNG shutoff valve

http://turnsealvalves.com/LNG_Cryo/manual_LNGcryogenics.php

Article 157. Material of liquefied gas unloading and transportation facility

Article 157-1. Main material

1. Material for pipeline and the like

   Piping materials such as deformed straight pipe and bend for pipeline must conform to the following standards (hereinafter referred to "standard material"). In addition, typical materials are summarized in the Table-4.

1) JIS B 2312 (1997) "Steel butt-welding pipe fittings"
2) JIS B 2316 (1997) "Steel socket-welding pipe fittings"
3) JIS B 2313 (1997) "Steel plate butt-welding pipe fittings"
4) JIS B 2311 (1997) "Steel butt-welding pipe fittings for ordinary use"
5) JIS G 3103 (1987) "Carbon steel and molybdenum alloy steel plates for boilers and pressure vessels"
6) JIS G 3106 (2004) "Rolled steels for welded structure"
7) JIS G 3114 (1998) "Hot-rolled atmospheric corrosion resisting steels for welded structure"
8) JIS G 3115 (1990) "Steel plates for pressure vessels for intermediate temperature service"
9) JIS G 3126 (1990) "Carbon steel plates for pressure vessels for low temperature service"
10) JIS G 3131 (1996) "Hot-rolled mild steel plates, sheet and strip"
11) JIS G 3201 (1988) "Carbon Steel Forgings for General Use"
12) JIS G 3454 (1988) "Carbon steel pipes for pressure service"
13) JIS G 3455 (1988) "Carbon steel pipes for high pressure service"
14) JIS G 3456 (1988) "Carbon steel pipes for high temperature service"
15) JIS G 3457 (1988) "Arc welded carbon steel pipes"
16) JIS G 3458 (1988) "Alloy steel pipes"

17) JIS G 3459（1997） “Stainless steel pipes”

18) JIS G 3460（1988） “Steel pipes for low temperature service”

19) JIS G 3461（1988） “Carbon steel boiler and heat exchanger tubes”

20) JIS G 3462（1988） “Alloy steel tubes for boiler and heat exchanger”

21) JIS G 3463（1994） “Stainless steel boiler and heat exchanger tubes”

22) JIS G 4051（1979） “Carbon steels for machine structural use”

23) JIS G 4303（1998） “Stainless steel bars”

24) JIS G 4304（1999） “Hot-rolled stainless steel plate, sheet and strip”

25) JIS G 4305（1999） “Cold-rolled stainless steel plate, sheet and strip”

26) JIS G 4312（1991） “Heat-resisting Steel Plates and Sheets”

27) JIS G 5101（1991） “Carbon steel castings”

28) JIS G 5102（1991） “Steel castings for welded structure”

29) JIS G 5111（1991） “High tensile strength carbon steel castings and low alloy steel castings for structural purposes”

30) JIS G 5121（1991） “Corrosion-resistant cast steels for general applications”

31) JIS G 5122（1991） “Heat-resistant cast steels and alloys for general applications”

32) JIS G 5131（1991） “High manganese steel castings”

33) JIS G 5151（1991） “Steel castings for high temperature and high pressure service”

34) JIS G 5152（1991） “Steel castings for low temperature and high pressure service”

35) JIS G 3101（1995） “Rolled steels for general structure”

36) JIS G 3453-2（2007） “Coated steel pipes for water service-Part2: Fittings”

37) JIS G 3452（1997） “Carbon steel pipes for ordinary piping”

38) JIS G 5502（2001） “Spheroidal graphite iron castings”

39) JIS G 5526（1998） “Ductile iron pipes”

40) JIS G 5527（1998） “Ductile iron fittings”

41) JIS G 5705（2000） “Malleable iron castings”

42) JIS H 5202（1992） “Aluminum alloy castings”

43) JIS H 5302（1990） “Aluminum alloy die castings”

44) JIS K 6774（2005） “Polyethylene pipes for the supply of gaseous fuels”

45) JIS K 6775-1（2005） “Polyethylene pipe-fittings for the supply to gaseous fuels-Part 1: Heat fusion fittings”

46) JIS K 6775-2（2005） “Polyethylene pipe-fittings for the supply to gaseous fuels-Part 2: Spigot fittings”

47) JIS K 6775-3（2005） “Polyethylene pipe-fittings for the supply to gaseous fuels-Part 3: Electro fusion fittings”

48) JIS H 3100（1992） “Copper and copper alloy sheets, plates and strips”

49) JIS H 3250（1992） “Copper and copper alloy rods and bars”

50) JIS H 3300（1997） “Copper and copper alloy seamless pipes and tubes”

51) JIS H 4311（1993） “Lead and lead alloy tubes for common industries”

52) JIS H 5120（1997） “Copper and copper alloy castings”

53) JIS H 5121（1997） “Copper alloy continuous castings”

54) JIS K 6741（1999） “Unplasticized poly vinyl chloride pipes”

55) JIS K 6742（1999） “Unplasticized poly vinyl chloride pipes for water supply”

56) JIS G 3443（1987） “Coated steel pipes for water service-Part 1: Pipes”

57) JIS G 3118（1987） “Carbon steel plates for pressure vessels for intermediate and moderate temperature services”

58) ISO 3183（API 5L） （2007） “Line pipe”

59) ASTM A694（2008） “Standard specification for carbon and alloy steel forgings for pipe flanges, fittings, valves and parts for high-pressure transmission service”

60) ASTM standard material stipulated in Annex1-3 of the interpretation of technical regulation for gas facility of Japan.

Table- 4: Typical material for LNG piping and vessel

Symbol	JIS standard	Component
SUS304TP	JIS G3459 “Stainless steel pipes”	18Cr-8Ni
SUS304LTP	JIS G3459 “Stainless steel pipes”	18Cr-8Ni very low carbon
SL9N520	JIS G3127 “Nickel steel plates for pressure vessels for low temperature services”	9%Ni
SL9N590	JIS G3127 “Nickel steel plates for pressure vessels for low temperature services”	9%Ni
SUS304TP	JIS G3459 “Stainless steel pipes”	18Cr-8Ni
SUS304LTP	JIS G3459 “Stainless steel pipes”	18Cr-8Ni very low carbon
SUS316TP	JIS G3459 “Stainless steel pipes”	16Cr-12Ni-2Mo
SUS316LTP	JIS G3459 “Stainless steel pipes”	16Cr-12Ni-2Mo very low carbon
STPL690	JIS G3460 “Steel pipes for low temperature service”	9Ni
—	JIS H4000 “Aluminum and aluminum alloy extruded shape”	—
—	JIS H4080 “Aluminum and aluminum alloy extruded tubes and cold-drawn tubes”	—
—	JIS H4090 “Aluminum and aluminum alloy welded pipes and tubes”	—

2. Use condition of the material listed above are as follows;

(1) Item-15) listed above can be used for those which the maximum operating pressure is less than 1.6MPa.

(2) Item-4), 35) to 43) and 56) listed above can be used for those which the maximum operating pressure is less than middle pressure. However, item-42) and 44) must not be used for buried part.

(3) Item-44) to 47) can be used for the part where protection measures as shown in following 1) to 3) are taken and the buried part where the maximum operating pressure is less than 0.3MPa. However, pipeline on the land is admitted as a special temporally measure in emergency case such as disaster. Note that a temporary period is until the restoration work is completed in case of disaster or other emergency.

1) A part from the rising or falling portion of pipeline engaging from underground to building and where the sheath tube or other protective measures are taken.
2) A part of culvert or pit to engaging to pipeline into building and where the sheath tube or other protective measures are taken.
3) A pipeline other than pipeline engaging into building and those which protective measure are taken.

(4) Item-48) to 55) listed above can be used for those which the maximum operating pressure is low. However, they can not be used as follows;

1) Item-50) to 26), 54), 55) listed above for the buried part.
2) Item-48), 49), 52), 53) listed above for the buried part and there is risk to loading by vehicle.
3) Item-51), 26) listed above for other than the inlet part of gas meter and the part from gas meter to gas tap.
4) Item-54), 55) listed above for the following condition;

a. Those which are installed in the inlet part of gas meter and the part from gas meter to gas tap.
b. Where other than flammable natural gas, liquefied petroleum gas and its reformed gas passing through.

(5) The use condition of item-60) listed above must be applied those of equivalent JIS material.

3. Material of vessel for the gas generation facility (limited that a volume is more than $0.04m^3$ or inner diameter is more than 200mm and length is more than 1,000mm) and which the maximum operating pressure is more than 0.2MPa must be pursuant to the provision of gas generation facility.

4. Material of the gas pipeline for other than the gas generation facility (exclude control air piping and instrument piping) must be pursuant to the provision of “Material for pipeline”.

5. Allowable stress

The allowable stress of the gas generation facility must be pursuant as follows;

(1) The allowable stress of gas generation facility must be pursuant to item-1) to item-7).

1) The JIS material stipulated in annex-1-1 and annex-2-1 of the interpretation for technical regulation of gas facility, the WES material, ISO material, API material, ASTM material and those that are used within the temperature range according to the allowable stress in the table.
2) The high tensile steel forgings to meet WES standard material that chemical composition, weld crack susceptibity composition, mechanical properties and impact properties are stipulated in annex-1-1 of the interpretation for technical regulation of gas facility and are used within the temperature range according to the allowable stress in the table.
3) The ASME material stipulated in ASME Boiler & Pressure Vessel Code Section-8 Div.1 (1998 Edition) that are used within the temperature range in such standard and is used within the temperature range in the equivalent JIS material (same as stipulation of item-2)).
4) The ASTM material stipulated in annex-1-3 of the interpretation for technical regulation of gas facility (limited to those there is equivalent ASME material in that table), that are used within the stipulated temperature range in the equivalent JIS material (same as stipulation of item-2)). The equivalent temperature range material means that are same range with ASME material.
5) The ASTM material stipulated in annex-1-3 of the interpretation for technical regulation of gas facility (limited to those there is equivalent ASME material in that table), that are used within the stipulated temperature range in the equivalent JIS material (same as stipulation of item-2)). The equivalent temperature range material means that are same range with JIS material.
6) The material stipulated in annex-1-4 f the interpretation for technical regulation of gas facility and is used within the temperature range according to the allowable stress.
7) The type-1 clad steel stipulated in JIS G3601-2002 “Stainless clad steel”, JIS G3602-1992 “Nickel and nickel alloy clad steel”, JIS G3603 “Titanium clad steel”, JIS B3604 “Copper and copper alloy clad steel” must be pursuant to JIS B8265-2008 “Construction of pressure vessel –General”.

(2) The allowable compressive stress of the material must be pursuant to “4.3.3: allowable compressive stress” of JIS B8265-2008 “Construction of pressure vessel−General”.
(3) The allowable shearing stress of the material “4.3.2: allowable shearing stress” of JIS B8265-2008 “Construction of pressure vessel−General”.
(4) The allowable bending stress at each temperature which does not reach to creep range of material must be pursuant to following item-1) to 3).

1) The allowable bending stress of carbon steel, low alloy steel and high alloy steel must be one of the larger yield points at each temperature, half of the 0.2% tensile strength or allowable tensile stress at each temperature.
2) The allowable bending stress of cast iron products must be 1.5 times of the allowable tensile stress values at each temperature.
3) The allowable bending stress of spheroidal graphite cast iron, black heart malleable cast iron, ductile iron cast iron, mareable cast iron and cast steel must be 1.2 times of the allowable tensile stress at each temperature (1.0 times in case of austenitic stainless cast steel and ferritic stainless cast steel).

(5) The material for membrane gas holder must be pursuant to "3.4.3: allowable stress" of "Guideline pertaining to the membrane gas holder" of "Chapter-3: design".
(6) The allowable stress of the insulation material for bottom construction must be pursuant to the provision of "7.3: allowable stress" of "Guideline for aboveground LNG storage tank: JGA 108-02".
(7) The allowable stress of material for bolt must be pursuant to the value listed in the same table.
(8) The allowable stress of material for membrane gasholder must be pursuant to "3.4.3: allowable stress" of "3: design" of "Guideline for membrane gasholder".

6. The allowable tensile stress for the pipeline must be as follows;
(1) In case of the material listed 1) to 59) in Article 116-12, the allowable stress prescribed in the interpretation of gas facility of Japan;
(2) Those for the material listed in Article 116-12-60) must be the value prescribed as follows;

1) The allowable stress of ASME standard material prescribed in ASME Boiler & Pressure Vessel Code Sec.-8 Div. 1 (1998), if listing as ASME standard material.
2) The equivalent allowable stress of JIS standard material, if ASME standard material is not prescribed.

Article 158. Construction, etc. liquefied gas unloading and transportation facility

Article 158-1. Structure

1. "Appropriate structure depending on the kind and size of facility against the load during operation at the maximum operation temperature and the minimum operation pressure" stipulated in design technical regulation means the structure prescribed in article 20 to 49 of "Interpretation of technical regulation for gas facility JP"

2. The corrosion or fatigue crack during service may be pursuant to the provision "3.2: evaluation method of corrosion", "3.3: evaluation method of fatigue crack", "4.3: repair welding), "4.5: inspection after repair" of "Guideline for inspection, evaluation, repair of vessel and piping due to corrosion and fatigue crack: JGA 109-07".

3. Austenitic stainless steel is used for LNG piping, because of its excellent low-temperature characteristics and stable quality. Austenitic stainless steel, however, requires a mechanism, such as bent piping, to absorb thermal contraction, when it is used in LNG facilities. The purpose of this development is to apply Invar alloy, which has a very low coefficient of linear expansion, for LNG piping, in order to reduce the construction cost of LNG piping.

1) Invar has a very low coefficient of linear expansion which is 1/10th that of austenitic stainless steel.
2) Invar alloy, with its stable austenitic structure, has excellent strength and ductility at LNG temperature.
3) Invar alloy has been used mainly in special applications in which thermal expansion or contraction must be minimized, such as CRT shadow masks and the cargo tank membranes of LNG tankers. However, since Invar alloy has difficulty of welding, it has never been used for thick plate and piping.
4) Application of Invar alloy will reduce the construction cost of LNG piping, because simple straight piping can be used and thus, installation space can be reduced. (When LNG piping is installed in a tunnel, the large cost reduction for civil work can be achieved) The difference between Inver and austenitic stainless steel are shown in Table-5 and Fig-8.

Table- 5: Difference nature between Inver alloy and stainless steel

	Inver alloy	Austenitic stainless steel
Basic component	64%Fe-36%Ni	18%Cr-8%Ni
Coefficient of linear expansion	1.7×10^{-6} /K	15×10^{-6} /K
Contraction at LNG temperature	0.3 mm/m	2.8 mm/m
0.2% proof stress	≧240 N/mm^2	≧205 N/mm^2
Tensile strength	≧440 N/mm^2	≧520 N/mm^2

http://www.osakagas.co.jp/company/efforts/rd/technical/1191154_3909.html

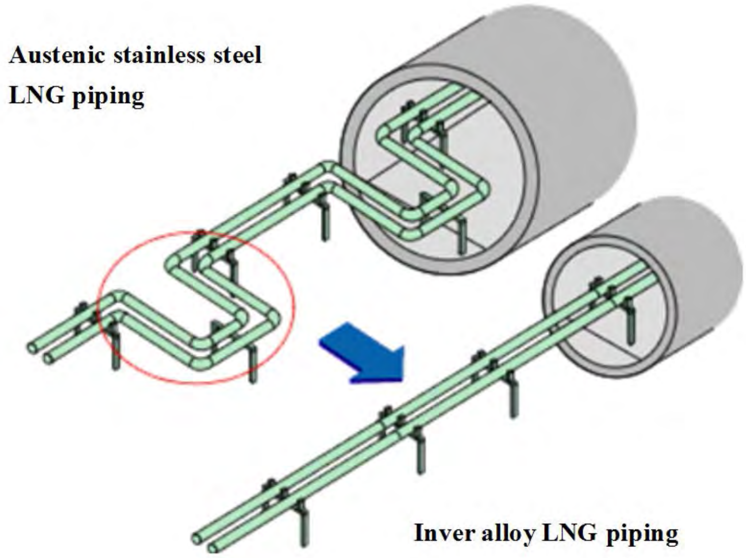


Fig- 8: Difference of thermal expansion performance

http://www.osakagas.co.jp/company/efforts/rd/technical/1191154_3909.html

Article 158-2. Foundation

1. Title 49 CFR 193 (Ref. 1) requires that LNG facilities built in the United States satisfy the design requirements of National Fire Protection Association (NFPA) 59A-2001 (Ref. 2). In addition, Title 33 CFR 127.103 (Piers and wharves) contains the U.S. Coast Guard's requirements for seismic design of LNG waterfront facilities.

   Although NFPA 59A-2001 requirements for seismic design address only the critical safety-related structures and systems of LNG facilities, other structures, systems, and components are typically designed and built in accordance with local building code requirements which may vary between jurisdictions. To ensure a level of consistency for FERC-jurisdictional LNG facilities across the entire United States, these Guidelines recommend use of the seismic design provisions of the 2006 edition of the International Building Code (IBC) (Ref. 3) as a basis for design of all structures, systems, and components of LNG facilities not specifically addressed in NFPA 59A. The 2006 IBC is consistent with and uses the latest material standards (e.g., ACI 318-05 (Ref. 4), AISC 341-05 (Ref. 5), etc.).

   NFPA 59A-2001 defines two levels of earthquake motions, the Operating Basis Earthquake (OBE) and the Safe Shutdown Earthquake (SSE). These motions are to be used as the basis for design for a limited specific list of critical safety-related structures and systems. These guidelines identify those structures and systems as Seismic Category I. The remaining structures, systems and components are classified as either Seismic Category II or III and should be designed in accordance with the seismic requirements of the 2006 IBC. The OBE and SSE ground motions are to be determined by site-specific evaluations and are defined in terms of 5 percent damped response spectra.

2. The OBE ground motions at the site are defined as the lesser of:

(1) ground motion with a 10% probability of exceedance within a 50 year period (475 year return period); or

(2) two-thirds (2/3) of the Maximum Considered Earthquake (MCE) ground motion
In NFPA 59A-2001 the MCE is defined as future potential ground motion with a 2 percent probability of exceedance within a 50 year period (2475 year return period) with deterministic limits; the same definition used for establishing the MCE specified in the 2006 IBC. Procedures to be used to establish site specific MCE ground motions with deterministic limits are provided in Chapter 21 of ASCE 7-05 (Ref. 6).

The SSE ground motions at the site are defined as the lesser of:

(1) 1% probability of exceedance within a 50 year period (4975 year return period); or

(2) two times the OBE

3. There are areas where NFPA 59A-2001 does not provide specific requirements and therefore there can be a wide range of opinions by technical experts on how it is to be applied. The seismic design guidelines contained within this document were developed to provide guidance to applicants on the requirements of NFPA 59A-2001 and the 2006 IBC, and provide a basis for uniform reviews of various LNG terminal structures, components and systems under FERC jurisdiction.
In general, the guidelines are based on existing rules and procedures found in ASCE 7-05 (Ref. 6), ASCE 4-98 (Ref. 7), API 650 Appendix E (Ref. 8) and other current standards documents. The guidelines also rely on the National Seismic Hazard Maps (Ref. 16) and the 2006 IBC MCE Ground Motion Maps (Chapter 22 of Ref. 3), which were developed specifically for use in the design of buildings and other structures in the United States by the United States Geological Survey (USGS). This document also provides guidance on the classification of structures, components and systems and the seismic criteria that applies to each classification (Seismic Categories I, II and III as shown Table-6). The guidelines provide minimum limits on the determination of OBE, SSE and MCE site specific ground motions relying on the aforementioned USGS National Seismic Hazard Maps and MCE maps. Also provided are minimum limits on the margins of uncertainty of soil properties to be considered when performing site response and soil-structure interaction analysis. Additional guidance is provided for LNG tank minimum freeboard limits and on LNG tank foundation design. Specific additional guidance is also provided for Category I, II and III structures, components and systems, as well as seismic recording instrumentation.
As noted, NFPA 59A-2001 does not provide specific requirements for Category II and III items, so the guidance provided herein for these items is based on the seismic requirements of 2006 IBC and are defined in terms of the "Design Earthquake" (DE) ground motions which is two-thirds (2/3) of the corresponding MCE considering site amplification effects. The 2006 IBC references ASCE 7-05

including Supplement No.1 for its seismic requirements (hereafter referred to as ASCE 7-05). Therefore, by meeting the seismic requirements of ASCE 7-05, the seismic requirements of the 2006 IBC are also being satisfied. For simplicity, in this document we generally refer to ASCE 7-05 rather than the 2006 IBC. The referencing of the NFPA 59A-2001 and ASCE 7-05 includes all published errata for these documents at the time of issuance of this document. Additional regulatory guidance may be issued in the future, as necessary.

4. Seismic Category

Table- 6: Seismic category

Category	Definition
I	The following structures, components and systems that are specified in Section 4.1.3.3 of NFPA 59A-2001 should be classified as Seismic Category I: 1) LNG storage containers and their impounding systems 2) System components required to isolate the LNG container and maintain it in a safe shutdown condition 3) Structures and systems, including fire protection systems, the failure of which could affect the integrity of (1) or (2) above.
II	Structures, components and systems not included in Category I that are required to maintain safe plant operation should be classified as Seismic Category II.
III	All other structures, components and systems of the LNG facility that are not included in Categories I and II should be classified as Seismic Category III.

Reference: NFPA 59A-2001 “Standard for the production, storage, and handling of liquefied natural gas (ING)”

Article 159. Welding part of liquefied gas unloading and transportation facility

Article 159-1. Gas part

1. “Shall have no harmful defects or cracks in the weld” stipulated in design technical regulation Article 159-1 means that welding penetration is sufficient and there is no crack, undercuts, and overlaps, craters, slag inclusion and other harmful defects.

Article 159-2. Liquefied gas and gas part

1. There are several types for LNG storage tank. The membrane inner tank has mechanism to absorb thermal shrinking corresponding to the thermal condition between room temperature to very low temperature (-162^{o}C) by SUS304 thin steel plate (1~2mm). When constructing such large tank that the membrane is the lifeline, the high quality welding management by means of precise control of welding heat input management, uniform, refinement of profiling accuracy, automatic welding considering the strain relief, high quality management of welding is important.

Article 159-3. Welding part

1. The repair welding of corroded and cracked due to fatigue on the gas generation facility during in service must be pursuant to the "3.3: fatigue crack" of "Guideline for inspection, evaluation, repair regarding corrosion and fatigue crack of vessel and piping: JGA-109-07".
2. "The appropriate welding method which is confirmed in advance by appropriate testing, etc." must be pursuant to following items. However, the longitudinal joint (limited to the tubing, piping, pipeline or the vessel which only gas passing through) and the cylinder with stamp must be considered "those which are confirmed in advance by appropriate welding method due to mechanical testing".

(1) The vessel must be confirmed according to the following standards;

1) The welding procedure must conform to the provision stipulated in Article 54 "welding procedure" according to "6.12: method of welding" of JIS B8265-2008 "construction of pressure vessel−general".
2) The welder must be qualified according to the qualification test stipulated in Article 55 "skill of welder" of the interpretation of gas facility Japan.
3) The welder must be qualified according to other reliable standard such as ASME Boiler & Pressure Vessel Code Sec.-9 "Welding and brazing qualifications PART QW" or equivalent standard.

(2) The piping and pipeline must be confirmed according to the following standards;

1) The welding procedure must conform to the provision stipulated in Article 54 "welding procedure" of the interpretation of gas facility Japan.
2) The welder must be qualified according to the qualification test stipulated in Article 55 "skill of welder" of the interpretation of gas facility Japan.
3) The welder must be qualified according to other reliable standard such as ASME Boiler & Pressure Vessel Code Sec.-9 "Welding and brazing qualifications PART QW" or equivalent standard.

(3) The welding procedure according to the article 28 "welding procedure "of annex of "Interpretation of technical regulation for gas facility JP" can be considered as "appropriate welding procedure which is confirmed in advance by proper mechanical examination, etc."

3. "Those which are welded according to the appropriate welding design (type of welding method, shape of welding part and the like, and is confirmed that it has no harmful defect and has appropriate mechanical nature by proper testing method.)" means those which conform article 53 and from 57 to 71 of "Interpretation of technical regulation for gas facility JP".

