SOCIALIST REPUBLIC OF VIETNAM
Ministry of Industry and Trade (MOIT)

Guideline for Technical Regulation Volume 2

Design of Thermal Power Facilities

Book 6/12

« Gas Fuel Handling Facility »

Final Draft

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List of Acronyms/Abbreviations

API	American Petroleum Institute
AS	Australia Standard
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing
BFG	Blast Furnace Gas
BS	British Standard
CFR	Code of Federal Regulations
CG	Converter Gas
COG	Coke Oven Gas
CSA	Canadian Standards Association
EN	European Norm
FBE	Fusion Bonded Epoxy
HPCC	High Performance Composite Coating
IEC	International Electrotechnical Commission
IGCC	Integrated Gasification Combined Cycle
ISO	International Organization for Standardization
JIS	Japanese Industrial Standard
JGA	Japan Gas Association
LDG	Linz-Donawitz Converter Gas
LNG	Liquefied Natural Gas
3LPE	3-Layer Poly Ethylene
LPG	Liquefied Petroleum Gas
3LPP	3-Layer Poly Propylene
MAOP	Maximum Allowable Operating Pressure
MSS	Manufacturers Standardization Society
NFPA	National Fire Protection Association
SYMS	Specific Minimum Yield Strength
WES	Welding Engineering Society
WPS	Welding Procedure Specification

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

Technical Regulation		Technical Guideline	
Article 114.	General provision for gas receiving and transportation facility	Article 114.	General provision for gas receiving and transportation facility
-1.	General provision	-1.	General provision
Article 115.	Classification of gas pressure for gas facilities	Article 115.	Classification of gas pressure for gas facilities
-1.	Classification of gas pressure for gas facility	-1.	Classification of gas pressure for gas facility
Article 116.	Incoming gas pipeline	Article 116.	Incoming gas pipeline
-1.	Length of pipeline	-1.	Length of pipeline
-2.	Buried pipeline	-2.	Buried pipeline
-3.	Drain slope	-3.	Drain slope
-4.	Water seal valve	-4.	Water seal valve
-5.	Purge system	-5.	Purge system
-6.	Insulation against direct sunshine	-6.	Insulation against direct sunshine
-7.	Supporting system	-7.	Supporting system
-8.	Joint of gas pipeline	-8.	Joint of gas pipeline
-9.	Trace heating for water seal valve	-9.	Trace heating for water seal valve
-10.	Painting	-10.	Painting
-11.	Location of vent pipe	-11.	Location of vent pipe
-12.	Purge steam or gas	-12.	Purge steam or gas
-13.	Vent pipe	-13.	Vent pipe
-14.	Vent valve and purge valve	-14.	Vent valve and purge valve
-15.	Drain system	-15.	Drain system
Article 117.	Material of gas transportation facility	Article 117.	Material of gas transportation facility
-1.	Material