4. “Appropriate testing” stipulated in design technical regulation Article 159-3 must be those which performed according to “4.3: repair welding” of “Guideline of inspection, evaluation and repair for corrosion and fatigue crack regarding vessel and piping: JGA-109-07” and confirmed according to the provision from Article 57 to 71 of “Interpretation of technical regulation for gas facility JP” and “4.5.1: non-destructive testing” of guideline JGA-109-07.
5. Liquefaction temperature (boiling point at atmospheric pressure) of Liquefied natural gas (LNG) is ultra-low (-162^{o}C) and its storage tank can be divided into the standing above ground and underground membrane storage tank as shown in Photo-24 and 25. 9% Ni steel (SL9N590) or aluminum alloy (5083-0) for the aboveground storage tank and stainless steel (SUS304) for the membrane of underground storage tank are used, which is a material characteristic respectively. Also, since it is both non-magnetic material, it can not be applied magnetic particle testing.
6. Welding procedure

(1) Welding of 9% Ni steel

The low carbon steel plate (SL9N590) with yield point of 590N/mm^2 and tensile strength of 690~830N/mm^2 which is added 9% Ni and was quenched and tempered is used to the body of LNG tank. 70Ni-15Cr system is applied to the wire rod for shield metal arc welding and 70Ni-20Mo-3W system is applied to the other automatic welding in order to prevent cracking, though welding material with high Ni alloy content of Ni about 50~70% is used for performance guarantee of the toughness of welding metal under very low temperature.

Tig welding and submerged arc welding are the main welding method as shown in Table-7. Although both are automatic welding, Tig welding have tried to streamline by a magnetic control or a two-electrode method, the lateral submerged arc welding by a high current density method. In addition, the welding heat input has been limited to less than 45kJ/cm, since 9% Ni steel is a heat treated steel.

Following considerations are required, since it is a kind of dissimilar welding.

1) In direct current welding, there occurs a magnetic blow. It has been addressed in the demagnetization process of the steel plate, though there are no aggressive measures to prevent.
2) It is necessary masks for adjusting when in the radiographic test, since the transparency of the radiation is different in the weld metal and base material. It is difficult to apply the ultrasonic testing, since weld metal is austenitic structure.

(2) Welding of aluminum alloy (5083-0)

There is a soft material of binary alloy that contains about 5% Mg, equivalent to mild steel speaking in steel. The standard minimum tensile strength is 275N/mm^2 and is rich in ductility and good weldability. Melting point is low and about 600°C and the heat is elusive, oxide layer with high melting point of about 2,700°C get in the way of welding.

The welding of tank is limited to Mig welding or Tig welding and has automated nearly 100% as shown in Table-7. Large current Mig welding is performed at high current 400~1,500Ausing a double shield torch. Characterized by deep penetration, the amount of high wear and low distortion, it can be welded each side a path up to about 80mm. DCEN Tig welding is characterized by deep penetration and is used to one side weld with temporary backing. It is necessary to remove the oxide layer in advance, since this method does not have cleaning effects. Welding wire A5183-WV which Ti and B are added is used for the purpose of preventing cracking and micro-miniaturization of crystal grains.

The biggest problem on the welding is the prevention of blowholes. It is required to remove hydrogen and moisture in the shield gas, degreasing of base metal and wire, removal of oxide layer in case of no effect of cleaning action due to the entering the welding zone.

(3) Welding of stainless steel (SUS304)

Austenitic stainless steel SUS304 (18Cr-8Ni) of 2mm thickness is used to the membrane of underground storage tank. This material is widely available, well known and not special welding. Tig welding has been primarily applied for the lap fillet joint or edge joint. Fig-9 shows the example. Automation is essential in order to cope with the increasing welding length due to the corrugation or fold like waveform to the thermal contraction corresponding to the giant storage tanks. However, the corrugation shape has become a strong color that reflects the creativity of the manufacturer’s original construction; it has become even automated equipment to fit. What is common is about welding method. It seems to be continued improvement of lightweight, compact, operability of device combined with efficiency and quality in future. This development of device is the most important feature of the welding of membrane. Usually, the wire diameter of 0.8mm of Y308L which has similar composition metals is used. It is aimed to smooth feeding of wire applied the 1.2mm strand wire twisted 7 of 0.4mm Y308L wires. Inspection of fitting part is performed mainly by liquid penetrant examination. The check of the airtightness and liquid tightness is most important and is performed using the vacuum chamber and leak test by ammonia.

Table- 7: Welding system for the LNG inner tank

Joint position \ Material for inner tank			9% Ni steel	Aℓ alloy
Roof part	Shingle × Shingle		MC, TIG or SMAW	MIG
	Knuckle × Knuckle		MC, TIG	MIG
	Shingle × Roof bone		SMAW	MIG
Side part	Vertical joint		MC, TIG	MIG
	Circumferential joint	Ground block	MC, TIG	MC, TIG
		Erection	HCD, SAW or MC, TIG	MIG
Bottom part	Bottom plate × Bottom plate		MC, TIG	DCEN, TIG
	Anyura × Anyura		MC, TIG or SAW	MIG or DCEN, TIG
	Anyura × Bottom plate		MC, TIG or SAW	MIG or DCEN, TIG
	Side plate × Anyura		SAW	MIG

Note: MC: Electromagnetic control, HCD: High current density, HC: High current, DCEN: Direct current electrode negative, TIG: Tungsten inert gas welding, SMAW: Shield metal arc welding, MIG: Metal inert gas welding

http://www-it.jwes.or.jp/qa/details.jsp?pg_no=0090040030

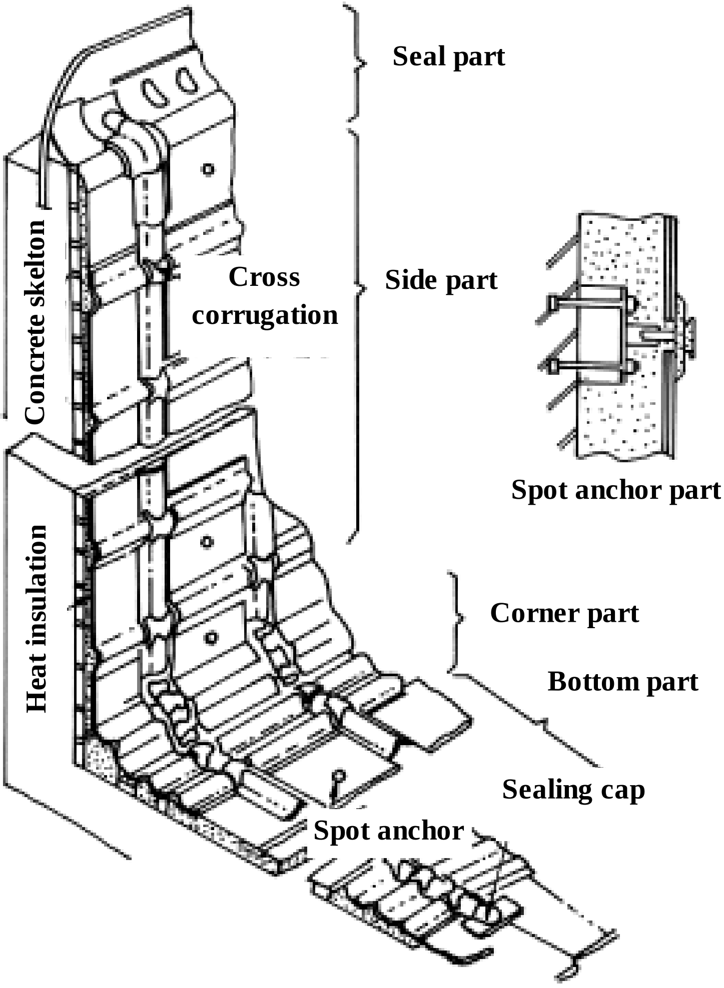


Fig- 9: LNG tank with membrane construction

http://www-it.jwes.or.jp/qa/details.jsp?pg_no=0090040030

(Non-destructive testing of flat-bottom cylindrical storage tank for LNG and LPG)

The non-destructive testing of flat-bottom cylindrical storage tank for LNG must be pursuant to “6.2.4: welding inspection” of “Guideline for aboveground type LNG storage tank (excluding underground type) (JGA: Japan Gas Association 108-02)” for the welding part of the flat-bottom cylindrical storage tank for LNG (excluding underground type) and “8.6.3: RT to UT for welding inspection” of “Guideline for underground type LNG storage tank (JGA: Japan Gas Association 107-02)” for the roof welding part of the underground storage tank for LNG and LPG. However, the criterion of non-destructive testing must be pursuant to Article 58-3 for radiographic testing, Article 59 for ultrasonic testing, Article 60-2 for magnaflux testing, Article 60-3 for penetrant testing of the interpretation of the technical regulation for gas facility Japan.

Article 160. Safety valve for liquefied gas unloading and transportation facility

Article 160-1. Safety valve

1. See Article 169-1 and 195-1.

Article 161. Instrument device for liquefied gas unloading and transportation facility

Article 161-1. Instrument device

1. See Article 196-1

Article 162. Alarm device for liquefied gas unloading and transportation facility

Article 162-1. Alarm device

1. See Article 197-1

Article 163. Fail-safe control and interlock for liquefied gas transportation facility

Article 163-1. Fail-safe isolation

1. "Measures necessary to prevent accidents and ensure the operation" stipulated in design technical regulation Article 163-1 means as follows;

(1) The shutoff device must be indicated the open or close direction (which has important impact on the safety in the gas facility, including the indication it's open or close status) must be explicit.

(2) The piping related to the emergency shutoff device (except those can be operated by operation button) which has important impact on the safety in the gas facility must be provided the type and direction of gas or other fluid in the pipe by the method can be easily distinguished adjacent to the shutoff device.

(3) The emergency shutoff device which has important impact on the safety in the gas facility and is not used in normal (except those used for emergency) must be locked; sealed and similar measures must be taken.

Article 163-2. Interlock

1. "An appropriate interlock for instrument circuits" stipulated in design technical regulation Article 163-2 means the following interlock provided for the equipment in LNG receiving terminal.

(1) Intertrip function to close the shutoff valve for receiving line due to the LNG tank level high.

(2) Interlock function to trip evaporator (close inlet shutoff valve) due to the LNG evaporator outlet temperature low.

(3) Interlock function to close the shutoff valve for receiving line due to the over turning of loading arm.

Article 164. Back-up power, etc. for liquefied gas transportation facility

Article 164-1. Back-up power

1. “Safety equipment due to power outage, etc. needed to safely close the liquefied gas unloading and transportation gas facility” stipulated in design technical regulation Article164-1 must be pursuant as follows;

    1) Emergency lighting system.
    2) Equipment to ensure rapid communication in case of emergency (except telephone subscriber equipment)
    3) Fire prevention and firefighting equipment.
    4) Gas leak detection and alarm equipment.
    5) Emergency shutoff valve.
    6) Emergency shutoff device.
    7) Cooling equipment.
    8) Water spraying system or equivalent facility that has the capacity to prevention of fire and firefighting.
    9) Water spraying system or equivalent facility that is effective for fire prevention.

Article 165. General provision for liquefied gas storage facility

Article 165-1. General provision

1. Two or more above ground tanks are generally installed for receiving and storing LNG. To reduce cost, designers try to minimize the number of tanks and maximize the amount of storage per tank. If the facility has only one tank then sends out and LNG unloading will be from the same tank. This does not cause any operating difficulties when properly designed and operated. Typical liquefied gas storage tank are shown in Photo-24, 25, 26, 27, 28, 29, 30 and 31.

    The main tank types are;

    1) Single containment
    2) Double containment
    3) Full containment
    4) Membrane

2. The single containment tank has an inner wall of 9% Ni steel that is self-supporting. This inner tank is surrounded by an outer wall of carbon steel that holds perlite insulation in the annular space. The carbon steel outer tank is not capable of containing cryogenic materials; thus the only containment is

that provided by the inner tank. However, single containment tanks are surrounded by a dike or containment basin external to the tank, either of which provides secondary containment in the event of failure.

3. The double containment tank is similar to a single containment tank, but instead of a dike there is an outer wall made of pre-stressed concrete. Thus if the inner tank fails the outer wall is capable of containing cryogenic liquid. The outer concrete wall adds to the tank cost but less land is required because the diked area is eliminated. Should the inner tank fail, then whilst the liquid will be contained, vapor will escape through the annular gap.
4. A full containment tank is one where the annular gap between the outer and inner tanks is sealed. Generally this type of tank has a concrete roof as well as a pre-stressed concrete outer wall. The outer wall and roof now can contain both cryogenic liquid and vapor generated. The weight of the concrete roof permits a higher design pressure 290 mbarg than a metal roof tank 170 mbarg. Double metallic tanks have also been constructed in Japan that can be considered as full containment. The outer tank is made of materials that can withstand LNG and retain both liquid and vapor. The size of LNG tanks has been increasing over the years. In general the largest common tank size is 160,000 m^3. Toyo Kanetsu K.K. has however now constructed a single180,000 m^3 tank for Osaka Gas in Japan.
5. The membrane type storage tank is a pre-stressed concrete tank with a layer of internal insulation covered by a thin stainless steel membrane. In this case the concrete tank supports the hydrostatic load which is transferred through the membrane and insulation (in other words, the membrane is not self-supporting). The membrane must shrink and expand with changing temperatures. Existing in-ground membrane tanks have capacities up to 200,000 m^3. The decision to use single, double, or full containment is based on capital and operating cost, land availability, separation distances to jetty and sometimes protection from external events such as vapor cloud blast pressure, missiles or small aircraft.
6. Full containment tanks are more expensive than single containment tanks. Before a particular type is finally selected it is important to consider the higher capital and operating cost of vapor handling equipment as well as the higher cost of safety features such the firewater system associated with single compared to full containment tanks. Where site conditions make land availability restrictive or where special protection from external events is required then a full economic analysis should be carried out that will generally favor concrete roof tanks.

   Current industry practice is to have all connections to the tank (e.g., filling, emptying, venting, etc.) through the roof so that if a failure of a line should occur it will not result in emptying the tank. Each tank has the capability to introduce LNG into the top or the bottom section of the storage tank. This allows mixing LNG of different densities and prevents the phenomenon known as “rollover” which can result in rapid vapor generation. Filling into the bottom section is accomplished using an internal standpipe with slots, and top filling is carried out using separate piping to a splash plate in the top of the tank.

Photo- 24: Large LNG tank

http://www.tokimati.com/save/katudou/21kengaku/21kengaku.html

Photo- 25: Underground LNG tank

http://www.shizuokagas.co.jp/information/news/2010/0114.html

Photo- 26: LNG tank for satellite base

http://www.shiromizu.co.jp/sh7.htm

Photo- 27: LNG tank for satellite base

http://www.yamaha.co.jp/news/2009/09021301.html

Photo- 28: Low temp. double hull LPG tank

http://www.shiromizu.co.jp/sh7.htm

Photo- 29: LPG tank (Zung Quat)

http://www.presscenter.org.vn/jp/content/view/1135/68/

Photo- 30: LPG tank

http://www.alibaba.com/buyofferdetail/103518248/Lpg_tank_china.html

Photo- 31: LPG tank

http://www.barata.co.id/gallery/project/02.php?iframe=true&width=800&height=360

Article 166. Material of liquefied gas storage facility

Article 166-1. Main material

1. 9% Ni steel have been applied as a material for mainly inner tank of LNG tank as a ferritic material for ultra-low temperature, since been applied to the liquid oxygen container for the first time in 1952. In particular, the characteristics of brittle fracture come heavily involved in the safety of the structure has been studied intensively from the conventional, it became clear that it has sufficient characteristics as a material for aboveground type LNG tank including the weld.
   However, the recent LNG tank aboveground has been enlarged beyond (mainly about 80,000m^3) in order for effective use of the site area or to reduction of construction costs, currently those of 180,000m^3 class are constructed and operated. In these tanks, 9% Ni steel plate of 50mm-thich which is significantly greater than the conventional thickness (about 30mm) has been used for these large yanks. There was a need to establish a technology to product steel plate stably having sufficient low temperature toughness in both base material and welding compared with conventional steel plate, since the decrease of fracture toughness value on like ultra-thick 9% Ni steel due to the increase in thickness is concerned about.
2. The heat treatment method and component of 9% Ni steel has been rigorously defied by ASTM and JIS and the like. In the development, consideration was examined focusing on the Si and Mo which can be improved the toughness of joint and components can be changed in the standard range. In addition, the proven two phase quenching method which can significantly improve the toughness of the base metal as heat treatment method has been applied.

Article 167. Structure of liquefied gas storage facility

1. The construction must be pursuant to any of following items. However, the seismic design must be limited those having storage capacity 3 tons and more.

(1) The construction of the storage tank for liquefied gas must be pursuant to follow item-1) to 6);

1) The foundation of the storage tank for liquefied gas must withstand the total weight of the liquefied storage tank including the stored liquefied gas.

2) Earthquake resistance of the liquefied gas storage tank (including the foundation) must be pursuant to the provisions of "Seismic design guidelines such as gas generation facility (JGA: Japan Gas Association 101-01)"

3) The structure of liquefied gas storage tank which has not applied insulation material must be pursuant to the provision of construction of vessel and the allowable stress stipulated in Article-157-1-5 must be applied.

4) The storage tank for liquefied gas having a cold storage facility must be sufficient to withstand the liquid head pressure, gas pressure and atmospheric pressure.

5) The storage tank for liquefied gas which all part is buried underground must be placed in a chamber of reinforced concrete (hereinafter referred as "tank room") with lid, wall and bottom more than 30cm thickness respectively. However, if measure to withstand the heavy load on the ground surface were taken, this must not be applied.

6) The storage tank for liquefied gas which a part of it is buried underground must be fixed to the ground.

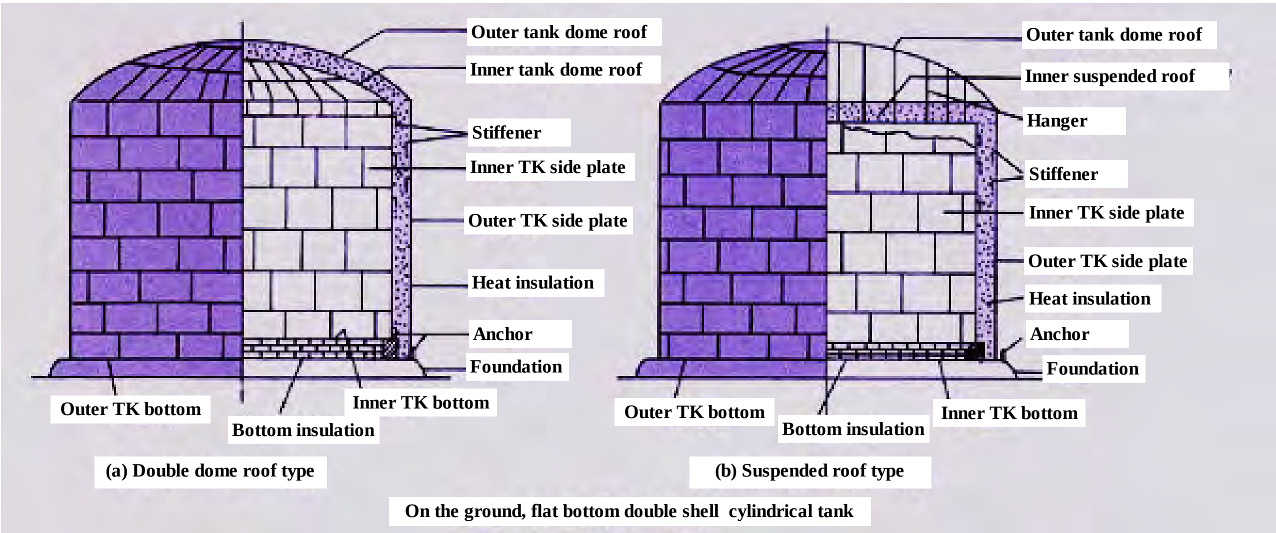
(2) The construction of the underground storage tank to store LNG or LPG must be pursuant to "3: basic design condition" , "4: ground survey", "5.1: filling", "6.1: general", "6.3: design value of material", "6.6: specification of structure", "6.8: testing and inspection", "from 7.1: general to 7.6: inspection", "8.3: structure and design", "9.3: design" and "9.4: structure" of "Guideline for LNG underground storage tank: JGA 107-02". However, the allowable stress for "8.3.3: allowable stress for normal and at earthquake level -1" must be pursuant the allowable stress stipulated in Article-157-1-5 must be applied.

(3) The construction of the flat-bottom cylindrical LNG storage tank (exclude underground storage tank) must be pursuant to "from 4.1: general to 4.5: construction and design of inner tank", "7.4: structure and design", "8.4: design value" and "8.5: construction and design" of "Guideline for aboveground LNG storage tank: JGC 108-02". However, the allowable stress for "3.2.2: (material) materials used for inner tank and ancillary facility" must be pursuant the allowable stress stipulated in Article-157-1-5 must be applied. The typical construction of on the ground, flat bottom double shell cylindrical tank is shown in Fig-10.

(4) The construction of the aboveground horizontal cylindrical storage tank, vertical cylindrical storage tank and spherical storage tank (LPG storage tank) which storage LOG under atmospheric temperature must be pursuant to "8.1.1: general", "8.1.4: design value", 8.1.5: construction and design" of "8: foundation and protection dikes" of "Guideline for LPG storage tank: JGA 106-05". However, However, "4.5.1. (1): long term allowable tensile stress" must be pursuant the allowable stress stipulated in Article-157-1-5 must be applied.

(5) The construction of the vertical cylindrical LNG storage tank and horizontal cylindrical LNG storage tank with vacuum heat insulation must be pursuant to the provision of pressure vessel and “4.3: structure and design”, “11.5: design” of “Guideline for LNG facility of small LNG base: JGA 105-02”. In addition, allowable stress of material must be pursuant the allowable stress stipulated in Article-157-1-5 must be applied.

(6) The construction of the vertical cylindrical LNG storage tank with ordinary heat insulation must be pursuant to the provision of pressure vessel and “4.3: structure and design”, “11.5: design” of “Guideline for LNG facility of small LNG base: JGA 105-02”. In addition, allowable stress of material must be pursuant the allowable stress stipulated in Article-157-1-5 must be applied.



<u>Fig- 10: Typical construction of on the ground, flat bottom double shell cylindrical tank</u>

http://www.nswelding.co.jp/tech/qa/f010/12grp1.jpg

Article 167-1. Liquefied gas part

1. “Pressure part of the liquefied gas storage tank” stipulated in design technical regulation Article 167-1 means the part where filling with liquefied gas.

Article 167-2. Main part of storage tank

1. “Main part of liquefied gas storage facility” stipulated in design technical regulation Article 167-2 means the main part of storage tank where supporting liquefied gas load or evaporated gas pressure such as Fig-11, 10 or 18.

Article 167-3. Gas tight function

1. There are several types for LNG storage tank. The membrane inner tank has mechanism to absorb thermal shrinking corresponding to the thermal condition between room temperature to very low temperature (-162°C) by SUS304 thin steel plate (1~2mm). When constructing such large tank that the membrane is the lifeline, the high quality welding management by means of precise control of

welding heat input management, uniform, refinement of profiling accuracy, automatic welding considering the strain relief, high quality management of welding is important.

Article 167-4. Stable deformation behavior

1. "Stable deformation behavior" stipulated in design technical regulation Article 167-4 means the ability to follow shrinking under very low-temperature to stretching under room temperature smoothly according to the structure as shown if Fig-9.

Article 167-5. Cold insulation

1. "Cold insulation material" stipulated in design technical regulation Article 167-5 means the insulation material to suppress generation of boil-off gas (BOG) due to the heat transfer from outside. The typical construction of metal double shell tank (suspended deck tank) is shown in Fig-11.

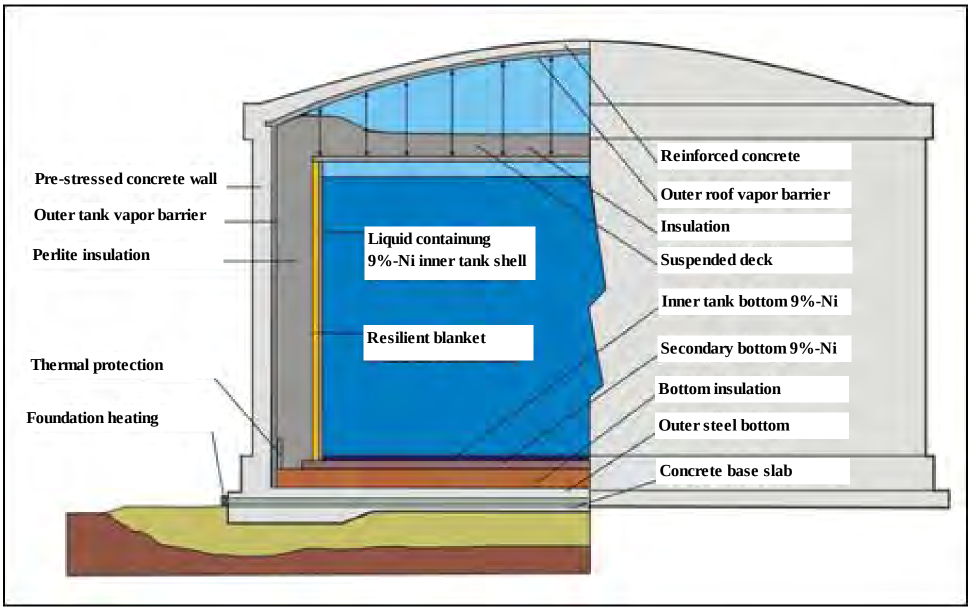


Fig- 11: Metal double shell tank (Suspended deck type)

http://www.epd.gov.hk/eia/register/report/eiareport/eia_1252006/html/eiareport/Part1/Sec1_3_v2.htm

Article 167-6. Performance of cold insulation material

1. "Appropriate structure" stipulated in design technical regulation Article 167-6 means those as provided below.

(1) In case of the body of liquefied gas storage tank, those which are covered with insulation material for cold storage and having adequate fire resistance performance.

(2) In case of the support of liquefied gas storage tank, those which is covered with fire resistant refractory concrete in 50mm thickness per1m length of support or non-flammable insulation having a performance equal to or greater than it.

2. “Appropriate cooling equipment” stipulated in technical regulation Article means those pursuant as any of follows for the liquefied gas storage tank. In addition, these water sprinkler system and fire hydrant must be connected to the water source with the amount of water that can be watering continuously for more than 30 minutes and the following sprinkler system (1) to (3) must be capable to operate from a safety location away from the outer surface of the object 5meters from tank and support. However, the level gauge and valves attached to the body for liquefied gas storage tank are not included.

(1) The sprinkle system which can sprinkle the amount of water that calculated at a rate of more than 5 liters per minute per square meter of surface area for liquefied gas storage tank and support structure uniformly to entire surface of liquefied gas storage tank and support structure.

(2) The sprinkle system which can sprinkle the amount of water that calculated at a rate of more than 5 liters per minute per square meter of surface area for liquefied gas storage tank that are covered by rock wool with 25mm thickness or equivalent insulation material and covered by JIS G3302-2007 “Galvanized steel sheet and steel strip” with 0.35mm thickness or other material which has equivalent strength and heat resistance or more and support structure uniformly.

(3) The sprinkle system which can sprinkle the amount of water that calculated at a rate of more than 2.0 liters per minute per square meter of surface area for underground storage tank and double shell flat-bottom aboveground liquefied gas storage tank to store low temperature liquefied gas and support structure uniformly to entire surface of liquefied gas storage tank and support structure.

(4) Those which the fire hydrant that can discharge from either direction against tank are provided within 40 meters from the outer surface of liquefied gas storage tank and more than the number calculated at a rate of one hydrant per 50 square meter area of tank are provided.

(5) Those which the fire hydrant that can discharge from either direction against tank are provided within 40 meters from the outer surface of semi-fire-proof liquefied gas storage tank and more than the number calculated at a rate of one hydrant per 100 square meter area of tank are provided.

3. “Periphery of flammable liquefied gas tank” means as follows;

(1) Within 10 meters from outside surface of dike, in case of the flammable liquefied gas tank with protection dikes.

(2) Within 20 meters from outside surface of dike, in case of the flammable liquefied gas tank without protection dikes.

Article 167-7. Cold insulation material for bottom

1. “Cold insulation material for tank bottom” stipulated in design technical regulation Article 167-7 means the material which has sufficient strength to withstand the load of liquefied gas. The typical arrangement of insulation material for tank bottom is shown in Fig-12, 13 and 14.

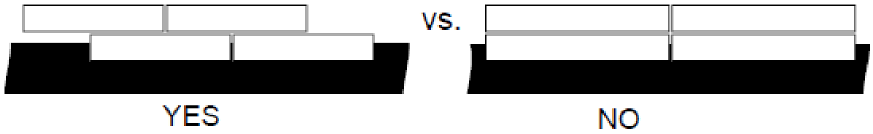
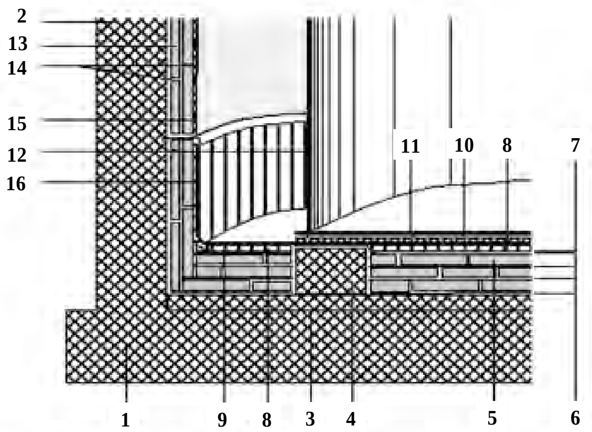
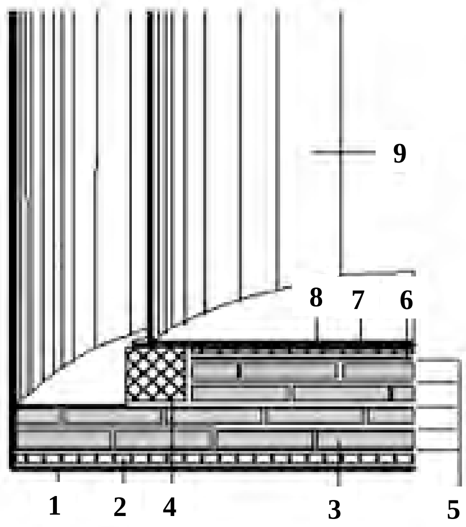


Fig- 12: Arrangement of insulation



1. Concrete or metal base
2. Concrete or metal outside tank wall (option)
3. Levelling Screed
4.Lightweight concrete ring beam
5. Cellular glass tank base insulation
6. Approved interleaving material
7. Slip layer
8. Fine dry sand (optional)
9. Emergency complementary protection (optional)
10. Concrete slab
11. Tank bottom
12. Tank wall
13. Cellular glass tank wall insulation system
14. Approved flexible adhesive to adhere and seal cellular glass tank base insulation
15. Optional finish
16. Slip layer

Fig- 13: Insulation for bottom of LNG tank



1. Outer tank wall
2. Leveling screed
3. Heavy load bearing cellular glass insulatior
4. Concrete ring beam
5. Approved interleaving layer
6. Slip layer
7. Repartition slab
8. Inner tank bottom
9. Inner tank wall

Fig- 14: Insulation for bottom of ING tank

Reference: http://www.insulation.org/articles/image.cfm?photoID=IO081101_01&ext=jpg&fig=1

http://www.insulation.org/articles/image.cfm?photoID=IO081101_02&ext=jpg&fig=2

Article 167-8. Joint of cold insulation

1. "Joint of the cold insulation material" stipulated in design technical regulation Article 167-8 means the appropriate structure preventing cold-paths due to the shrinking of tank, piping or insulation material. The typical arrangement of insulation material for tank bottom is shown in Fig-15 and 16.

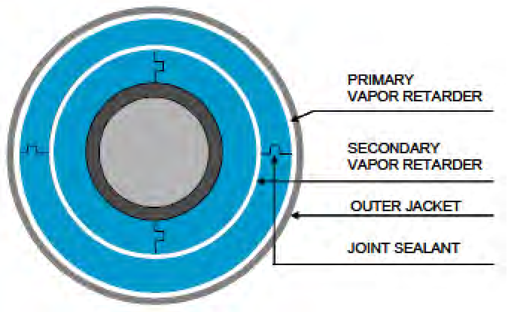


Fig- 15: 2 layer insulation for LNG piping

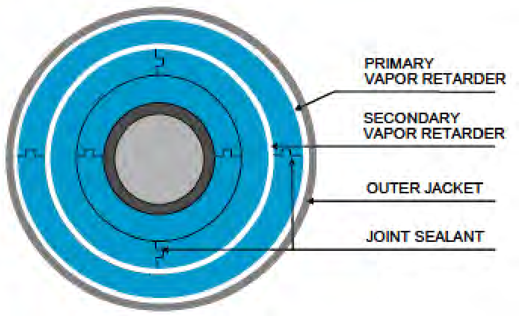


Fig- 16: 3 layer insulation for LNG piping

http://www.lngexpress.com/itm/Pres/JimYoung.pdf

Article 168. Sign for liquefied gas storage facility

Article 168-1. Sign

1. The border of gas storage facility or gas production plant must be expressed clearly by means of providing wall, gate, fence, trench and the like or painting mark on the ground.
2. The sign board for gas storage facility or gas production plant must be provided in the location in the vicinity of the each entrance on the fence or trench where easy to see as shown in Photo-32.

Photo- 32: Warning sings for LNG base

http://www.aygazdg.com.tr/content/EN/technicalities-and-safety/104/

Article 169. Safety valve, etc. for liquefied gas storage facility

Article 169-1. Safety valve

1. See Article 195-1.

   The typical safety valve is shown in Photo-33, 34 and Table-8.

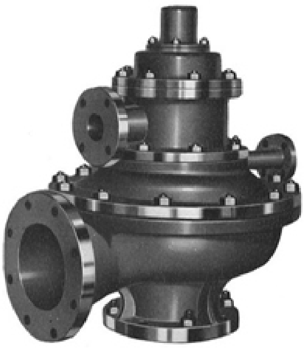


Photo- 33: Pilot Operated safety Valve for LPG

http://www.niikura.co.jp/products/barb08.html

Photo- 34: Pilot Operated safety Valve for LNG

http://www.niikura.co.jp/products/barb08.html

Table- 8: Pilot operated safety valve for LNG (Fukui Seisakusho)

Type	Pilot operated safety relief valve	
Service	• LNG/LEG/LPG/Liquefied gas • Low pressure storage tank • Cryogenic temp. to ambient temp.	• LPG/Liquefied gas/Ammonia • Liquefied gas carrier and low pressure storage tank (Non cryogenic temp.)
Series	PSL-MD (　) 3&4 Teflon diaphragm with Support/Flangeless type	PSL-MD (　) 2 Elastomeric diaphragm with Non support type
Photo		
Size	2” ~ 14”	2” ~ 20”
Pressure range(max)	0.005 ~ 0.25MPa 0.7 ~ 35psi	0.001 ~ 0.35MPa 0.15 ~ 50psi

Type	Pilot operated safety relief valve	
Temp. range (max)	-196 ~ 125°C	-196 ~ 125°C
ASME code	UV	UV

Reference: Fukui Valve: http://www.fkis.co.jp/j_welcome.html

Article 169-2. Quantity of safety valve

1. See Article 195-1.

Article 170. Prevention vacuum in liquefied gas storage tank

Article 170-1. Vacuum condition

1. "All measures necessary" stipulated in design technical regulation Article 170-1 means to provide any one or more of the vacuum relief valve, pressure equalizing pipe from other liquefied storage tank or facility, refrigeration control equipment which is provided in conjunction with pressure or pumping equipment which is provided emergency shutoff device in conjunction pressure. However, in case of the underground storage tank for LNG or LPG, it may be pursuant to the provision "10.3.5: measures to prevent negative pressure" of "Guideline for underground LNG storage tank (JGA: Japan Gas Association 107-02)".
2. Notwithstanding the provisions of the preceding paragraph, those of he following items can be deemed to conform to the regulation.

(1) Those which have no fear that pressure inside the liquefied gas tank does not drop lower than external pressure such as those which is not used pump and compressor for withdrawal of liquefied gas and boil-off gas, those which the boil-off gas line is connected to the water seal gasholder.

(2) High vacuum insulation between the inner tank and outer tank is provided and the liquefied storage tank is designated to withstand the negative pressure.

Article 171. Instrument device for liquefied gas storage tank

Article 171-1. Instrument device

1. "Instrument measuring apparatus" stipulated in design technical regulation Article 171-1 means the instrument device to monitor abnormal situation of LNG storage tank or associated piping such as the level meter, flow meter, low temperature detector, re-bar strain meter, concrete strain meter, subsidence meter, inclinometer, hydro pressure meter, settlement gauge to prevent leakage of gas and liquefied gas due to destruction of storage tank or associated piping as shown if Fig-17, 18 and Photo-35.

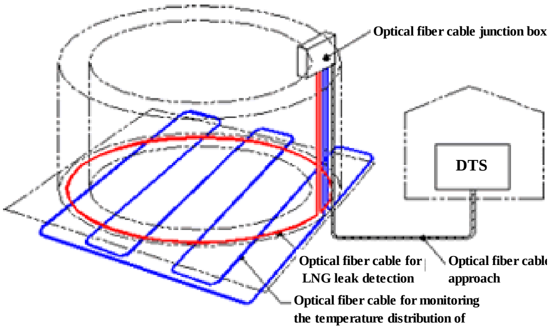


Fig- 17: Leak detector for LNG tank

http://www.nksystems.jp/applications/lng-tank.html

Photo- 35: Sensor for LNG tank piping

http://www.tokyo-gas.co.jp/techno/stp3/02a2_e.html

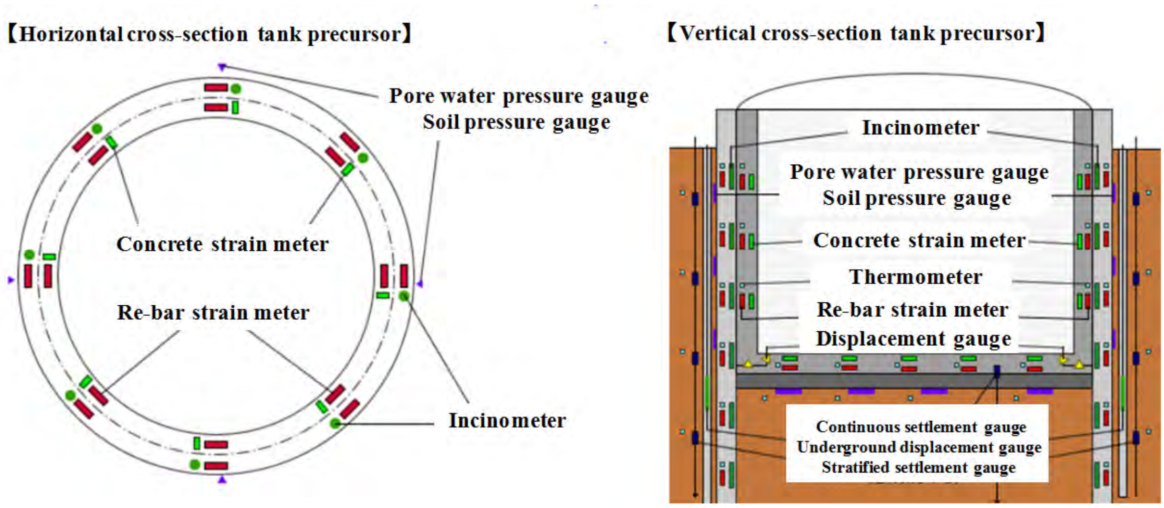


Fig- 18: Instrument device for underground LNG tank

http://www.sakatadenki.co.jp/product/power-plant/LNG_tank.html

Article 172. Alarm device for liquefied gas storage tank

Article 172-1. Alarm device

1. “Alarm device” stipulated in design technical regulation Article 172-1 means those to product warning in the following cases. However, this must not be applied, if there is no possibility of such state because of the structure of equipment.

(1) In case of the gas generation facility, the following cases;

1) When the pressure of operation fluid drops abnormally, with regard to those which use fluid to operate the autopilot equipment.

2) When the water supply to the water seal vessel stop or the liquid surface of the water seal vessel

drops abnormally, with regard to those which have the water seal vessel.

3) When the pressure of steam drops abnormally, with regard to those which feed steam into the furnace.

4) When the pressure of combustion gas drops abnormally, with regard to those which feed air into furnace and burn a part of raw material.

5) When the pressure of fed fuel drops abnormally, with regard to those which are heated externally.

6) When the pressure of the part where gas passing raises abnormally, with regard to those which is high pressure or middle pressure.

(2) When the liquid level of LPG vaporizer raises abnormally, with regard to the gas generation facility for liquefied petroleum gas.

(3) When the outlet gas temperature of LNG vaporizer raises abnormally, with regard to the gas generation facility for liquefied natural gas.

(4) When the gas pressure raises abnormally, with regard to the gas purification facility that the maximum operation pressure is high or medium.

(5) When the amount of gas storage has decreased abnormally, with regard to the gasholder that the maximum operation pressure is low (limited to those which discharge gas by blower or compressor).

(6) When the hydraulic pressure of the lubricating oil has dropped abnormally, with regard to the blower and compressor (limited to those which has the external forced lubricating equipment).

(7) When the pressure of gas part rises abnormally, with regard to the liquefied gas storage tank (limited to the low temperature storage tank with capacity 100 ton and more).

(8) When the pressure of gas part rises abnormally, with regard to the low temperature storage tank.

(9) When supply of gas or air is stopped, with regard to the heat regulating device (limited to those regulating calorific value by air.

Article 173. Shut-off device of liquefied gas storage tank

Article 173-1. Shut-off device

1. “Isolation equipment capable to shutoff rapidly*****shall be provided” stipulated in design technical regulation Article 173-1 means those listed as follows;

(1) In case of the liquefied gas storage tank with capacity less than 5,000ℓ, to install the attached piping on the liquefied gas storage tank (limited to the incoming or outgoing piping and from tank to the remote control valve, etc.) and remote control valve which can be operated 5 m (more than 0m in case of buried piping) far from the surface of the liquefied gas storage tank in the vicinity of the connection of such piping with the liquefied storage tank. However, in case of the piping attached to the liquefied gas storage tank installed in the large scale gas generation plant and used it may be substituted with a manual valve or check valve for the piping to be used only to receive liquefied gas.

(2) The liquefied gas storage tank with capacity 5,000ℓ and more must be pursuant to following 1) and 2).

1) In case of the piping attached to the liquefied gas storage tank (limited to the part from tank to the emergency shutoff device), the emergency shutoff device must be provided in the position away from at least 5 meters (at least 10 meter in case of large scale generation plant and 0 meter in case of buried piping) the exterior of the vessel and piping. However, it may be substituted with a check valve for the piping to be used only to receive liquefied gas.

2) The manual valve and remote operation valve and the like must be provided adjacent to the connection part of liquefied gas storage tank with piping (limited to those which are used for discharging and receiving liquefied gas).

2. "Isolation equipment capable to shutoff rapidly*****shall be provided" stipulated in design technical regulation Article 173-1 means those listed as follows;

(1) When the capacity of vessel is less than 5,000 ℓ;

1) In case of the high gas cylinder, emergency shut-off device such as a manual valve must be provided on the piping adjacent to the connection of the vessel and the piping.

2) In case of the gas cylinder other than above, the emergency shutoff device must be provided in the position away from the exterior of the piping attached to the cylinder (limited to those used for discharging or receiving liquefied gas and those which have no possibility of leakage of liquefied gas from the cylinder). However, it may be substituted with a manual valve or check valve for the piping to be used only to receive liquefied gas.

(2) When the capacity of vessel is 5,000 ℓ and more;

In case of the piping attached to the cylinder (limited to the part from cylinder to the emergency shutoff device and exclude those which have no possibility of leakage of liquefied gas from the cylinder), the emergency shutoff device must be provided in the position away from at least 5 meters (0 meter in case of buried piping) the exterior of the vessel and piping. However, it may be substituted with a manual valve or check valve for the piping to be used only to receive liquefied gas.

Article 174. Heat insulation measure for liquefied gas storage tank

Article 174-1. Heat insulation

1. "Withstand any heat condition" stipulated in design technical regulation Article 174-1 must be pursuant followings;

(1) In case of the body of storage tank for liquefied gas, those which are covered by heat insulation material to keep cool and have sufficient fire-resistance performance.

(2) In case of the support of storage tank for liquefied gas, those which are covered by the refractory

concrete with at least 50mm thick per more than 1m long or non-flammable insulation material having a performance equal to or greater than.

2. In case of the storage tank for liquefied gas, “appropriate cooling system” stipulated in design technical regulation Article 174-1 must be pursuant to following items; In addition, these sprinkler and water hydrant must be connected with the water source that has amount water enough for sprinkle in more than 30 minutes continuously and the sprinkle equipment listed in item-(1) to (3) can be operated in the safety place 5m away from the outer surface of the supporting structures and storage tank. However, gauges and valves which are attached to the body for liquid gas storage tank are not included.

(1) The sprinkler system which can be sprinkled uniformly the amount of water that is calculated at a rate of more than 5 liters per minute per square meter of surface area for liquefied gas storage tank and supporting structure to the entire surface and supporting structure for liquefied gas storage tank

(2) The sprinkler system which can be sprinkled uniformly the amount of water that is calculated at the rate of more than 2.5 liters per minute per square meter of surface area for liquid gas storage tank, which is The liquefied gas storage tank which is coated with an insulation material having a fire-resistance equal to or better than this or rock wool of more than 25mm thick and covered by the JIG G3302-2007 “Steel strip and galvanized steel sheet” of more than 0.35mm thickness having a strength and fore resistance of at least equivalent to (hereinafter referred to as “semi-fire-proof construction tank”) and supporting structure to the entire surface and supporting structure for liquefied gas storage tank.

(3) The sprinkler system which can be sprinkled uniformly the amount of water that is calculated at a rate of more than 2.0 liters per minute per square meter of surface area for the low pressure underground liquefied gas storage tank and the double shell cylindrical flat bottom aboveground storage tank to store low temperature liquefied gas and supporting structure to the entire surface and supporting structure for liquefied gas storage tank.

(4) The water hydrant which can be sprinkle from either direction against storage tank are provided calculating at a rate of one fore hydrant per 50 square meter surface area of the storage tank within 40 meters from the outside surface of the liquefied gas storage tank.

(5) The water hydrant which can be sprinkle from either direction against storage tank are provided calculating at a rate of one fore hydrant per 100 square meter surface area of the storage tank within 40 meters from the outside surface of the “semi-fire-proof construction tank”.

3. “Around the tank for flammable liquefied gas” means as follows;

(1) When the protection dike is provided for the storage tank of liquefied gas storage tank, refers to within 10 meters from the outer surface of such protection dike.

(2) When the protection dike is not provided for the storage tank of liquefied gas storage tank, refers to within 20 meters from the outer surface of such protection dike.

Article 175. Dike for liquefied gas storage tank

Article 175-1. Protection dike

1. "Appropriate protection dike" stipulated in design technical regulation Article 175-1 means the dike conforms to followings. However, (3) and (4)-1)-c. will not be applied for the liquefied gas storage tank which the outer tank and dike are combined (limited to inner tank and dike are independent of each other in strength).

(1) When installing a dike for a storage tank, the capacity of dike must be capable to accommodate the amount of gas as a liquid in the tank (hereinafter referred to as "equivalent capacity equal to storage volume", if remaining liquefied gas in the tank spill instantly.

(2) When installing a dike for two and more storage tanks (limited to cases when the partition is provided to each tanks), the capacity of dike must be capable to accommodate the amount of gas as a liquid in the tank (equivalent capacity equal to storage volume) and added 10% of equivalent capacity equal to storage volume of other tank.

(3) The distance between tank and dikes must be sufficient to perform maintenance and disaster prevention activities.

(4) The construction must conform to any of following 1) to 3).

1) The dikes for storage tank must be following a. to e. (except for the underground cylindrical storage tank with flat-bottom (excluding underground storage tank))

a. Dikes must be constructed by the soil, concrete, metal, concrete blocks or those combinations.

b. Those which is liquidtight.

c. The measure to provide a stairs, ladder, or lifting or slope for in every 50m for lifting. However, if the length of dike is less than 100m, they must be provided in two or more places.

d. Drainage equipment which can be operated and isolated outside the dike must be provided.

e. Those which can be withstood the large one of following.

a) Liquid head pressure, when the liquid is filled to the top of the dikes.

b) Seismic force. (stipulated in "Seismic design guidelines such as gas generation facility (JGA: Japan Gas Association 101-01)"

c) Wind load.

2) The dikes for LNG underground cylindrical storage tank (excluding underground storage tank) must be pursuant to "from 9.1: general to 9.5: construction and design and 10.5.2: protection

dike, etc." Of "9: protection dike" of "Guideline for LNG storage tank aboveground (JGA: Japan Gas Association 108-02)".

3) The dikes for aboveground storage tank which store LPG under atmospheric temperature must be pursuant to "from 8.2.1: general to 8.2.4: design and 10.6.1: protection dike" in "8: foundation and dikes" of "Guideline for LPG storage tank aboveground (JGA: Japan Gas Association 106-05)".

2. "Equivalent capacity equal to storage volume" stipulated in 1-(1) means the amount obtained by subtracting from the amount of storage capacity of liquefied gas when pressure of the tank will be opened, it may be the capacity obtained by multiplying factor shown in Table-9 (1.0 for the low temperature tank) with the storage capacity depending on the type and pressure of the stored gas in the tank.

Table- 9: Equivalent capacity factor

Pressure in the tank	$P < 0.2$	$0.2 \le P < 0.4$	$0.4 \le P < 0.7$	$0.7 \le P < 1.1$	$1.1 \le P$
Propane	1	0.9	0.8	0.7	0.6
Pressure in the tank	$P < 0.1$	$0.1 \le P < 0.25$	$0.25 \le P$	—	—
Butane	1	0.9	0.8	—	—

Note: (1) The unit of pressure is MPa.

(2) The value for other than listed in above table must be reduced 1 from a rate of vaporization of gas according to the pressure in the tank.

Reference: Article 95 of Interpretation of technical regulation for gas facility (25/Mar/2010): NISA (Nuclear and Industrial Safety Agency) of METI (Ministry of Economy, Trade and Industry)

3. "The partition wall for each storage tank" must be provided depending on the capacity obtained by multiplying the percentage that is divided equivalent capacity equal to storage volume for one storage tank by the total storage capacity, and its height must be 10cm lower than dikes as shown in Photo-36, 37 and Fig-19.

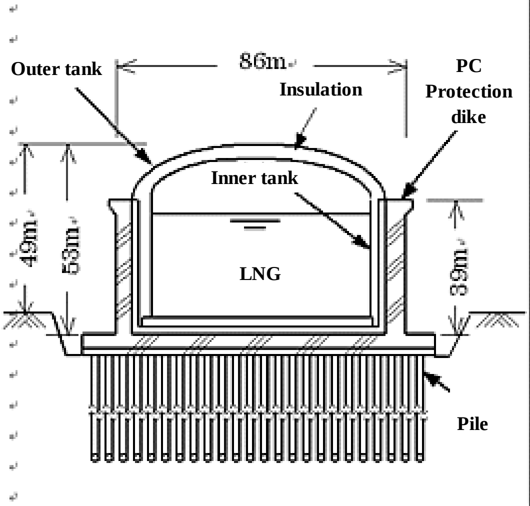
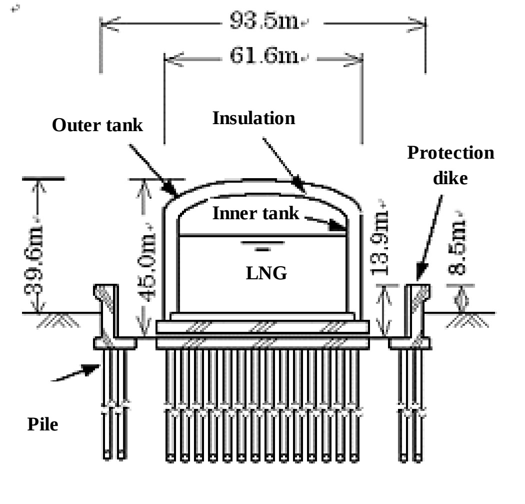
	PC type LNG tank 180,000kℓ	Metal double shell type LNG tank 80,000kℓ
Construction concept		
Capacity	180,000kℓ	80,000kℓ
Tank	9% Ni steel, carbon steel	9% Ni steel, carbon steel
Protection dike	・Pre-stressed concrete that is close contact with outer tank. ・39m height.	・Structure that is independent of outer tank. ・14m height.

Fig- 19: LNG protection dike

Reference: http://www.osakagas.co.jp/company/press/pr_2000/000309.html

Photo- 36: Protection dike

http://www.meisei-kogyo.co.jp/kankyou/index.html

Photo- 37: Protection dike

http://www.fudotetra.co.jp/doboku/nanao.html

4. Storage capacity of storage tank

(1) The storage capacity of gas must be calculated according to the following formula in the Table-10.

Table- 10: Calculation of gas storage capacity

Classification	Storage capacity
Storage tanks and vessels for compressed gas	$Q = (10 \times P + 1) \times V_1$
Storage tanks for liquefied gas	$W = C_1 \times w \times V_2$
Vessels for liquefied gas	$W = \frac{V_2}{C_2}$

Q	: Storage capacity	(m^3)
P	: 35°C	(MPa)
V_1	: Volume of the tank or vessel	(m^3)
W	: Storage capacity	(kg)
w	: Specific gravity of liquefied gases at regular temperature	(kg/ℓ)
V_2	: Volume of the tank or vessel	(ℓ)
C_1	: 0.9 (ratio of the part can be store liquefied gas in the volume in case of low temperature storage tank, 0.85 for bulk storage tank other than those above 2,000ℓ in volume and placed underground)	—
C_2	: Value stipulated in article 22 of safety rule for vessel	—

Reference: http://www.pref.saitama.lg.jp/uploaded/attachment/358855.pdf

Article 175-2. Installation of equipment in the dike

1. "Distance necessary for emergency work" stipulated in design technical regulation Article 175-2 means 10m for liquefied storage tank. (8m for the storage capacity is less than 1,000ton)
2. "Facilities which is not interfere to prevent the spread of fire or leakage of liquefied gas" means those listed in the following items;

(1) Those which can be installed inside the dikes are as follows;

1) Transportation facility of liquid, storage tank for inert gas, water spray or sprinkle equipment, firefighting equipment, gas leak detection and alarm device (limited to the detection part), lighting facility, instrumentation facility, drainage facility, piping, support and their ancillary equipment.
2) Those which are not interfere with security in addition to the matters listed in 1).

(2) Those which can be installed outside the dikes are as follows;

1) Transportation facility of liquid, compressor relating to receiving, storage tank for inert gas, heat exchanger, gas leak detection and alarm device, lighting facility, instrumentation facility, drainage facility, piping, support and their ancillary equipment.
2) Pipeline or piping (limited to those having sufficient height that does not interfere with the disaster prevention activities) and support, firefighting equipment, passage (limited to those that are installed in the gas production plant) and facility buried underground (limited to those taking measures that can withstand the heavy load on the ground surface).
3) Those which are not interfere with security in addition to the matters listed in 1) and 2).

Article 176. Anti-corrosion measure of liquefied gas storage tank

Article 176-1. Corrosion measure of buried part

1. "Appropriate measures" stipulated in design technical regulation Article 176-1 means those which waterproof measure are taken for liquefied gas storage tank that are all buried under the ground surface and is installed in the tank room.
2. It must be no risk to cause corrosion in case of the underground storage tank conforming to "Guideline for LNG underground storage tank: JGA 107-02".

Article 177. General provision of pump, compressor and blower for liquefied gas storage tank

Article 177-1. Fuel for LNG carrier

1. BOG will be inevitably generated due to heat penetration from outside the tank on the LNG vessel to transport LNG in the deep cold. It is processed as the fuel for boiler and is used as the driving force in the main steam turbine engine in order to reduce suppression of the tank pressure rise. If the combustion heat is surplus compared with the driving force, steam will be dump to seawater and is covered by additional combustion of C-heavy oil or forced evaporation of LNG, if combustion heat is insufficient. It can be selected the most economical operation by LNG and C-heavy oil as fuel.
2. Generated BOG wile sailing have been used for the fuel of main boiler or gas diesel engine using a steam turbine propulsion plant, since the re-liquefaction equipment of BOG was large so far. In the 21st century, adoption of "DFD: dual fuel diesel engine" which using both LNG and heavy oil and "DRL: diesel and re-liquefaction" which using only heavy oil has increased. Especially, the commercialization of re-liquefaction equipment which is capable to re-liquefaction of BOG on the ship has become a factor for DRL.

Article 177-2. Fuel for LPG carrier

1. Propane becomes a gas at about -40°C and butane at about -0.5 °C under atmospheric pressure. It is necessary to cool down the liquid propane and butane, since the heat of atmosphere enters the tank during the voyage and the temperature of propane and butane rise, even if there installing the

insulation. For this reason, the re-liquefaction equipment has been installed for LNG vessel.
It is possible to transport LPG cargo without any loss and to adopt the diesel main engine which has good efficiency by the method to back re-liquefied BOG to cargo tank; transportation system and propulsion system are separated.

Article 177-3. Unloading of LNG

1. The LNG receiving terminal receives liquefied natural gas from special ships, stores the liquid in special storage tanks, vaporizes the LNG, and then delivers the natural gas into a distribution pipeline. The receiving terminal is designed to deliver a specified gas rate into a distribution pipeline and to maintain a reserve capacity of LNG. The amount of reserve capacity depends on expected shipping delays, seasonal variations of supply and consumption, and strategic reserve requirements (strategic reserves are needed when the terminal may be called upon to replace another large source of gas from either a pipeline or another receiving terminal on short notice).
   The terminal consists of:

   1) LNG unloading system, including jetty and berth
   2) LNG storage tanks
   3) LNG vaporizers
   4) In-tank and external LNG pumps
   5) Vapour handling system
   6) Supporting utilities, piping, valves, control systems, and safety systems required for the terminals' safe operation.
   7) Infrastructure (roads, fencing and buildings)

   Receiving terminals to date are expected to operate close to 365 days per year and have spared equipment to achieve this availability. The one exception is that a shutdown may be necessary for a statutory inspection of vessels or maintenance of some critical items such as the flare. Spare equipment can be eliminated and cost savings achieved if line packing can be used or if some of the gas consumers can tolerate interruptions in the send-out supply.

(1) LNG ship unloading
Following ship berthing and cool-down of the unloading arms, LNG is transferred to the onshore LNG tanks by the ship pumps. The unloading facility is often designed to accommodate a wide range of tanker sizes from 87,000 m3 to 145,000 m3. The liquid unloading rate from the ship is usually 10-12,000 m3/hr carried out by eight pumps with two pumps located in each of four cargo tanks onboard a typical ship. It takes approximately 12-14 hours to unload one 135,000m3 ship. From the ship the LNG flows through the unloading arms and the unloading lines into the storage tanks. The loading lines can be two parallel pipes or a single larger pipe.

During ship unloading some of the vapour generated in the storage tank is returned to the ship's cargo tanks via the vapour return line and arm, in order to maintain a positive pressure in the ship. Due to the low pressure difference between the storage tank and the ship, vapour return blowers are sometimes needed. However, for full containment storage tanks where the design pressure is approximately 290 mbarg, enough pressure is often available to return vapour without using vapour return blowers.

It is customary to have three unloading arms for LNG and one arm for return vapour, but there is cost-saving potential in reducing the number of LNG arms to two if hydraulics permit and the ultimate unloading duration have some flexibility. Phased installation of arms could also be considered. Eliminating the vapour return to the ship is another cost savings measure that is worth exploring but has yet to be incorporated. New LNG ships could be designed to generate enough vapour to make up for liquid displacement, and strictly speaking would not need a vapour return line. LNG ships already include vaporizers to enable the cargo to be used as fuel when gas is less costly than Bunker C and this system could be extended to provide displacement gas. It would however be necessary to stipulate the use of customised ships that could be at a premium. The drawback of eliminating the vapour return line is that in the event the ship boil-off vapours build up to the point of venting before unloading begins; the vapours will exit via the ship vent and become a safety issue. With a vapour return line any excess ship boil-off is vented to the receiving terminal vapour handling system.

Article 178. Pump for liquefied gas

Article 178-1. Operation condition

1. Conventionally, high-pressure gas send out LNG compression is performed in two stages by an in-tank pump and pot-type one as shown in Fig-20. Ball bearings lubricated with LNG are installed in the LNG pumps. Since LNG has low viscosity, the ball bearings are easily damaged, and the service life is consequently very short. In order to eliminate the pot-type pump and to compress the process into one stage, a high head and large capacity in-tank pump was developed. Hydrostatic journal bearings are adopted for this pump to suppress wear of bearings and extend the maintenance cycle, thus substantially reducing construction costs and maintenance expenses. The of LNG pump are shown in Fig-21, 22, Photo-38 and 39.

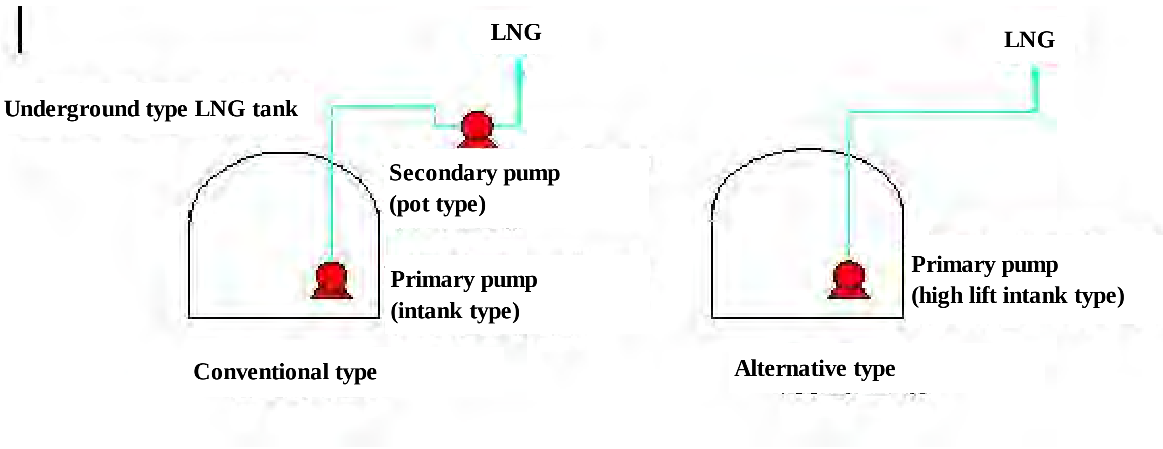


Fig- 20: Typical pumping system

http://www.netdecheck.com/emerging_technologies/LNG_PUMP/page1.htm

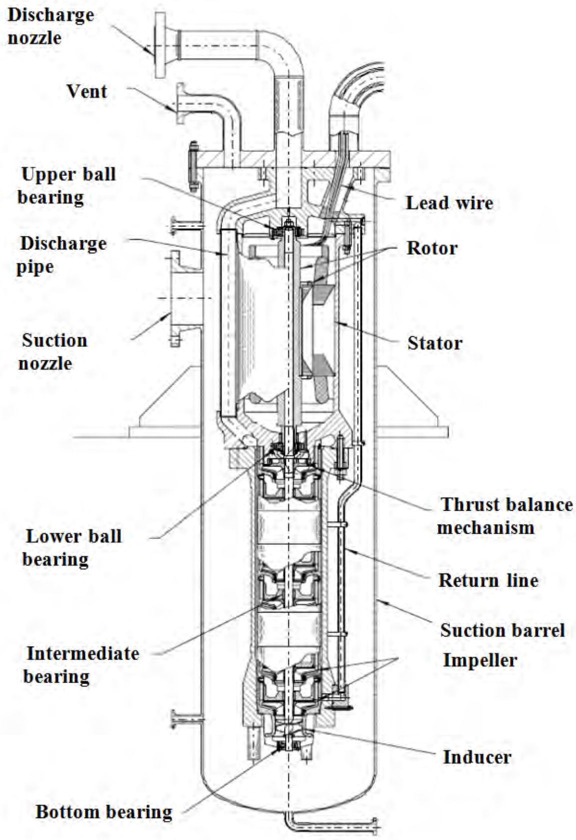


Fig- 21: LNG pump (pot type)

Reference: Ebara technical report No.213: Oct. /2006)

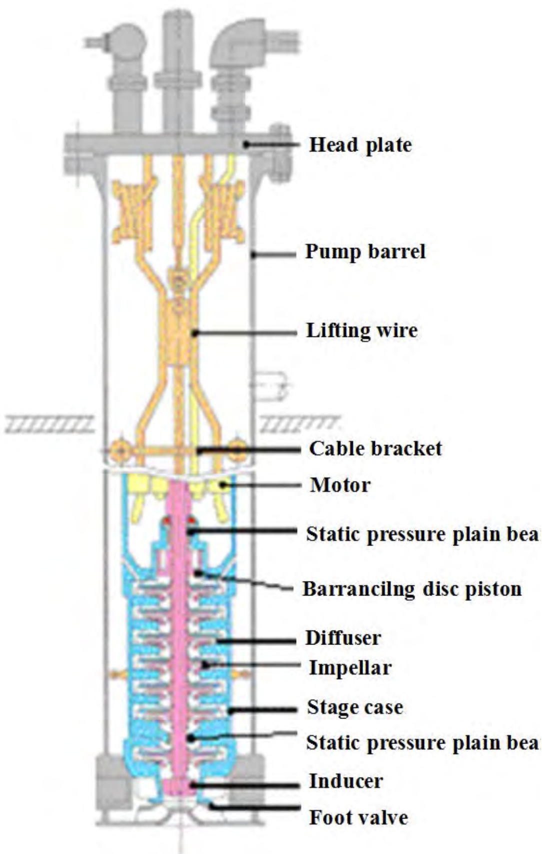


Fig- 22: LNG pump (intank type)

http://www.netdecheck.com/emerging_technologies/LNG_PUMP/page1.htm

Photo- 38: LNG pump (pot type)

http://www.lngglobal.com/lng-company-product-spotlight/ebara-international-cryogenic-performance-test-facility.html

Photo- 39: LNG pump (intank type)

http://www.lewa.com/main/en/4342/

Article 178-2. Heat effect

1. It is necessary to design in higher pressure than the saturated vapor pressure corresponding to the liquid temperature, since insufficient amount of cooling at sliding parts and lack of lubrication occur due to the fluid blockage in the flow path when the gasification of LNG in the pump.
2. The material for the part which generating high stress in the pump structure must be selected that corresponds to the low-temperature brittleness, since LNG have a around -160^{o}C. In addition, it is necessary to design a combination of materials and clearance in considering the expansion and construction resulting from temperature changes from room temperature up to low temperature.
3. The conducting paths of the motor winding are directly immersed in LNG and are cooled directly by liquid, since LNG liquid is non-conductive. In addition, the insulation material between wires must be material to withstand temperature cycling between room temperature and low temperature.

Article 178-3. Gas accumulation

1. The generated gas must be discharged to gas phase of LNG storage tank by vent pipe quickly.

Article 178-4. Discharge rate

1. LNG pumps for transportation is increasing its capacity with development of scale-up of LNG plant and has been also extended to 2,500m^3/h. It has become more important to optimizing of aluminum casing, analysis of the fluid and high-efficiency with the development of scale up of pump.

Article 178-5. Protection for moving part

1. The cold part or moving part of LNG pump must be protected by the thermal insulation or the protection guard as shown in Photo-40 and 41.

Photo- 40: LNG pump

http://www.khi.co.jp/kplant/business/infra/cold/base.html

Photo- 41: LPG pump

http://www.j-lpgas.gr.jp/genzai/environment.html

Article 178-6. Maintenanceability

1. Maintenance interval of LNG pump is highly depending on the state of deterioration such as wear of bearing parts which supporting rotation of pump. There are two types of bearings, one is using a static plane bearing and the other is ball bearing. It is required long term operation of LNG pump in order to reduce maintenance cost significantly and to improve safety by reducing the frequency of work under gas atmosphere that occurs when inserting or removing the pump from tank. It is necessary measures, since the short life of bearing caused by the ball sticking, cracking and flaking due to the excessive load under conditions of extremely poor self-lubricating fluid.

Article 178-7. Gas purge

Photo- 42: N^2rolley with vaporizer

http://www.tgc.jp/product/nitrogen.html

Photo- 43: Hot bath N^2 vaporizer

http://www.tgc.jp/product/nitrogen.html

1. It is necessary to purge the residual gas, when performing cleaning, inner inspection, airtight inspection and repair of the clued oil tank, LPG storage tank, LNG storage tank, LPG vessel, LNG vessel and the like. Generally, purging is performed by the special purpose tank truck for purging as shown in Photo-42 by means of vaporizing large amounts of the liquefied gas by the vaporizer such as Photo-42, 43.

Article 179. Blower for return gas

Article 179-1. Operation condition

1. A return gas blower (RGB) is one of various unloading facilities for receiving liquefied natural gas (LNG) from LNG tankers. As LNG is unloaded from an LNG tanker into a receiving tank, the tanker cargo tank pressure drops gradually. The purpose of the RGB is to return boil-off gas (BOG) from the receiving tank to the cargo tank, thereby maintaining a constant cargo tank pressure. BOG thus returned to the cargo tank is called "return gas". Fig-23 shows the concept of LNG unloading operation.

   Normally, BOG is returned under pressure by operating the RGB, to compensate for pressure loss in the return-gas piping. If the return-gas piping is short, with little pressure loss in the piping, BOG may be returned in free flow, using the differential pressure between the receiving tank and the cargo tank.

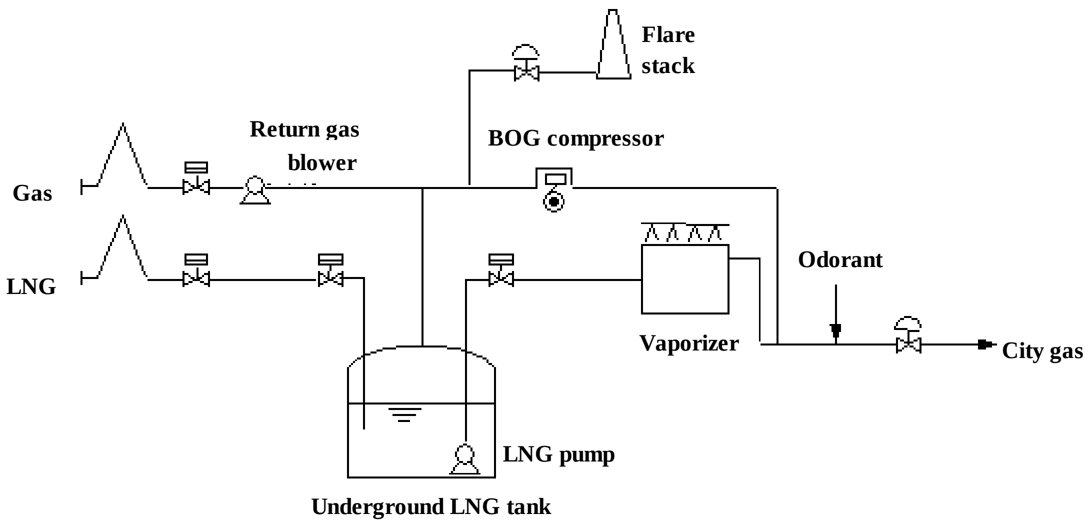


Fig- 23: Return gas blower

http://www.tokyo-gas.co.jp/techno/stp3/03a1_j.html

Article 179-2. Minimum flow operation

1. The return gas flow rate required to maintain a constant cargo tank pressure varies depending on the LNG tanker type, the cooling performance of the cargo tank, LNG temperature, season, cargo pump capacity, unloading rate, progress of unloading operation, etc. It is therefore necessary to control the return gas flow rate, which is conventionally controlled via damper (damper control). The following paragraphs describe this control method and the occurrence of surging.
2. Figs-22 and 23 show the flow and the concept, respectively, of damper control. In Fig-24, the horizontal axis represents the flow rate, the vertical axis the discharge pressure. RGB performance decreases as the flow rate increases. By contrast, the required RGB discharge pressure, which is the sum of the cargo tank pressure setting and the pressure loss in the return-gas piping from RGB to LNG tanker, increases with the flow rate. The point of intersection between the RGB performance

curve and the required discharge pressure curve is the RGB operating point.

Assuming that RGB is operated at point-1., if cargo tank pressure rises above the PIC setting, damper opening is throttled. Damper pressure loss ΔPV then increases, resulting in steeper required discharge pressure curve. As a result, RGB is operated at point-2., to decrease the flow rate. If required flow rate is still lower, damper opening is further throttled, so that RGB is operated at point-3., which is in the surging region. Surging is the phenomenon in which a turbo compressor, such as a return gas blower, vibrates and generates noise as the discharge flow rate and pressure fluctuates periodically in the low flow rate range. Since continued surging would cause mechanical damage to the blower, appropriate measures must be taken to prevent surging.

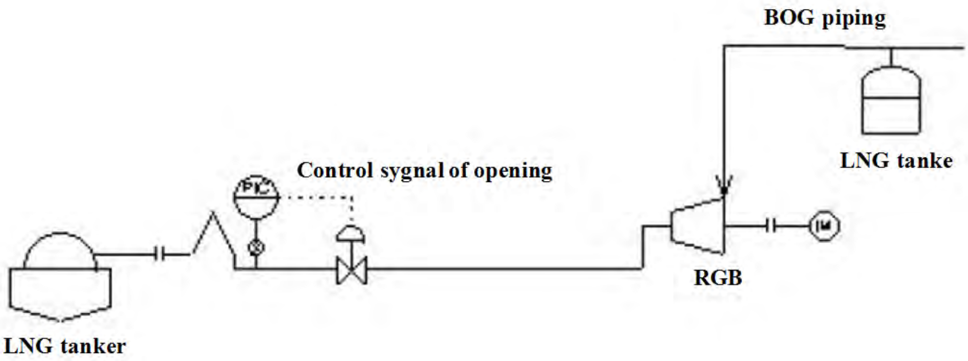


Fig- 24: Control flow diagram (damper control)

Reference: P-C.6-3 of “Speed control to prevent return gas blower surging” (Y.Kimoto: Osaga Gas)

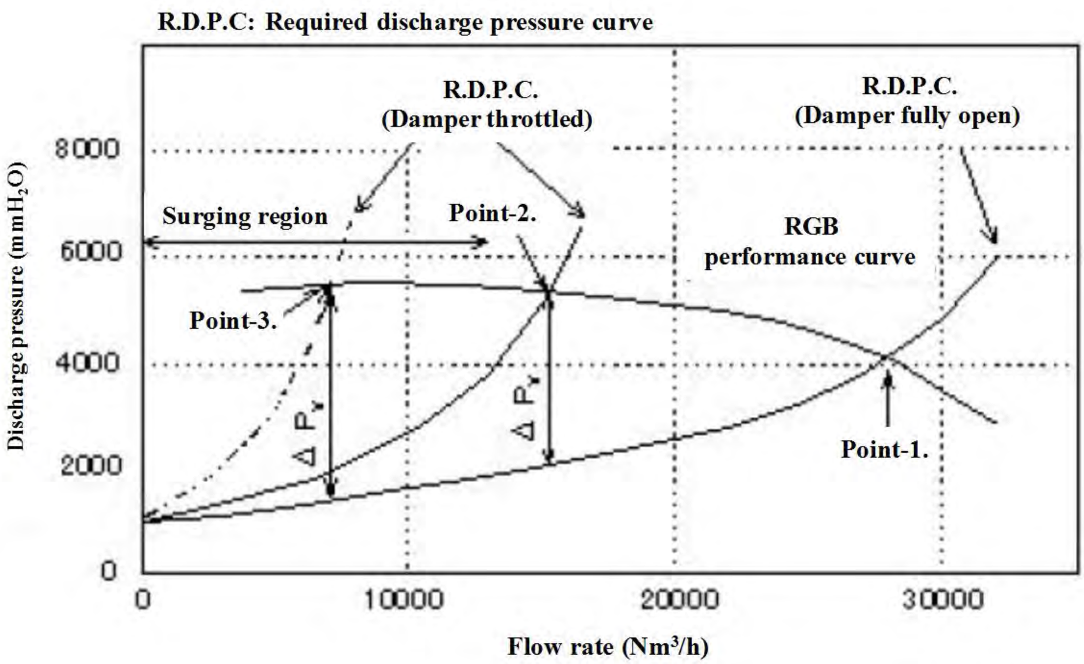


Fig- 25: Control concept (damper control)

Reference: P-C.6-3 of “Speed control to prevent return gas blower surging” (Y.Kimoto: Osaga Gas)

Article 179-3. Alarm system

1. See Article 197-2

Article 180. Compressor, blower

Article 180-1. Structure

1. Roll on process
   1) The BOG compressor is responsible for sending NG gas to supply system by means of boosting the boil-off gas (BOG) generated in the LNG tank in order to control LNG tank operation pressure constant.
2. Used materials and construction
   1) The horizontally opposite reciprocating compressor is often employed as the model of compressor. The construction of it is shown in Fig-26, Photo-44 and 45.
   2) Stainless cast iron and aluminum which has excellent low temperature toughness is used for the low temperature part in the compressor body.
3. Design and manufacturing
   1) The part which is not contacted with BOG such as the cylinder has the oilless structure that does not use lubricant, since inlet gas (BOG) is too low temperature.
   2) The piston ring, piston rod packing is used those which have sufficient sealability and excellent wear resistance. (operation time is more than 12,000 hours)

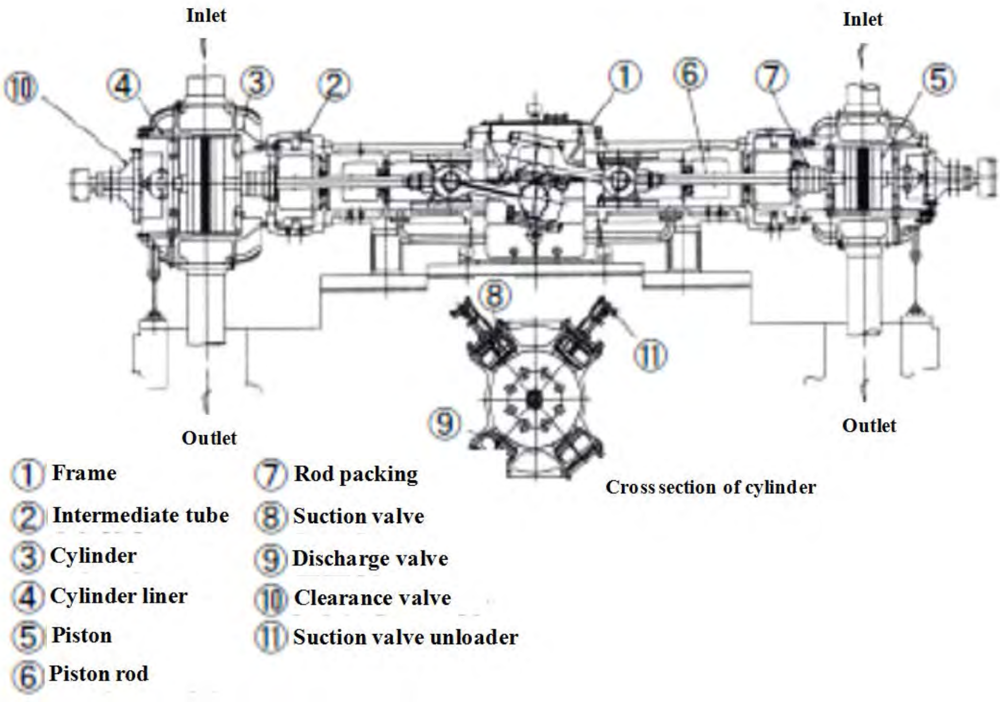


Fig- 26: Construction of BOG compressor

Reference: P-8 of "Concept for inspection of LNG receiving terminal facility" (High pressure Gas LNG Association: Jan. /2003)

Photo- 44: BOG compressor

http://blog.daum.net/krwelder/274

Photo- 45: BOG compressor

http://www.oitalng.co.jp/annai/kichi/bogkonpu.html

Article 180-2. Discharge rate

1. In LNG storage tank, ultra low temperature of -162℃ boil off gas (BOG) is continuously generated from LNG liquid level due to externally applying heat and fluctuations to that level. Thus, the storage tank internal pressure is increased by boil off gas continuous generated. To keep the tank pressure in designated value, boil off gas has to be pumped out from the storage tank. LNG Boil off Gas (BOG) compressor is operated to achieve the function of this purpose, suctions directly at low temperature and almost atmospheric pressure and pressurizes to require condition. Pressurized boil off gas by compressor discharges for re-condenser to return the storage tank, for boiler or gas turbine as fuel to generate electric power, for pipeline to send natural gas and other use.

Article 180-3. Protection for moving part

1. The moving part such as piston rod or motor coupling must be protected by protector so that the hands of people does not enter, though basically the piston and connecting rod is located in inner part.

Article 180-4. Maintenanceability

1. The reciprocating compressor is assembled with bolts tightened to a large number of each component. It often tends to be a long time for dis-assembling and assembling in maintenance compared with other type of compressor, since they have numbers of parts. The trend is even stronger in large compressor, since the main parts are big and the tightening force is increased greatly. For this reason, it is promoting efforts to improve maintenance in various parts.
2. For example, the hydraulic tightening method is employed to the parts such as the connection part piston rod with cross-rod, main bearing cap, bolt for big end of con-rod, and piston nut that large tightning torque is required, is secured proper tightning torque and workability have improved. This has led to the improvement of safety and reliability.

Article 180-5. Gas purge

1. It is necessary to purge the residual gas, when performing cleaning, inner inspection, airtight inspection and repair of the clued oil tank, LPG storage tank, LNG storage tank, LPG vessel, LNG vessel and the like. Generally, purging is performed by the special purpose tank truck for purging as shown in Photo-40 by means of vaporizing large amounts of the liquefied gas by the vaporizer such as Photo-40, 41.

Article 181. General provision of liquefied gas vaporization facility

Article 181-1. General provision

1. LNG terminal facilities have multiple parallel operating vaporizers with spares. Open Rack Vaporizers (ORV) as shown Fig-27, 28, Photo-46 are common worldwide and use seawater to heat and vaporize the LNG. Submerged Combustion Vaporizers (SCV) as shown in Fig-30 and Photo-48 use send-out gas as fuel for the combustion that provides vaporizing heat. Due to the high cost of the seawater system ORV installations tend to have a higher installed capital cost while the SCV installations have a higher operating cost because of the fuel charge. At many facilities an economic design can be achieved by using ORVs for the normal range of send out and SCVs as spares.
2. Other site factors also impact the decision of whether to use ORVs or SCVs. If the seawater temperature is below approximately 5°C, ORVs are usually not practical because of seawater freezing. At some sites it is not practical to separate the seawater discharge from the seawater inlet, and SCVs must be installed to avoid recirculation problems. Use of submerged combustion vaporizers leads to environmental concerns because of carbon dioxide and NOX emissions. The excess water produced as a result of the fuel combustion requires treating before discharge. In addition to ORVs and SCVs, shell and tube vaporizers as shown in Fig-29 and Photo-47 are now being considered for specific applications, particularly where an alternate source of heat is available such as from a power plant or ‘cold energy’ utilization process. And other air type as shown in Fig-31 and Photo49, or bath type as shown in Fig-32 and Photo-50 are applied depending on the site conditions.

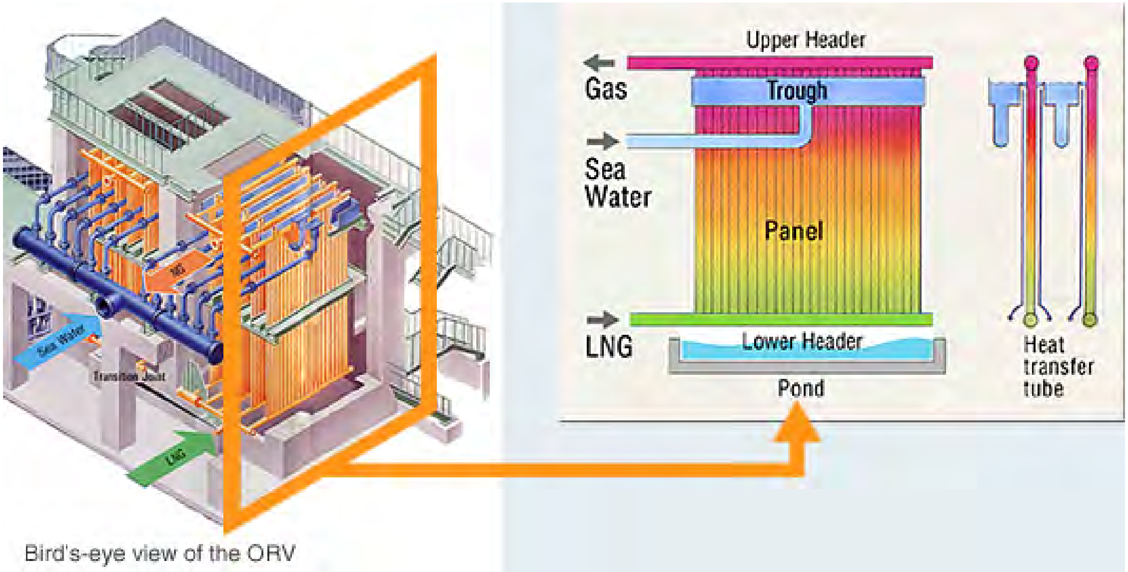


Fig- 27: Open rack vaporizer (ORV)

http://www.tokyo-gas.co.jp/lngtech/orv/index.html

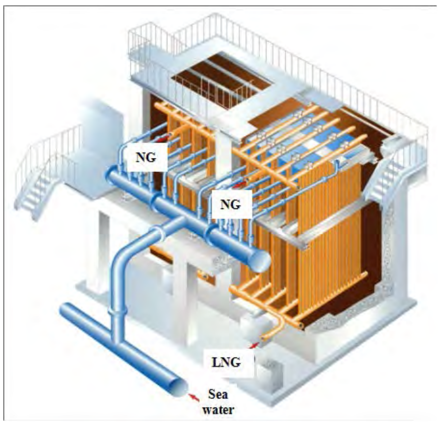


Fig- 28: Sea water type vaporizer

http://www.oitalng.co.jp/equipment/vaporizer.shtml

Photo- 46: Sea water type vaporizer

http://www.oitalng.co.jp/business/evapora_send.shtml

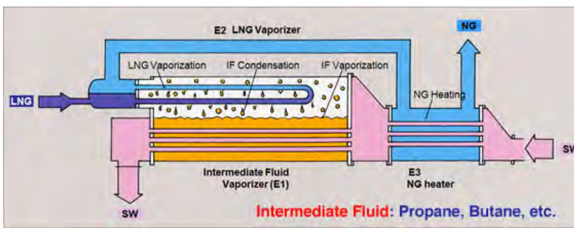


Fig- 29: Intermediate vaporizer

http://www.kobelco.co.jp/english/machinery/products/ecmachinery/lng/ifv.html

Photo- 47: Intermediate vaporizer

http://www.kobelco.co.jp/english/machinery/products/ecmachinery/lng/ifv.html

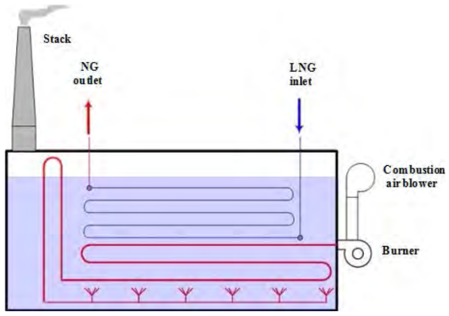


Fig- 30: Submerged combustion vaporizer

http://www.cryonorm.nl/submergedcombustionvaporiser.html

Photo- 48: Submerged combustion vaporizer

http://www.cryonorm.nl/submergedcombustionvaporiser.html

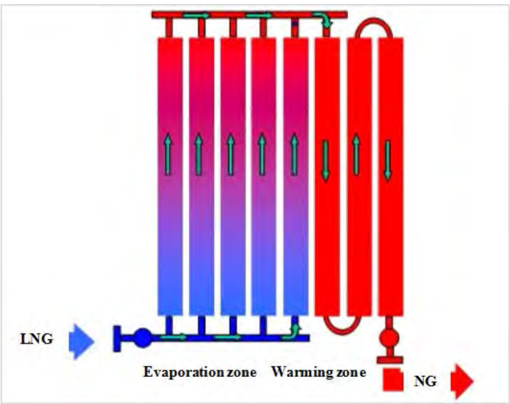


Fig- 31: Air type vaporizer

http://www.sdk.co.jp/news/2010/aanw_10_1255.html

Photo- 49: Air type vaporizer

http://doris-wu365.en.made-in-china.com/product/OeXmiQJxvHhY/China-Ambient-Air-Vaporizer.html

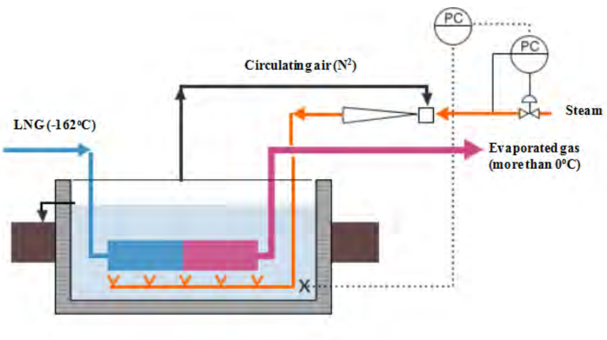


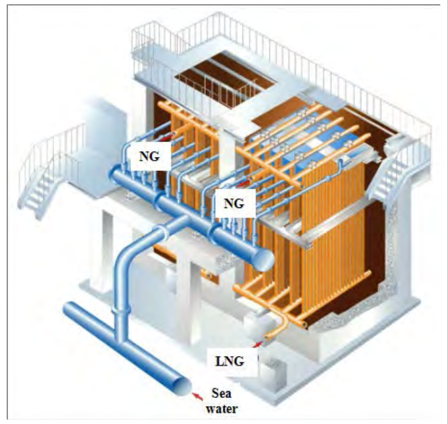
Fig- 32: Concrete bath type vaporizer

http://www.chiyoda-corp.com/technology/lng/steam.html

Photo- 50: Hot water type vaporizer

http://www.shinkoen-m.jp/product/plant/lng2.html

Table- 11: List for type of liquefied gas vaporizer

Type	Open rack vaporizer (ORV)	Intermediate fluid type vaporizer (IFV)	Submerged combustion vaporizer (SCV)	Air type vaporizer (AFV)	Hot type vaporizer (HWV)
Typical picture					
Heat source	Seawater, River water, Warm discharge water, etc.	Seawater, River water, Warm discharge water, etc.	Fuel gas	Atmospheric air	Hot water
Usage	Base load	Base load	Peak shaving, Emergency use	Satellite facility	Satellite facility, Emergency use
Capacity	Medium ~ Large	Medium ~ Large	Medium ~ Large	Small ~ Medium	Small ~ Medium
Feature	● LNG flows inside of panel, seawater flows on the outside of panel.	● LNG is vaporized by intermediate fluid, and then heated to specified temperature by seawater or hot water.	● Pressure drop is higher than other type vaporizer.	●LNG is vaporized by natural convected or forced drafted air. ● Defog system is available (option).	● LNG is vaporized by hot water supplied from other system. ● Easy maintenance
Operation	● LNG flow is controlled by discharge demand. ● Simple operation	●LNG flow is controlled by discharge demand. ● In case of overhaul maintenance, intermediate fluid has to be removed and filling.	● LNG flow and fuel gas for burner are controlled by discharge demand.	● LNG flow is controlled by discharge demand. ● Simplest operation ● Defrost operation is required.	● Compact size for small capacity vaporizer
Maintenance	● Visual inspection and cleaning for seawater distribution system ● Inspection for thermal sprayed coating on panel	● Visual inspection and cleaning for inner side of shell	● Inspection for blower working ● Inspection for control system of fuel	● Inspection for fan (applied for forced draft type)	● Inspection and cleaning for heating medium path
Cost	● Construction cost: High ● Running cost: Low	● Construction cost: High ● Running cost: Low	● Construction cost: Low ● Running cost: High	● Construction cost: Low ● Running cost: Low	● Construction cost: Low ● Running cost: High
Main material	Aluminum alloy	Austenite stainless steel, Titanium alloy	Austenite stainless steel	Aluminum alloy	Austenite stainless steel

Article 182. Off limit, etc. to liquefied gas vaporization facility

Article 182-1. Off limit

1. "Appropriate measures" stipulated in design technical regulation Article 182-1 means the measure to provide the fence, wall, barbed wire, hedge (hereinafter referred to "fence, etc.") and display the warning board which prohibit to close the gas facility in the gas production or supply facility in the gas factory premises. However, if the sea, rivers, lakes, cliffs, etc. has become a boundary, it is deemed appropriate measures have been taken.
2. "Appropriate measures" stipulated in design technical regulation Article 182-1 means those which pursuant to following items;

(1) In case of the large capacity mobile gas generation facility, it means to provide fence and indication to prohibit close to the equipment.
(2) In case of mobile gas generation facility (excluding the large capacity mobile gas generation facility), it means to provide fence. In addition, if it is installed in the place where a person other than the user does not enter without good reason and is installed the cover which nobody can operate without approval, it is deemed the fence, and etc. has been installed.
(3) In case of pressure regulator, it means the either measures listed below;

    1) Measures to install pressure regulator in the room (including box, etc.).
    2) Measures to install pressure regulator in underground manhole and pit.
    3) Measures to install fence, etc. around pressure regulator.
    4) Measures to install pressure regulator in the height where the public can not manipulated without good reason.
    5) Measures to install pressure regulator having structure which the public can not operate without good reason.

Article 183. Security communication facility for liquefied gas vaporization facility

Article 183-1. Security communication equipment

1. "Appropriate communication equipment" stipulated in design technical regulation Article 183-1 means equipments which is capable to communicate between the workplace to manage gas production, supply or pipeline, or between control centers if there is a control center to give appropriate instructions to determine the status of these facilities to each other between control center and through the control center, and refers to any of the followings;

(1) Subscriber telephone equipment (refers to the communication equipment to set up a communication line between the equipment and the subscriber location specified by the exchange).
(2) Dedicated telephone facilities (refers to the communication equipment using the communication line

to be established in the specified interval).

(3) Wireless telephone communication facility (refers to the communication equipment to send or receive audio, etc. using radio waves).

Article 184. Off-set distance for liquefied gas vaporization facility

Article 184-1. Security distance

1. “Distance for security” stipulated in design technical regulation Article 184-1 means the distance pursuant as follows:

(1) The value either of greater than or equal to 1m or one-half of the maximum diameter of storage tank (underground storage tank (those which is the maximum liquid level in that storage tank locate below the end face and buried part is contacted with the surrounding ground)) in case of the distance between the outer surface of liquefied storage tank and the outer surface of other storage tank, and the value of greater than or equal to one-fourth of the diameter, in case of the underground low pressure storage tank which maximum operation pressure is low. However, if the water sprays equipment or equipment for fire protection and firefighting having effective capacity equal to or greater than them is provided for the storage tank, this must not applied.

(2) 1m, in case of the distance between the outer surfaces of tank that is buried underground all and the outer surfaces of other tank that is buried underground all.

(3) The value either of greater than or equal to 1m or one-fourth of the maximum diameter of the gasholder, in case of the distance between the outside surface of a gasholder and the outer surface of other gasholder.

(4) The value either of greater than or equal to one-half of the maximum diameter of the storage tank or one-fourth of he maximum diameter of the gasholder, incase of the distance between the outer surface of storage tank and the outer surface of gasholder.

Article 185. Security compartment for liquefied gas vaporization facility

Article 185-1. Sedulity compartment

1. “Necessary safety distance” stipulated in design technical regulation Article 185-1 must be as follows;

(1) The area of security compartment must be less than or equal to 20,000m^2.

(2) The sum of heating combustion value of the gas facility that passing through high pressure gas or liquefied gas in the security compartment must be less than or equal to 6.0×108.

2. The calculation method of the area of the security compartment must be as follows;

(1) The area of security compartment must be sum of the area (1) and (2).

(2) The security compartment stipulated in paragraph-(1) must be the area surrounded by passage more than 5m or a border of the factory and compartment for gas facility (except storage tank and its ancillary equipment), and is surrounded by a polygon so that they don't have signed all the interior angle s is greater than 180 degrees horizontal projection surface bounding line of gas facility.

3. Width of passage stipulated in above item-(2) must be measured by the following standard;

(1) The width must be measured as a base curb, gutter, etc., if passage has been clearly demarcated by curb, gutter, and etc.

(2) If the boundaries of the passage are not clear, it must be measured with the boundary line of passage and pulse the width of 1m to the outer edge of the horizontal projection surface of the gas facility in the security compartment.

(3) "The distance necessary for safety" means at least 30meters against the high pressure gas facility in the security compartment adjacent to the security compartment.

Article 186. Firefighting facility for liquefied gas vaporization facility

Article 186-1. Firefighting facility

1. "Appropriate firefighting facility for the gas generation and supply facility shall be installed in proper location" stipulated in design technical regulation Article 186-1 means those which is installed pursuant to following items;

(1) The firefighting facility for the large scale gas facility.

1) The fire protection equipment must be provided for the gas facility listed in a. must be installed pursuant from 2) to 6).

a. Fire protection equipment must be provided to the followings as listed (a) to (d) (except those are dangerous due to watering sprinkling , since the inner surface is touching water or steam and has high temperature surface).

(a) Gas generation facility

(b) Gas purification facility

(c) Vessel belonging to the ancillary facility (excluding those belonging to the liquefied gas storage tank)

(d) Loading arm which is used for unloading of flammable liquefied tanker with 2,5000 gross tons and more

2) The gas facility from (a) to (d) of a. and those passing through high, medium gas or liquefied gas with maximum operation pressure must be provided following fire protection facility;

a. The facility that has been installed in the height more than 20 m above ground (including equipment that has been installed in more than 20 m) and containing liquefied gas (excluding those which can isolate by remote shutoff device and transport immediately liquefied gas retaining in the facility) must be installed sprinkle equipment and water hydrant or water cannon must be installed in two or more places within the 40m from outer surface of such facility.

b. The facility other than 2)-a. must be provided sprinkle equipment and water hydrant or water cannon must be installed in two or more places within the 40m from outer surface of such facility. In addition, fixed water cannon can be regards as a water cannon or fixed fire hydrant water facility or such fire hydrant water facility that is placed in the center of a circle of 40meter radius to encompass equipment involved in the provision of 2)-a and b.

3) The fire protection facility for the gas facility stipulated in a.-(a) to (d) and passing through low pressure gas must be installed fire water hydrant for each 75m walking distance around the target partition.

4) The water curtain facility that has a sufficient capacity in the vicinity of a.-(d) must be installed.

5) The fire protection facility must have following performance depending on its type.

a. In principle, the sprinkle facility or spray equipment must be fixed for every single facility. However, it can be regarded as consolidated watering facility depending on the placement of equipments and configuration, etc. Location to sprinkle must be made from the top of the equipment in principle, and it must be placed so as to allow watering of more than 5 liters per minute per unit area of the facility (one square meter). However, the facility which is covered by rock wool with more than 25mm or the material which has equivalent strength or fire resistance may be the amount of watering in 2.5 liter per minute. In addition, if such facility exceeds 5meters in height above ground (10m in case of a large scale gas generation facility) can be said that the surface area when cut into in the horizontal place of the 5m interval (10m in case of a large scale gas generation facility) so as to maximize the surface area. Also, measures such as installing a sprinkler pipe or auxiliary water spray header must be taken even if insufficient in installing spray pipe on the top or in case in appropriate method for the object.

b. The fixed deck gun must be installed fixed target, have water pressure at least 0.34MPa at water cannon and have water flow at least 400 liters per minute.

c. The water hydrant must have hose, water cannon, handle and the like and have water pressure at least 0.34MPa at the tip of water cannon and have water flow at least 400 liters per minute.

6) The supply facility of fire protection water must be pursuant following standard;

a. Sufficient amount of water that can be supplied continuously for at least 30 minutes watering must be retained in consideration such placement of equipment in gas production plant and the area take them valid and appropriate fire prevention activity in the plant, and require large amounts of water for fire protection.
b. The supply valve and operation valve for fire protection water supply facility must be installed in the safety position and be operated remotely depending on the situation of the facility.

2) The firefighting equipment which is stipulated for each must be provided for following gas facilities listed in from a. to c.
a. At least one or more powder fire extinguisher with B-10 unit capacity per 10 tons of flammable gas held inside each group of target equipment such as the gas generation facility, gas purification facility, blower, compressor and ancillary vessel (excluding those belonging to the liquefied gas). In this case, the minimum quantity is 3 for high pressure and 2 for other than high pressure.
b. At least three powder fire extinguishers with B-10 unit capacity must be provided for the gasholder with maximum operation pressure high. At least 2 powder fire extinguishers with B-10 unit capacity must be provided for the gasholder with maximum operation pressure medium.
c. The gas facility which liquefied gas is passing through as listed below must be pursuant to following provisions;
   (a) The numbers of lower column of the Table-12 powder fire extinguishers with B-10 unit capacity must be provided to storage tank depending on the classification of storage capacity listed in the upper column of the table for each storage tank. In addition, 2 or more fire extinguishers with B-10 unit capacity must be installed for 50meters walking distance around the protective dikes in case the storage capacity of 1,000tons.

Table- 12: Required numbers of fire extinguisher depending on storage capacity

Storage capacity	100 ton or less	100 ton and more
Number of powder fire-extinguisher	3	4

Reference: Article 5 of guideline for gas facility Japan

   (b) At least 3 or more powder fire extinguishers with B-10 unit capacity must be provided for each group of the liquefied gas pump.

(c) At least 3 or more powder extinguishers with B-10 unit capacity must be provided for each group of the liquefied gas vaporizers which generate gas from liquefied gas.

(d) At least 3 or more powder fire extinguishers with B-10 unit capacity must be provided in the vicinity of the liquefied gas handling facility in the place where incoming and outgoing by tank lorry.

(e) The number of powder fire extinguisher installed for two or more from (a) (limited to those which has not dikes) to (d) can be equivalent to the value obtained by dividing the site area including storage facility by 50 square meter (round up), notwithstanding the provisions of from (a) to (d). In case of this, the minimum number of required fire extinguisher must be 3. In addition, in case of 100 tons storage tank, the required minimum number must be 4.

(f) The equipment which can release 2 tons and more of dry chemical must be installed in the vicinity of the loading arms that are used for loading and unloading of flammable liquefied gas tanker of 25,000 gross tons and more on berth.

(g) At least 2 or more powder fire extinguishers with B-10 unit capacity must be provided in the vicinity of the liquefied gas facility in the place where fire is used.

(2) The firefighting equipment for large scale gas facility must be pursuant as follows;

1) In case of bulk storage tank, the following facility must be provided.

a. In case the storage capacity of less than 3 tons.

2 or more if storage capacity is less than 2 tons, 3 or more if storage capacity is more than 2 tons, powder fire extinguishers must be provided in the safety place around them.

b. In case the storage capacity of 3 tons and more.

(a) 3 or more powder fire extinguishers with B-10 unit capacity must be provided in the safety place around them.

(b) Following fire protection equipment (sprinkler or water hydrant) must be provided.

a) Sprinkle equipment can be watering the amount of water which is more than 5 liters per minute per square meter of surface area of bulk storage tanks.

b) The water hydrant must be capable to discharge from two or more directions and to discharge either amount of water greater than equal to 1.6 times the capacity of sprinkle equipment or 350 liters per minute.

c) The facility for water supply to fire-proof must be connected to the water source that can intake continuously for at least 30minutes fire fighting and the place to operate facility such as valves must be more than 15 m away and in a safe place. However, if the shielding device and safe for fire is expected around the storage tank, this must not applied.

2) The following equipments must be provided for the storage tank.

a. At least three fire extinguishers which have unit capacity more than B-10 must be provided in a safe surrounding place.

b. The following fire protection equipments (sprinkler or water hydrant) must be installed.

(a) The sprinkler equipment can be watering the amount of water at least 5 liters per minute per square meter of surface area of storage tank.

(b) The water hydrant must be either those which can be discharging from two or more direction or discharge at least 1.6 times of sprinkler capacity or 350 liters per minute.

(c) The facility for water supply to fire-proof must be connected to the water source that can intake continuously for at least 30minutes fire fighting and the place to operate facility such as valves must be more than 15 m away and in a safe place. However, if the shielding device and safe for fire is expected around the storage tank, this must not applied.

c. The equipment for incoming and outgoing of liquefied petroleum gas must be provided at least 2 powder extinguishers with B-10 unit capacity in the vicinity of parking area of tank lorry.

3) In case of high gas pressure, following facility must be provided;

a. In case the storage capacity of less than 3 tons.
Fire extinguisher with B-10 unit capacity of at least numbers obtained by dividing area of container yard by 50 square meters must be provided. In addition, fire extinguisher must be placed in the position where the work does not interfere to bring in or carry-out containers in principle.

b. In case the storage capacity of 3 tons and more.

(a) Firefighting equipment stipulated in a. must be provided.

(b) Fire protection equipment for storage tank stipulated in 2) must be provided. However, if the wall of the container yard has fireproof performance, it must be deemed to be fire protection wall.

2. “Appropriate fire protection and firefighting equipment” related to the large capacity movable gas generation facility means one or more powder fire extinguisher with B-10 unit capacity.

Article 187. Prevention of gas accumulation of liquefied gas vaporization facility

Article 187-1. Indoor gas accumulation

1. “Structure that avoids the accumulation ” stipulated in design technical regulation Article 187-1 means those conformed to follows;

(1) Those of one of the following structure considering the nature of gas, volume of processing or

storage, characteristics or size of room, etc.

1) The structure with an operation of at least two directions with sufficient area for ventilation.
2) The structure which is capable to ventilate effectively and mechanically.
3) In case of the liquefied gas storage tank which all are buried underground in the chamber of reinforced concrete, those which is filled with dry sand around them.

2. “Suitable place where gas may be possible to accumulate in the gas manufacturing works” stipulated in design technical regulation the Article 187-2 means the place where it is considered the circumstances surrounding placement of equipment, properties of gas, draft, ventilation and the like.

Article 187-2. Leakage detector and alarm device

1. “Appropriate detection and alarm equipment to detect gas leakage shall be provided” stipulated in design technical regulation Article 187-2 means those which can be ensure security measures equivalent to the odorization.

Article 188. Explosion-proof structure of electric facility for liquefied gas vaporization facility

Article 188-1. Explosion-proof electric facility

1. “Shall be of an explosion-proof type design depending on the conditions of place and the kind of gas or liquefied gas” stipulated in design technical regulation Article 188 means those which is installed according to the standard relating to explosion-proof electrical equipment prescribed in the Occupational Safety Health Act and the Electricity Business Act, considering the selection of wiring methods and selection of electrical equipment with explosion-proof structure according to the dangerous area classified depending on the explosion danger and type of flammable gas.

Article 189. Distance from flammable facility of liquefied gas vaporization facility

Article 189-1. Distance from flammable facility

1. “Sufficient distance” stipulated in design technical regulation Article 189-1 means 8m and more from such gas generation facility to the equipment handling fire. However, it may be the distance as prescribed as follows; either of the following measures is taken in order to prevent leaked gas flowing to the equipment handling a fire between such gas facility and the equipment handling a fire.

(1) Equipment must be placed at least 8m in horizontal distance detour, when providing barrier with sufficient height between equipment and a fire.
(2) It can be at least 0m when installing gas leak detection and alarm device adjacent to the equipment handling the fire, when detecting a gas leak and when measures are taken immediately to be able to

extinguish the fire by interlocking equipment.

2. “The equipment handling a fire” above mentioned means boiler, furnaces, incinerators, smoking room and the like that is usually placed stationally.

Article 190. Static electric removal for liquefied gas vaporization facility

Article 190-1. Static electricity removal

1. “Measures to eliminate static electricity” stipulated in design technical regulation Article 190 means followings;

(1) Grounding resistance value must be less than or equal to 100Ω.

(2) Static electricity must be removed to ensure due to direct contact with the ground before installing the vessel in case of vessel for the specific gas generation facility or the mobile gas generation facility.

Article 191. Gas displacement of liquefied gas vaporization facility

Article 191-1. Gas displacement

1. Airtight test, open inspection of large storage tank, underground storage tank and piping is performed by filling with an inert gas as shown in Fig-23.

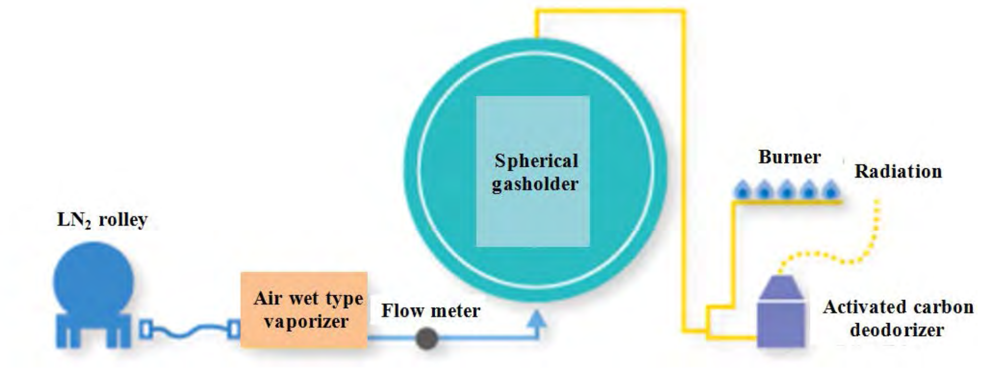


Fig- 33: Gas displacement of gasholder

http://www.tgc.jp/product/nitrogen.html

Generally, the nitrogen gas is used for displacement and there is other way to use carbon dioxide gas. When propane gas is contained in, there is advantage such as cheaper cost of gas or work compared with the nitrogen gas, reliable purge compared with the nitrogen gas, since the carbon dioxide that has same molecular weight 44 is heavier than natural gas.

Article 191-2. Vent-stack

1. "Appropriate measures" stipulated in design technical regulation Article 191-2 means the installation of vent-stack taking into account the installation of valves that is capable to control the height, position or diffusion depending on the surroundings, etc.
2. During upset, extreme turndown or emergency conditions, vapors may be generated within the terminal that exceeds the capacity of the recondenser and pipeline compressor (if it is included). If this occurs the vapor is vented to the atmosphere through an elevated vent stack or a flare for safe disposal as shown Fig-34, Photo-51 and 52. The preferred method of disposal is generally to flare the gas. Venting is feasible but it requires special consideration. Although it may be preferred because it is less visible to local residents the vent still has to be designed for accidental ignition by lightning so does not reduce the sterile area requirement and deletion of the ignition system is not a significant cost advantage.
3. Dispersion of cold gases from a vent is more problematic than flaring - flared gases will always rise. Cold methane could slump after discharge from a vent and linger at grade above the LFL. Heating could be considered but quick response could be difficult. The global warming potential of methane is ~21 times that of CO^2 - so each methane molecule would be 21 times better burnt than just vented. The tank vapor system is manifold and a pressure control valve sends vapor to the vent or flare stack before the storage tank safety valves open. The storage tanks themselves are equipped with relief valves as the last line of defense against overpressure. Vacuum breakers are also provided to protect against external overpressure.

Photo- 51: Flaire stack pilot burner

http://www.flares-stacks.com/combustion_process_equipment_company_blog/2011/11

Photo- 52: Flaire stack

http://jp.123rf.com/photo_8179285_sphere-and-flare-stacks.html

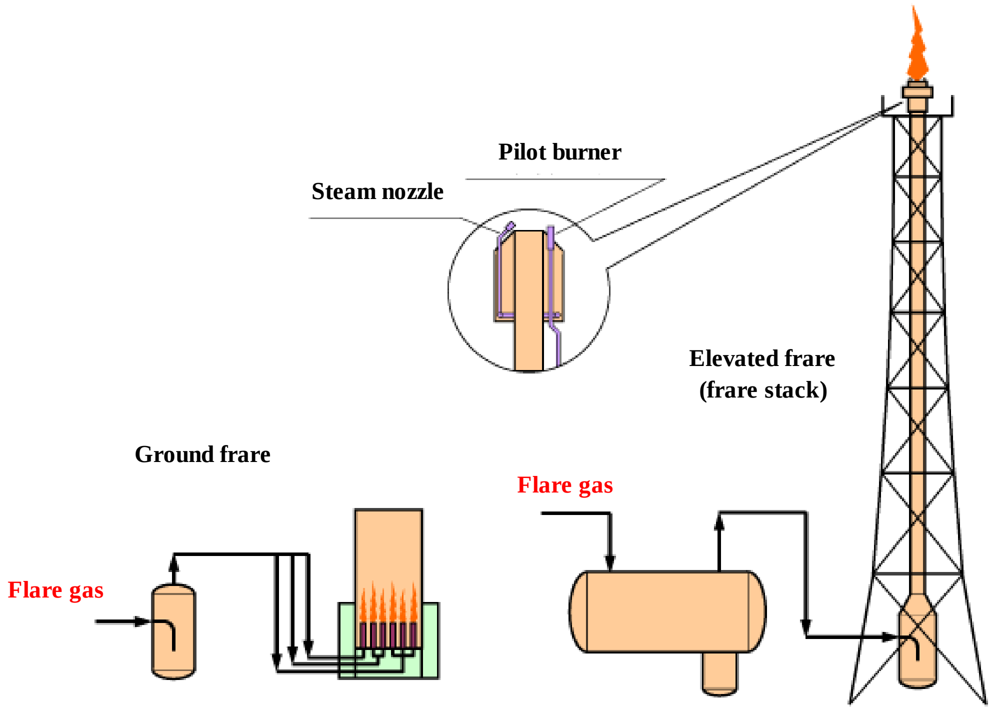


Fig- 34: Basic flow of elevated flare and ground flare

http://www.shinkoen-m.jp/product/plant/flare1.html

Article 191-3. Heat radiation from friar-stack

1. "Keep from damaging its surroundings due to heat radiation and to be able to release gas safely" stipulated in design technical regulation Article 191-3 must be pursuant as follows;

(1) The material must withstand the generated heat on that flarestack.
(2) Its height and location must not give failure to surroundings from the radiation heat generated on the flarestack.
(3) The flair stack must be taken measures to prevent explosions.

Article 192. Material of liquefied gas vaporization facility

Article 192-1. Material

1. "Shall have stable mechanical properties depending on the system and size against chemical and physical impacts on the materials at maximum and minimum operation temperatures" stipulated in design technical regulation Article 192-1 means the material for gas generation facility or gas storage facility pursuant to Article 157-1, Article-166-1.

Article 193. Structure of liquefied gas vaporization facility

Article 193-1. Direct fire

1. "Structure which can be heated by direct fire" stipulated in design technical regulation Article

193-1 means as follows;

(1) Those having the construction to heating the part where gas or liquefied gas passing through by naked flame.

(2) Those which heat the part where gas or liquefied gas passing through by contacting heating element (including the heat transfer part) or heat by radiant heat of heating element, and those which surface temperature of such heating element is equal or greater than ignition temperature of gas or liquefied gas.

Article 193-2. Thermal expansion

1. In case of the ORV method, the panels are jointed (blocking) through the manifold and is hanging from the top frame which is passed between concrete structure at the installation site. Also, the sliding type support is installed at the bottom of block to absorb thermal expansion and contraction.

Article 193-3. Heat exchanger tube

1. In case of AFV method, the stress occurs repeatedly in the welding part of header with tube due to changes in flow rate of LNG to each header and the generated stress is reduced by providing appropriate support for rigidity between the heat exchanger tubes.

Article 193-4. Sea water part

1. In case of ORV method, the panel made of aluminum alloy is protected the base metal from seawater having a sacrificial anode effect by spraying the surface of aluminum-zinc alloy metal.
2. In case of IFV method, when use seawater as a heating medium, titanium alloy for tube material and lining material for shell material are used, since it is necessary to protect heat exchanger tube from corrosion.

Article 193-5. Freezing

1. This will not be applied when installing in a location other than the cold area.
2. “Prevent freezing” stipulated in design technical regulation Article 193-5 means the measures to provide cover on the hot water part, to heat and to use antifreeze.

Article 193-6. Leakage of liquefied gas

1. “To prevent leakage of liquefied gas” stipulated in design technical regulation Article 193-6 means that conform to follows;

(1) There is no danger of flowing out of liquefied gas in the state of liquid structurally.

(2) The facility which prevents flowing out of liquefied gas in the state of liquid.

Article 194. Welding parts of liquefied gas vaporization facility

Article 194-1. Liquid gas part

1. See Article 159-2.

Article 194-2. Liquid gas and gas part

1. See Article 159-3.

Article 194-3. Appropriate welding standard

1. Welding of liquefied gas piping, pipeline and storage tank must be performed according to reliable and proven welding standard.
2. The typical international welding standard are summarized and detailed in the guideline "Welding" edition.

Article 195. Safety valve for liquefied gas vaporization facility

Article 195-1. Safety valve

1. "Appropriate safety valve" stipulated in design technical regulation Article 195-1 must be the spring type safety valve or the safety valve with pilot valve and installed conforming to following items. (excluding for gasholder)

(1) The safety valve must be provided to each facility. However, in case of continuous facility, if there is no shutoff device (excluding the shutoff device which is applied measures to prevent fail operation) and if there is no danger of over-pressure is caused, it may be provided in one place when installing in a low pressure side of the maximum operation pressure.

(2) When providing a safety valve, the valve must be of the vertical axis.

(3) The total capacity of the safety valve blow-off must be pursuant to following 1) or 2.

1) In case of gas facility other than the one which liquefied gas passing through, it must be greater or equal to the gas supplied to gas equipment which providing the safety valve or the maximum amount of gas generated in the gas facility.

2) In case of gas facility the one which liquefied gas passing through, it must be greater or equal to the maximum amount of gas generated in the gas facility, and must be the amount of liquefied gas volume that is calculated by the formula a. and b. (it must be the amount of liquefied gas to be retained in the gas facility, if the amount of calculated gas exceeds the amount to be retained in the gas facility)

a) If insulation measures have been taken (limited to those which can be withstood more than 30 minutes against frame of fire and the impact due to the fire-extinguishing equipment.);

$$t = \frac{9400 \times \lambda \times (650 - t) \times A^{0.82}}{\delta \times L} + \frac{H}{L}$$

b) In other case;

$$t = \frac{2.56 \times 10^8 \times A^{0.82} \times F + H}{L}$$

Where

W	: blow-out amount per hour	(kg/h)
A	: external surface in case of the liquefied gas storage tank, value obtained by multiplying the outside surface area of vessel with the percentage of the liquefied gas volume in the container in case of other vessel	(m^2)
L	: latent heat of vaporization in determining the pressure for the blow-out amount	(J/kg)
λ	: thermal conductivity of insulating material at room temperature	(W/m°C)
t	: gas temperature in determining the pressure for the blow-out amount	(°C)
F	: 0.6 (if providing water spray equipment to spray water in more than 7ℓ/min/m^2 to for entire surface or sprinkler system to sprinkle in more than 10 ℓ/min/m^2) 0.3 (if burring underground) 1.0 (in other cases) 0.8 (9n case of bulk storage tank)	—
δ	: thickness of insulation material	(m)
H	: a collection factor depending on the direct sunlight and heat input from other sources of heat and obtained by the following formula set forth in a) and b) respectively	—

c) Direct sunshine

For equation listed in a. $H = \frac{3600 \times \lambda \times (650 - t) \times A_1}{\delta}$

For equation listed in b. $H = 4190 \times 10 \times (65 - t) \times A_1$

d) In other heat source $H = Q \times A_2$

- Q : heat input $(J/h/m^2)$
- A_1 : area subjected to sunlight (m^2)
- A_2 : area subjected to heat (m^2)

(4) The nominal blowing amount calculated according to (if the compressibility factor is unknown, Z=1.0) is “3: nominal blowing amount for gas” of “calculation method of the nominal amount of blowing for safety valve in annex” of JIS B8210-1994 “Spring safety valve for steam and gas” must be greater than equal to the blowing capacity that prescribed in the preceding item.

(5) The safety valve must be set to operate as listed below;

1) In case of one safety valve, it must be set to operate at a pressure of less than the maximum operation pressure in such location. However, if there is a pressure relief valve operating at less than the maximum operation pressure of gas facility or device that automatically stops the flow of gas; it must be a pressure of less than 1.03 times the maximum operation pressure of such location.

2) In case of 2 and more safety valves, one is set in the pressure provisions above 1) and the other must be set to operate at a pressure of less than 1.03 times the maximum operation pressure in such location.

(6) The pressure to determine blowing amount of safety valve must be as follow;

1) In case of those for high and medium pressure gas facility, it must be 1.1 times or less of maximum operation pressure.

2) In case of those which liquefied gas passing through, it must be 1.2 times or less of maximum operation pressure.

(7) The safety valve must not exceed the pressure that have been prescribed in the preceding item in the state have been a discharge

(8) The safety valve must be pursuant to “5: structure” and “8: material” of JIS B8210 “spring safety valve for steam and gas”.

Article 196. Instruments device, etc. for liquefied gas vaporization facility

Article 196-1. Instrument device

1. “Appropriate instrumentation equipment to measure and check” stipulated in design technical regulation Article 196-1 means those which is capable to measure and confirm following items;

(1) Those which is capable to measure the following matters, with regard to the gas generation facility which the maximum operation pressure is low.

1) Flow rate and pressure, in case of those which the raw material is petroleum, liquefied petroleum gas or natural gas.
2) Air flow or pressure, in case of burning a part of raw material with air into furnace.
3) Flow rate and pressure (outlet temperature, with regard to those having steam saturation tower), in case of those which use steam.
4) Furnace pressure and outlet temperature of reactor or furnace, in case those which has reactor.
5) Pressure, in case of those which use fluid to operate the autopilot.

(2) Those which is capable to measure the following matters, with regard to the gas generation facility which the maximum operation pressure is high or medium.

1) Flow rate and pressure, in case of those which the raw material is petroleum, liquefied petroleum gas or natural gas.
2) Flow rate and pressure, in case of those which use steam to generate gas.
3) Inlet and outlet temperature, and inlet and outlet pressure of reactor.
4) Flow rate and pressure of fuel, in case of the external type thermal reactor.
5) Liquid surface, in case of condensed water separator which have construction to discharge water by hand.
6) Pressure, in case of those which use fluid to operate the autopilot.

(3) Those which is capable to measure the stored gas capacity, with regard to the gasholder which maximum operating pressure is low.
(4) Those which are capable to measure the stored gas pressure, with regard to the gasholder which maximum operating pressure is middle and high.
(5) Following matters, with regard to the blower and compressor.

1) Those which are capable to measure outlet gas temperature.
2) Those which are capable to measure inlet and discharge gas pressure of compressor.
3) Those which are capable to measure temperature and pressure of lubricant, in case of those that have forced lubrication equipment.
4) These which are capable to measure flow of its cooling water, in case of those that have blower or compressor that has construction applying cooling water.

2. The level gauge used for paragraph-1 must be the tubular glass gauge (measures to prevent destruction of glass tube must be taken and automatic and manual stop valve on the connection pipe

must be provided), Klinger type liquid level gauge, float type liquid level gauge, differential pressure type liquid level gauge, capacitive type liquid level gauge, displacer type liquid level gauge, radio type liquid level gauge, ultrasonic type liquid level gauge or those which has the function of safety and equal to greater than them. Those which use glass must be used the glass stipulated in JIS B8211 “boiler water gauge glass” or a glass having strength equal to greater than them (pressure resistance, thermal shock resistance and corrosion resistance). However, other than tubular glass gauge must be applied to the gas facility which passing through high pressure gas or liquefied gas.

Article 197. Alarm device for liquefied gas vaporization facility

Article 197-1. Warning device

1. “Appropriate warning device” stipulated in design technical regulation Article 197-1 means those which alarm in following cases. However, if will not be a state due to the structure of facility, this must not be applied.

(1) In case of the gas generation equipment for liquefied petroleum gas, when the liquid surface of vaporizer has increased abnormally.

(2) In case ob the gas generation equipment for liquefied natural gas, when the gas temperature at the outlet of the vaporizer is decreased abnormally.

(3) In case of the low pressure gasholder with low maximum operating pressure (limited to those which discharge gas by the blower or compressor), when the amount of gas storage has decreased abnormally.

(4) In case of the blower and compressor (limited to those which have the forced lubrication equipment), when the hydraulic pressure of the lubricant oil has decreased abnormally.

(5) In case of liquefied gas storage tank (limited to the low temperature storage tank with capacity 100 tons and more), when the pressure of the gas phase is increased abnormally.

(6) In case of low temperature storage tank, when the pressure of the gas phase is increased abnormally.

Article 198. Shut-off device for liquefied gas vaporization facility

Article 198-1. Shut-off device

1. “Appropriate location” stipulated in design technical regulation Article 198-1 means as follow;

(1) The location between the vaporizer, purifier, blower, compressor, and their ancillary equipment (limited vessel for calorie regulation). However, if it can not divide gas generation facility and purifier and can be stopped easily in emergency, this must not be applied.

Article 199. Back-up power, etc. for liquefied gas vaporization facility

Article 199-1. Back-up power

1. “Safety equipment” stipulated in design technical regulation Article199-1 must be pursuant as follows;

1) Emergency lighting system.
2) Equipment to ensure rapid communication in case of emergency (except telephone subscriber equipment)
3) Fire prevention and firefighting equipment.
4) Gas leak detection and alarm equipment.
5) Emergency shutoff valve.
6) Emergency shutoff device.
7) Cooling equipment.
8) Water spraying system or equivalent facility that has the capacity to prevention of fire and firefighting.
9) Water spraying system or equivalent facility that is effective for fire prevention.

Article 200. Odor measurement for liquefied gas vaporization facility

Article 200-1. Odorization facility

1. "Shall be odorized in order to easily be detected" stipulated in design technical regulation Article 200-1 means that it is possible to confirm smell 1/1000 gas in the air by volume mix ratio measured in any of the following method and frequency.

(1) In case of the panel method, the odor concentration in the gas must be found by means of preparing a dilute gas by either of following method, determining the presence or absence of odor by 4 or more judge having a normal sense of smell, obtaining the perceived dilution from dilution of each panel that was able to sense. However, if there is data of less than 1/10 times or more than 10 times of its arithmetic mean value which are determined from arithmetic mean value of the perceived dilution of each panel, such data must not adopted.

1) In case of the odor meter method, to mix the test gas flow into constant flow of odorless air.
2) In case of the syringe method, to collect a certain amount of test gas in the syringe and dilute by odor-free air transferring into syringe for dilution.
3) In case of the sachet method, to add test odor gas into the sachet that filled with 3 liters of odorless air by syringe.

(2) In case of the measurement method of odorant concentration, the odor concentration in the gas must be determined using conversion formula (linear regression equation) from odorant concentration in the gas (mg/m^3) that is measured by either of the following methods as shown in Table-13. The conversion formula must be calculated using the data which are measured standard odor concentration and odorant concentration at the same time (hereinafter referred to "measurement data") according to the methods listed in the right column of the table and the classification of either of following listed in the left column of the table. Administrative value of the odor

concentration in this method must be more than 2,000 times (smell can be checked in the mixing volume ratio of gas in the air in a 1/2,000).

1) In case of FPD gas chromatograph method, it must meet "5.2.3: analysis conditions" of JIS K0091 "Gas analysis method of carbon disulfide in the exhaust gas".
2) In case of the detector tube method, the detection tube to meet JIS K0804 "Detector tube type gas detector" .
3) In case of the THT instrument method, a certain amount of test gas must be passed through a certain amount of absorption solution containing iodine, generated complex (THT-iodine) and the degree of absorption at 308nm of the complex must be measured.

Table- 13: Calculation of rate equation

Classification		Calculation method
In case the odorant is not contained in the gas prior to the most downstream odorizer,		1: When calculating the rate of equation, data must be taken back and forth of odorizer. However, if the standard odorant concentration is 1,000 times and more (it is possible to confirm smell in 1/1,000 volume mix ratio gas in the air), it can be calculate the odor concentration before odorizing as zero after taking data back and forth of such odorizer.
In case the odorant is contained in the gas forth of the most downstream odrizer,	In case such odorant is same as the odorant which is added by gas producer,	Ditto
Ditto	In case such odorant is different with the odorant which is added by gas producer,	2: When calculating the rate of equation, data must be taken back and forth of odorizer. The odor concentration of produced gas back and forth of odorizer must be measured after creating a conversion formula for the odorant added by the gas producer. (1) The odor concentration of production gas forth of odorizer must be calculated from the odor concentration of production such gas. (2) The rate equation in case of no measurement of the odor concentration of production gas prior to odorizer must be calculated as the odor concentration forth of odorizer zero.
In case the odorant is not added in gas production plant by gas producer,		3: It must be calculated according to 1: assuming the gas backward of odrizer.

Reference: Article 74 of guideline for gas facility Japan

2. The measurement of odor concentration must be performed at least once a month in the place where odor concentration in the supply gas can be measured (exit of gas generation facility or exit of the factory which receive gas from others by pipeline). The typical odorization system is shown in

Fig-35, Photo-53 and 54.

3. The stipulation as follow means "those which can be perceived presence or absence of odor gas in the air with mixing volume ratio 1/1,000." "Baseline" means those which can be perceived smell in case that gas in the air mixing volume ratio is 1 in 1,000.

(1) In case of gas generation facility or gas factory which is supplied gas from others by pipeline, the writing which certifies the odor concentration in the supplied gas beyond the standard level.

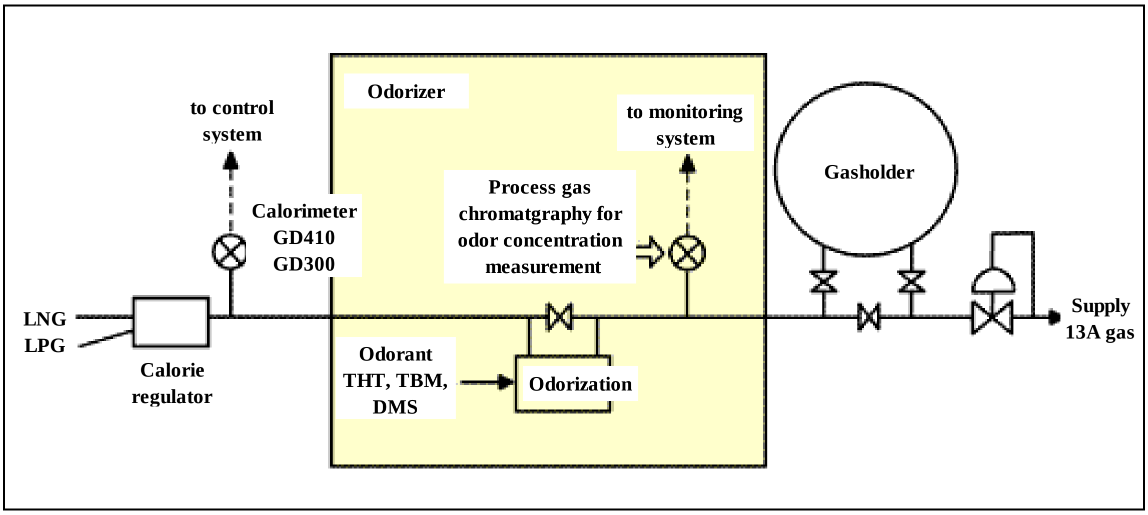


Fig- 35: Odorization system

http://www.yokogawa.co.jp/gas/solution/lng/gas-kban03.htm

Photo- 53: LPG odorant tank

http://www.tmex.jp/products/product17.html

Photo- 54: LPG odorizer

http://www.tmex.jp/products/product17.html

Article 201. Control room for liquefied gas vaporization facility

Article 201-1. Control room

1. "Shall be capable of controlling the gas safely in an emergency" stipulated in the design technical regulation Article 201-1 means those that can be ensure following function;

   1) Operation and maneuver of gas generation facility.
   2) Operation of firefighting equipment.
   3) Emergency contact.

2. Monitoring and communication systems

   The requirements for monitoring pressure, temperature, flow rate, physical characteristics of the fluid being conveyed, information on pumps, compressors, valve positions, meters and tank levels, together with alarm conditions such as power supply failure, high temperature of electric motor windings and rotating machinery bearings, excessive vibration levels, low suction pressures, high delivery pressures, seal leakage, abnormal temperatures, and the detection of fire and hazardous atmosphere shall be defined and included in the system design in accordance with clause 5. Supervisory control and data acquisition (SCADA) systems may be used for controlling equipment. Operating requirements of the pipeline system, as well as safety and environmental requirements shall be the basis for determining the need for redundant monitoring and communication components, and back-up power supply. The typical LNG base central control room is shown in Photo-55 and 56

Photo- 55: LNG base central control room

http://www.oitalng.co.jp/annai/kichi/chuouseigyo.html

Photo- 56: LNG base central control room

http://www.oge.co.jp/plant_lng/lgn_base/operate.html

Chapter-3. Technical Standards for pipeline

The technical standards related to the gas pipeline, oil pipeline and liquefied piping and storage tank are summarized in the Table-14.

Table- 14: Pipeline industry standards incorporated by reference in 49 CFR part 192, 193 and 195

SDO acronomy	Standards	Title	Latest edition	Federal reference
American Gas Association (AGA)	AGA XK0101	Purging principles and practices	3rd Edition, 2001	§§193.2513; 193.2517; 193.2615
American Petroleum Institute (API)	ANSI/API Spec 5L/ISO 3183	Specification for line pipe	47th Edition 2007	§§192.55 (e); 192.113; item-1 of Appendix-B
(API)	RP5L1	Recommended Practice for Railroad Transportation of Line Pipe	6th Edition, 2002	§ 192.65(a)
(API)	RP5LW	Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessel...	2nd Edition 1996	§ 192.65(b)
(API)	Spec. 6D/ISO 14313	Pipeline Valves	23rd Edition and Errata June 2008	§ 192.145(a)
(API)	RP 80	Guidelines for the Definition of Onshore Gas Gathering Lines	1st Edition, 2000	§§192.8(a); 192.8(a)(1); 192.8(a)(2); 192.8(a)(3); 192.8(a) (4). 192.8(a); 192.8(a ...
(API)	Std. 1104	Welding of Pipelines and Related Facilities	20th Edition and Errata2, 2008	§§ 192.227(a); 192.229(c)(1); 192.241(c); Item -2, Appendix-B
(API)	RP1162	Public Awareness Programs for Pipeline Operators	1st Edition, 2003	§§ 192.616(a); 192.616(b); 192.616(c)
(API)	ANSI/API Spec. 12F	Specification for Shop Welded Tanks for Storage of Production Liquids	11th Edition and Errata, 2007	§§195.132(b)(1); 195.205(b)(2); 195.264(b)(1); 195.264(e)(1); 195.307(a); 195.56 ...
(API)	Stan. 510	Pressure Vessel Inspection Code: Maintenance Inspection, Rating, Repair, and Alt ...	9th Edition, 2006	§§195.205(b)(3); 195.432(c).
(API)	Stan. 620	Design and Construction of Large, Welded, Low- Pressure Storage Tanks	11th Edition, 2008	§§195.132(b)(2); 195.205(b)(2); 195.264(b)(1); 195.264(e)(3); 195.307(b).

SDO acronomy	Standards	Title	Latest edition	Federal reference
(API)	Stan. 650	Welded Steel Tanks for Oil Storage	11th Edition, 2007	§§195.132(b)(3); 195.205(b)(1); 195.264(b)(1); 195.264(e)(2); 195.307I; 195.307(...
(API)	RP651	Cathodic Protection of Aboveground Petroleum Storage Tanks	3rd Edition, Jan. 2007	§§195.565; 195.579(d).
(API)	RP652	Lining of Aboveground Petroleum Storage Tank Bottoms	3rd edition, Oct. 2005	§195.579(d).
(API)	Stan. 653	Tank Inspection, Repair, Alteration, and Reconstruction	3rd Edition, Addendum 1-3 and Errata,2008	§§195.205(b)(1); 195.432(b).
(API)	Stan. 1130	Computational Pipeline Monitoring for Liquid Pipelines	1st edition, September, 2007	§§195.134; 195.444.
(API)	Stan. 2000	Venting Atmospheric and Low-Pressure Storage Tanks	5th Edition and Errata, 1999	§§195.264(e)(2); 195.264(e) (3).
(API)	RP2003	Protection Against Ignitions Arising Out of Static, Lightning, and Stray Current...	7th Edition, 2008	§195.405(a).
(API)	Stan. 2026	Safe Access/Egress Involving Floating Roofs of Storage Tanks in Petroleum Servic ...	2nd Edition, Reaffirmation, 2006	§195.405(b).
(API)	RP2350	Overfill Protection for Storage Tanks In Petroleum Facilities	3rd Edition, Jan. 2005	§195.428I.
(API)	Stan. 2510	Design and Construction of LPG Installations	8th Edition, 2001	§§195.132(b)(3); 195.205(b)(3); 195.264(b)(2); 195.264(e)(4); 195.307(e);195.428 ...
American Society of Mechanical Engineers (ASME)	B16.1–2005	ANSI/ASME B16.1-2005 Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 12...	2006 Edition	§192.147(c).
(ASME)	B16.5–2003	Pipe Flanges and Flanged Fittings	2003 Edition	§§192.147(a); 192.279.
(ASME)	B16.9–2007	Factory-Made Wrought Steel Butt Welding Fittings	2007 Edition	§195.118(a).
(ASME)	B31.4–2006	Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids	2006 Edition	§195.452(h) (4) (i).

SDO acronomy	Standards	Title	Latest edition	Federal reference
(ASME)	B31G–1991	Manual for Determining the Remaining Strength of Corroded Pipelines	1991 Edition	§§192.485(c); 192.933(a).; §§195.452(h)(4)(i)(B); 195.452(h) (4) (iii) (D).
(ASME)	B31.8–2007	Gas Transmission and Distribution Piping Systems	2007 Edition	§192.619(a) (1) (i); §195.5(a)(1)(i); 195.406(a) (1) (i).
(ASME)	B31.8S–2004	Supplement to B31.8 on Managing System Integrity of Gas Pipelines	2004 Edition	§§192.903(c); 192.907(b); 192.911, Introductory text; 192.911(i); 192.911(k); 19 ...
(ASME)	ASME Section I	ASME Boiler and Pressure Vessel Code, Section I, "Rules for Construction of Powe ...	2007 Edition	§192.153(a).
(ASME)	ASME Section VIII - DIV. 1	ASME Boiler and Pressure Vessel Code, Section-8, Division 1, Rules for Constr ...	2007 Edition	§§192.153(a); 192.153(b); 192.153(d); 192.165(b) (3); §193.2321; §§195.124; 195. ...
(ASME)	ASME Section VIII - Div. 2	ASME Boiler and Pressure Vessel Code, Section-8, Division-2, Rules for Constr ...	2007 Edition	§§192.153(b); 192.165(b)(3); §193.2321; §195.307(e).
(ASME)	AMSE Section-9	ASME Boiler and Pressure Vessel Code, Section-9, Welding and Brazing Qualificat ...	2007 Edition	§§192.227(a); Item-2, Appendix-B.; §195.222.
American Society for Testing and Materials (ASTM)	A53/A53M–07	Standard Specification for Pipe, Steel, and Black and Hot- Dipped, Zinc- Coated, Welde...	2007 Edition	§§192.113; Item-1, Appendix-B.; §195.106(e).
(ASTM)	A106/A106M–08	Standard Specification for Seamless Carbon Steel Pipe for High- Temperature Servi ...	2008 Edition	§§192.113; Item-1, Appendix-B.; §195.106(e).
(ASTM)	A333/A333M–05	Standard Specification for Seamless and Welded Steel Pipe for Low- Temperature Se ...	2005 Edition	§§192.113; Item -1, Appendix-B.; §195.106(e).
(ASTM)	A372/A372M–08	Standard Specification for Carbon and Alloy Steel Forgings for Thin-Walled Press ...	2008 Edition	§192.177(b) (1).
(ASTM)	A381–96	Standard Specification for Metal-Arc Welded Steel Pipe for Use With High- Pressur ...	2005 Edition	§§192.113; Item-1, Appendix-B.; §195.106(e).

SDO acronomy	Standards	Title	Latest edition	Federal reference
(ASTM)	A671–06	Standard Specification for Electric-Fusion-Welded Steel Pipe for Atmospheric and ...	2006 Edition	§§192.113; Item-1, Appendix-B.; §195.106(e).
(ASTM)	A672–08	Standard Specification for Electric-Fusion-Welded Steel Pipe for High-Pressure S ...	2008 Edition	§§192.113; Item-1, Appendix-B.; §195.106(e).
(ASTM)	A691–98	Standard Specification for Carbon and Alloy Steel Pipe, Electric-Fusion-Welded f ...	2007 Edition	§§192.113; Item-1, Appendix-B.; §195.106(e).
(ASTM)	D638–03	Standard Test Method for Tensile Properties of Plastics	2003 Edition	§§192.283(a)(3); 192.283(b) (1).
(ASTM)	D2513–87	Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings	1987 Edition	§192.63(a) (1).
(ASTM)	D2513–99	Standard Specification for Thermoplastic Gas Pressure Pipe, Tubing, and Fittings	1999 Edition	§§192.191(b); 192.281(b)(2); 192.283(a)(1)(i); Item-1, Appendix-B.
(ASTM)	D2517–00	Standard Specification for Reinforced Epoxy Resin Gas Pressure Pipe and Fittings	2000 Edition	§§192.191(a); 192.281(d)(1); 192.283(a)(1)(ii); Item-1, Appendix-B.
(ASTM)	F1055–98	Standard Specification for Electrofusion Type Polyethylene Fittings for Outside ...	1998 Edition	§192.283(a) (1) (iii).
Gas Technology Institute (GTI)	GRI 02/0057	Internal Corrosion Direct Assessment of Gas Transmission Pipelines Methodology	2002 Edition	§192.927(c) (2).
Gas Technology Institute (GTI)	GTI-04/0032	LNGFIRE: A Thermal Radiation Model for LNG Fires	2004 Edition	§193.2057.
Gas Technology Institute (GTI)	GTI–04/0049	LNG VaporDispersion Prediction with the DEGADIS2.1: Dense Gas Dispersion Model ...	2004 Edition	§193.2059.
(GTI)	GRI–96/0396.5	Evaluation of Mitigation Methods for Accidental LNG Releases, Volume 5: Using FE ..	1996 Edition	§193.2059.
Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MCC)	SP-44-2006	Steel Pipe Line Flanges	2006 Edition	§192.147(a).
(MCC)	SP–75–2004	Specification for High Test Wrought Butt Welding Fittings	2004 Edition	§195.118(a).

SDO acronomy	Standards	Title	Latest edition	Federal reference
National Association of Corrosion Engineers (NACE)	SP0169–2007	Control of External Corrosion on Underground or Submerged Metallic Piping System ...	2007 Edition	§§195.3; 195.571; 195.573(a)(2)
(NACE)	SP0502–2008	Pipeline External Corrosion Direct Assessment Methodology	2008 Edition	§§ 192.923; 192.925; 192.931; 192.935; 192.939
National Fire Protection Association (NFPA)	NFPA 30	Flammable and Combustible Liquids Code	2008 Edition	§192.735(b); §195.264(b) (1).
(NFPA)	NFPA 58	Liquefied Petroleum Gas Code (LP-Gas Code)	2004 Edition	§192.11(a); 192.11(b); 192.11(c).
(NFPA)	NFPA 59	Utility LP-Gas Plant Code	2004 Edition	§§192.11(a); 192.11(b); 192.11(c).
(NFPA)	NFPA 70	National Electrical Code	2008 Edition	§§192.163(e); 192.189(c).
(NFPA)	NFPA 59A	Standard for the Production, Storage, and Handling of Liquefied Natural Gas(LNG ...	2001 Edition	§§193.2019; 193.2051; 193.2057; 193.2059; 193.2101; 193.2301; 193.2303; 193.2401 ...
Plastics Pipe Institute, Inc. (PPI)	TR–3/2008	Policies and Procedures for Developing Hydrostatic Design Basis(HDB), Pressure ...	2008 Edition	§192.121.
American Gas Association (AGA)	RSTRENG 3.0 User's Manual and Software (Includes: L51688B, Modified Criterion fo ...	A Modified Criterion for Evaluating the Remaining Strength of Corroded Pipe	1993 Edition	§§192.933(a)(1); 192.485(c).
American Petroleum Institute (API)	ANSI/API RP 2RD	Design of Risers for Floating Production Systems(FPSs) and Tension-Leg Platform ...	1st	N/A
American Petroleum Institute (API)	ANSI/API RP 1110	Pressure Testing of Steel Pipelines for the Transportation of Gas, Petroleum Gas...	5th	N/A
(API)	Pub 1161	Guidance Document for the Qualification of Liquid Pipeline Personnel	1st	N/A
(API)	Std 1163	In-Line Inspection Systems Qualification Standard	1st	N/A
(API)	RP 1165	Recommended Practices for Pipeline SCADA Displays	1st	N/A

SDO acronomy	Standards	Title	Latest edition	Federal reference
(API)	RP 1167	Alarm Management	1st	N/A
(API)	RP 1168	Pipeline Control Room Management	1st	N/A
American Society of Mechanical Engineers (ASME)	ANSI/ASME B31Q	Pipeline Personnel Qualification	2006	N/A
American Society for Nondestructive Testing (ASNT)	ANSI/ASNT ILI-PQ	In-line Inspection Personnel Qualification and Certification	2005	N/A
National Association of Corrosion Engineers (NACE)	RP 0102	In-line Inspection of Pipelines	2002	N/A
(NACE)	TG 256	"Electrodes, Field-Grade Test Methods"Internal Corrosion Direct	Under Development	N/A
(NACE)	NACE SP0206	Assessment Methodology for Pipelines Carrying Normall ...	2006	N/A
(NACE)	NACE SP0208	Internal Corrosion Direct Assessment Methodology for Liquid Petroleum Pipelines	2008	N/A
Gas Piping Technology Committee (GPTC)	ANSI/GPTC Z380.1	Guide for Gas Transmission and Distribution Piping Systems	2003 Addenda 1 through 12	N/A
Gas Piping Technology Committee (GPTC)	ANSI/GPTC Z380.1	DIMP Guidance		N/A
National Association of Corrosion Engineers (NACE)	SP0106-2006	Internal Corrosion Control in Pipelines		192
(NACE)	TM0106-2006	Detection, Testing and Evaluation of Micorbially Inlfuenced Corrosion(MIC) on E ...		192 and 195
(NACE)	SP0207	Performing Close-Interval Potential Surveys and DC Surface Potential Gradient Su ...		192 and 195
(NACE)	SP0200-2008 (formerly RP0200)	Steel-Cased Pipelines Practices		195

Chapter-4. Reference International Technical Standards

The reference international standards for designing liquefied gas fuel handling facility are organized in Table-15.

Table- 15: Reference International Technical Standards

Number	Rev.	Title	Content
NFPA 59A	2009	Standard for the production, storage and handling of liquefied natural gas	This standard shall apply to the following: (1) Facilities that liquefy natural gas (2) Facilities that store, vaporize, transfer, and handle liquefied natural gas (LNG) (3) The training of all personnel involved with LNG (4) The design, location, construction, maintenance, and operation of all LNG facilities 1.1.2 This standard shall not apply to the following: (1) Frozen ground containers (2) Portable storage containers stored or used in buildings (3) All LNG vehicular applications, including fueling of LNG vehicles.
API 620 Appendix-Q	1985	Design and construction of large, welded, low-pressure storage tanks	The API Downstream Segment has prepared this standard to cover large, field-assembled storage tanks of the type described in 1.2 that contain petroleum intermediates (gases or vapors) and finished products, as well as other liquid products commonly handled and stored by the various branches of the industry. The rules presented in this standard cannot cover all details of design and construction because of the variety of tank sizes and shapes that may be constructed. Where complete rules for a specific design are not given, the intent is for the Manufacturer “subject to the approval of the Purchaser's authorized representative to provide design and construction details that are as safe as those which would otherwise be provided by this standard. The Manufacturer of a low-pressure storage tank that will bear the API 620 nameplate shall ensure that the tank is constructed in accordance with the requirements of this standard. The rules presented in this standard are further intended to ensure that the application of the nameplate shall be subject to the approval of a qualified inspector who has made the checks and inspections that are prescribed for the design, materials, fabrication, and testing of the completed tank.
API STD 1105	2011	Standard for Welding of Pipelines and Related Facilities	API STD 1104 is a standard that covers the gas and arc welding of butt, fillet, and socket welds in carbon and low-alloy steel piping used in the compression, pumping, and transmission of crude petroleum, petroleum products, fuel gases, carbon dioxide, nitrogen and, where applicable, covers welding on distribution systems. It

Number	Rev.	Title	Content
			applies to both new construction and in-service welding. The welding may be done by a shielded metal-arc welding, submerged arc welding, gas tungsten-arc welding, gas metal-arc welding, flux-cored arc welding, plasma arc welding, oxyacetylene welding, or flash butt welding process or by a combination of these processes using a manual, semiautomatic, mechanized, or automatic welding technique or a combination of these techniques. The welds may be produced by position or roll welding or by a combination of position and roll welding. This standard also covers the procedures for radiographic, magnetic particle, liquid penetrant, and ultrasonic testing, as well as the acceptance standards to be applied to production welds tested to destruction or inspected by radiographic, magnetic particle, liquid penetrant, ultrasonic, and visual testing methods.
API STD 650	2007	Standard for Welded Tanks for Oil Storage Tanks	API STD 650 is a standard that establishes minimum requirements for material, design, fabrication, erection, and testing for vertical, cylindrical, aboveground, closed- and open-top, welded storage tanks in various sizes and capacities for internal pressures approximating atmospheric pressure (internal pressures not exceeding the weight of the roof plates), but a higher internal pressure is permitted when additional requirements are met . This Standard applies only to tanks whose entire bottom is uniformly supported and to tanks in non-refrigerated service that have a maximum design temperature of 93°C (200°F) or less. This Standard is designed to provide industry with tanks of adequate safety and reasonable economy for use in the storage of petroleum, petroleum products, and other liquid products. This Standard does not present or establish a fixed series of allowable tank sizes; instead, it is intended to permit the Purchaser to select whatever size tank may best meet his needs. This Standard is intended to help Purchasers and Manufacturers in ordering, fabricating, and erecting tanks; it is not intended to prohibit Purchasers and Manufacturers from purchasing or fabricating tanks that meet specifications other than those contained in this Standard.
EN 1473	2007	Installation and equipment for liquefied natural gas. Design of onshore installations	Liquefied natural gas, Natural gas, Installation, Materials handling, Equipment safety, Environmental engineering, Safety measures, Hazards, Occupational safety, Risk assessment, Fire safety, Liquefaction of gases, Fuel storage, Tanks (containers), Thermal insulation, Pumps, Pipework systems, Electrical equipment, Measuring instruments, Detectors, Fire safety in buildings,

Number	Rev.	Title	Content
			Firefighting equipment, Control systems, Vaporization, Odours, Quality assurance systems, Acceptance (approval), Performance testing, Approval testing, Corrosion protection, Training, Marking, Classification systems, Radiant flux density, Radiative heat transfer
BS 7777	1993	Flat-bottomed, vertical, cylindrical storage tanks for low temperature service. Specification for the design and construction of single, double and full containment metal tanks for the storage of liquefied gas at temperatures down to -165°C	Tanks (containers), Bulk storage containers, Containers, Vertical, Cylindrical shape, Liquefied gases, Temperature, Double-skinned pressure vessels, Pressure vessels, Low temperatures, Welding, Shell structures, Steels, Aluminum, Aluminum alloys, Internal pressure, Stiffeners, Design, Stress, Structural design, Reinforcement, Design calculations, Seatings, Holes, Stairs, Gangways (buildings), Thickness, Anchorages, Erecting (construction operation), Leak tests, Pressure testing, Impact strength, Inspection, Grades (quality), Manholes, Dimensions, Acceptance (approval), Approval testing, Radiographic testing
CAN/CSA-Z276-07	2001	Liquefied Natural Gas (LNG) - Production, Storage, and Handling	This Standard applies to the (a) design; (b) location; (c) construction; (d) operation; and (e) maintenance of facilities for the liquefaction of natural gas and facilities for the storage, vaporization, transfer, handling, and truck transport of LNG. It also contains requirements for the training of personnel.
ISO 8943	2007	Refrigerated light hydrocarbon fluids -- Sampling of liquefied natural gas -- Continuous and intermittent methods	ISO 8943:2007 specifies methods for the continuous and the intermittent sampling of LNG while it is being transferred through an LNG transfer line.
ISO 18432-2	2008	Refrigerated light hydrocarbon fluids -- General requirements for automatic level gauges -- Part 2: Gauges in refrigerated-type shore tanks	ISO 18132:2008 establishes the general requirements for the specification, installation and calibration/verification testing of automatic level gauges (ALG) used for refrigerated light hydrocarbon fluids, i.e., LNG and LPG, stored in bulk storage tanks on shore at pressures close to atmosphere. ISO 18132:2008 is not applicable to pressurized shore tanks.
ISO 28460	2010	Petroleum and natural gas industries -- Installation and equipment for liquefied natural gas -- Ship-to-shore interface and port operations	ISO 28460:2010 specifies the requirements for ship, terminal and port service providers to ensure the safe transit of an LNG carrier through the port area and the safe and efficient transfer of its cargo. It is applicable to 1. pilotage and vessel traffic services (VTS); 2. tug and mooring boat operators; 3. terminal operators; 4. ship operators; 5. suppliers of bunkers, lubricants and stores and other providers of services whilst the LNG carrier is moored alongside the terminal.

Number	Rev.	Title	Content
			ISO 28460:2010 includes provisions for ▪ a ship's safe transit, berthing, mooring and unberthing at the jetty; ▪ cargo transfer; ▪ access from jetty to ship; ▪ operational communications between ship and shore; ▪ all instrumentation, data and electrical connections used across the interface, including OPS (cold ironing), where applicable; ▪ the liquid nitrogen connection (where fitted); ▪ ballast water considerations. ISO 28460:2010 applies only to conventional onshore LNG terminals and to the handling of LNGC's in international trade. However, it can provide guidance for offshore and coastal operations.
ISO 23251	2006	Petroleum, petrochemical and natural gas industries -- Pressure-relieving and depressuring systems	ISO 23251:2006 is applicable to pressure-relieving and vapour-depressuring systems. Although intended for use primarily in oil refineries, it is also applicable to petrochemical facilities, gas plants, liquefied natural gas (LNG) facilities and oil and gas production facilities. The information provided is designed to aid in the selection of the system that is most appropriate for the risks and circumstances involved in various installations. ISO 23251:2006 is intended to supplement the practices set forth in ISO 4126 or API RP 520-1 for establishing a basis of design. ISO 23251:2006 specifies requirements and gives guidelines for examining the principal causes of overpressure; and determining individual relieving rates; and selecting and designing disposal systems, including such component parts as piping, vessels, flares, and vent stacks.
ISO 18132	2011	Refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels -- General requirements for automatic tank gauges -- Part 1: Automatic tank gauges for liquefied natural gas on board marine carriers and floating storage	ISO 18132-1:2011 establishes general principles for the accuracy, installation, calibration and verification of automatic tank gauges (ATGs) used for custody transfer measurement of liquefied natural gas (LNG) on board an LNG carrier or floating storage. The LNG described in ISO 18132-1:2011 is either fully refrigerated (i.e. at the cryogenic condition), or partially refrigerated, and therefore the fluid is at or near atmospheric pressure. ISO 18132-1:2011 also specifies the technical requirements for data collection, transmission and reception. Specific technical requirements for various

Number	Rev.	Title	Content
			automatic tank gauges and accuracy limitations are given in the annexes.
ANSI B31.4	2009	Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids	This Code prescribes requirements for the design, materials, construction, assembly, inspection, and testing of piping transporting liquids such as crude oil, condensate, natural gasoline, natural gas liquids, liquefied petroleum gas, carbon dioxide, liquid alcohol, liquid anhydrous ammonia and liquid petroleum products between producers' lease facilities, tank farms, natural gas processing plants, refineries, stations, ammonia plants, terminals (marine, rail and truck) and other delivery and receiving points. Piping consists of pipe, flanges, bolting, gaskets, valves, relief devices, fittings and the pressure containing parts of other piping components. It also includes hangers and supports, and other equipment items necessary to prevent overstressing the pressure containing parts. It does not include support structures such as frames of buildings, buildings stanchions or foundations
NFPA 58	2011	Liquefied petroleum gas code	This code applies to the storage, handling, transportation, and use of LP-Gas. A.1.1 General Properties of LP-Gas. Liquefied petroleum gases (LP-Gases), as defined in this code (see 3.3.36), are gases at normal room temperature and atmospheric pressure. They liquefy under moderate pressure and readily vaporize upon release of the pressure. It is this property that permits the transportation and storage of LP-Gases in concentrated liquid form, although they normally are used in vapor form. For additional information on other properties of LP-Gases, see Annex B. Federal Regulations. Regulations of the U.S. Department of Transportation (DOT) are referenced throughout this code. Prior to April 1, 1967, these regulations were promulgated by the Interstate Commerce Commission (ICC). The Federal Hazardous Substances Act (15 U.S.C. 1261) requires cautionary labeling of refillable cylinders of liquefied petroleum gases distributed for consumer use. They are typically 40 lb (13 kg) and less and are used with outdoor cooking appliances, portable lamps, camp stoves, and heaters. The Federal Hazardous Substances Act is administered by the U.S. Consumer Product Safety Commission under regulations codified at 16 CFR 1500, Commercial Practices, Chapter 11, "Consumer Product Safety Commission."

Number	Rev.	Title	Content
49 U.S.C § 60103.	2009	Standards for liquefied natural gas pipeline facilities	a) Location Standards. - The Secretary of Transportation shall prescribe minimum safety standards for deciding on the location of a new liquefied natural gas pipeline facility. In prescribing a standard, the Secretary shall consider the - (1) kind and use of the facility; (2) existing and projected population and demographic characteristics of the location; (3) existing and proposed land use near the location; (4) natural physical aspects of the location; (5) medical, law enforcement, and fire prevention capabilities near the location that can cope with a risk caused by the facility; and (6) need to encourage remote siting. (b) Design, Installation, Construction, Inspection, and Testing Standards. - The Secretary of Transportation shall prescribe minimum safety standards for designing, installing, constructing, initially inspecting, and initially testing a new liquefied natural gas pipeline facility. When prescribing a standard, the Secretary shall consider - (1) the characteristics of material to be used in constructing the facility and of alternative material; (2) design factors; (3) the characteristics of the liquefied natural gas to be stored or converted at, or transported by, the facility; and (4) the public safety factors of the design and of alternative designs, particularly the ability to prevent and contain a liquefied natural gas spill. (c) Nonapplication. - (1) Except as provided in paragraph (2) of this subsection, a design, location, installation, construction, initial inspection, or initial testing standard prescribed under this chapter after March 1, 1978, does not apply to an existing liquefied natural gas pipeline facility if the standard is to be applied because of authority given - (A) under this chapter; or (B) under another law, and the standard is not prescribed at the time the authority is applied. (2)(A) Any design, installation, construction, initial inspection, or initial testing standard prescribed under this chapter after March 1, 1978, may provide

Number	Rev.	Title	Content
			that the standard applies to any part of a replacement component of a liquefied natural gas pipeline facility if the component or part is placed in service after the standard is prescribed and application of the standard - (i) does not make the component or part incompatible with other components or parts; or (ii) is not impracticable otherwise. (B) Any location standard prescribed under this chapter after March 1, 1978, does not apply to any part of a replacement component of an existing liquefied natural gas pipeline facility. (3) A design, installation, construction, initial inspection, or initial testing standard does not apply to a liquefied natural gas pipeline facility existing when the standard is adopted. (d) Operation and Maintenance Standards. - The Secretary of Transportation shall prescribe minimum operating and maintenance standards for a liquefied natural gas pipeline facility. In prescribing a standard, the Secretary shall consider - (1) the conditions, features, and type of equipment and structures that make up or are used in connection with the facility; (2) the fire prevention and containment equipment at the facility; (3) security measures to prevent an intentional act that could cause a liquefied natural gas accident; (4) maintenance procedures and equipment; (5) the training of personnel in matters specified by this subsection; and (6) other factors and conditions related to the safe handling of liquefied natural gas. (e) Effective Dates. - A standard prescribed under this section is effective on the 30th day after the Secretary of Transportation prescribes the standard. However, the Secretary for good cause may prescribe a different effective date when required because of the time reasonably necessary to comply with the standard. The different date must be specified in the regulation prescribing the standard. (f) Contingency Plans. - A new liquefied natural gas pipeline facility may be operated only after the operator submits an adequate contingency plan that states the action to be taken if a liquefied natural gas accident occurs. The Secretary of Energy or appropriate State or local authority shall decide if the plan is adequate. (g) Effect on Other Standards. - This section does not preclude applying a

Number	Rev.	Title	Content
			standard prescribed under section 60102 of this title to a gas pipeline facility (except a liquefied natural gas pipeline facility) associated with a liquefied natural gas pipeline facility.
API Std625	2010	Tank systems for refrigerated liquefied gas storage	This standard covers low pressure, aboveground, vertical, and cylindrical tank systems storing liquefied gases requiring refrigeration. This standard provides general requirements on responsibilities, selection of storage concept, performance criteria, accessories/appurtenances, quality assurance, insulation, and commissioning of tank systems. This standard covers tank systems having a storage capacity of 800 cubic meters (5000 bbls) and larger. Stored product shall be liquids which are in a gaseous state at ambient temperature and pressure and require refrigeration to less than 5 °C (40 °F) to maintain a liquid phase. Tank systems with a minimum design temperature of –198 °C (–325 °F), a maximum design internal pressure of 50 kPa (7 psig), and a maximum design uniform external pressure of 1.75 kPa (0.25 psig) are covered. The tank system configurations covered consist of a primary liquid and vapor containment constructed of metal, concrete, or a metal/concrete combination and, when required, a secondary liquid containment. Metallic container materials, design, fabrication, inspection, examination, and testing are covered in API 620 Appendix Q or Appendix R. The applicable appendix of API 620 depends on the design metal temperature and the applicable temperature ranges given in these appendices.

Chapter-5. Reference Japanese Technical Standards

The reference Japanese industrial standards for designing liquefied gas fuel handling facility are organized in Table-16.

Table- 16: Reference Japanese Technical Standards

Number	Rev.	Title	Content
JIS A4201	1992	Protection of structures against lightning	In case of underground PCLNG storage tank which the standard of Gas Business Act is applied, this standard is applied at present. The wires have been cut up at intervals of 50m or less around the exterior PC wall from metal structure roof which receive lighting as lighting protection system.
JIS S2145	1997	Metallic flexible hoses for gas	This stipulates about metallic flexible hose which is used in order to connect gas valve and a fixed type combustor for liquefied petroleum gas or city gas with gas pressure less than 3.2kPa.
JIS M8010	1993	Measuring methods of quantity of natural gas	This stipulates the method of gas metering for natural gas.
JIS B8241	2007	Seamless steel gas cylinder	This stipulates about seamless steel high pressure gas container that filling high pressure gas more than 1ℓ and less than 700ℓ.
JIS B8242	2011	Horizontal type cylindrical storage tanks used for liquefied petroleum gas--Construction	This stipulates structure about aboveground horizontal cylindrical storage tank which store liquefied petroleum gas at room temperature.
JIS B8245	2008	Valves for liquefied petroleum gas cylinder	This stipulates about valve which is used for the liquefied petroleum gas container with inner volume more than 3ℓ and less than 120ℓ to fill liquefied petroleum gas of more than 1.53MPa and less than 1.82MPa at 48°C.
JIS B8246	2008	Valves for high pressure gas cylinders	—
JIS B8502	2011	Construction of welded aluminum and aluminum alloy storage tanks	This stipulates structure about vertical cylindrical fixed roof storage tank which is made of aluminum in the height of 8m by welding and store such as liquid chemicals at room temperature.
JIS H4000	1999	Aluminum and aluminum alloy sheets and plates, strips and coiled sheets	—
JIS K2301	2002	Fuel gases and natural gas--Methods for chemical analysis and testing	This stipulates test methods for specific gravity and calorific value and how to analyze the general component and a special component of natural gas and fuel gas. This is not applied to liquefied natural gas and liquefied petroleum gas.

Number	Rev.	Title	Content
JIS K2240	2011	Liquefied petroleum gas	This stipulates about liquefied petroleum gas used for household, commercial, industrial and automotive as fuel and industrial raw materials.
JIS M1006	1992	Crude oil and natural gas –Calculation of reserves	This stipulates standards for calculation of ore of crude oil and natural gas in the area that is already discovered.
JIS Z3050	2010	Method of nondestructive examination for weld of pipeline	This stipulates about nondestructive testing method of circumferential butt weld part of pipeline which transport oil and gas at operation pressure 0.98MPa and more with outside diameter more than 2,000mm and less than 100mm or thickness more than 6mm and less than 40mm.
JGA-102-03	2006	Guideline for equipments of LNG receiving terminal	—
JGA-104-03	2004	Guideline for spherical gas storage tank	—
JGA-105-02	2002	Guideline for equipments of small-scale LNG base	—
JGA-106-05	2005	Guideline for LPG storage tank	—
JGA-107-02	2002	Guideline for underground LNG storage tank	—
JGA-108-02	2002	Guideline for aboveground LNG storage tank	—
JGA	2006	Guideline for high pressure gas pipeline	—
JGA	2008	Check point of the welding procedure	—

Chapter-6. Reference TCVN

The reference Vietnamese national standards for designing liquefied gas fuel handling facility are organized in Table-17.

Table- 17: Reference TCVN

Number	Rev.	Title	Content
TCVN 6223	2011	Liquefied Petroleum Gas (LPG) store. General safety requirements	Qui định các yêu cầu an toàn trong thiết kế, xây dựng, sử dụng các loại cửa hàng khí đốt hoá lỏng đóng trong chai dung tích chứa tới 150 lít
TCVN 6486	2008	Liquefied Petroleum Gas (LPG). Pressurised Storage. Requirements for Design and Location of Installation	Tiêu chuẩn này qui định các yêu cầu về thiết kế và vị trí lắp đặt đối với các bồn chứa khí dầu mỏ hoá lỏng cố định có dung tích chứa nước từ 0,15m3 trở lên, dùng để tồn chứa LPG dân dụng, thương mại và công nghiệp.
TCVN 7567	2006	Liquefied Petroleum Gas (LPG). Handling Principles, Measurement and Calculation	Tiêu chuẩn này áp dụng cho việc giao nhận khí dầu mỏ hoá lỏng tại các kho tồn trữ và cung cấp LPG, trên các phương tiện đường thuỷ, đường bộ và đường sắt.

Chapter-7. Referenced Literature and Materials

The referenced books, literatures, standards to establishing this guide line are organized as follows.

1. Interpretation of technical regulation for gas facility(25/Mar/2010): NISA (Nuclear and Industrial Safety Agency) of METI (Ministry of Economy, Trade and Industry)
2. The outline—boiler (No.583: Apr/2006): TENPS (Thermal and Nuclear Engineering Society of Japan)
3. Management of fuel (Fuel for thermal; power plant) (Journal: No.611: Aug/2007): TENPES (Thermal and Nuclear Engineering Society of Japan)
4. ISO 13623: Petroleum and natural gas industries—Pipeline transportation systems (15/4/2000)
5. LNG pump and LNG expander turbine (M.Matsumire: Ebara technical report No.213: Oct/2006)
6. "presentation of a loading arm installation" of FMC Energy Systems
7. NFPA-59A-2001 "Standard for the production, storage, and handling of liquefied natural gas (ING)" of the authority on fire, electrical, and building safety USA
8. "Concept for inspection of LNG receiving terminal facility" (High pressure Gas LNG Association: Jan/2003)
9. "Speed control to prevent return gas blower surging" (Y.Kimoto: Osaka Gas)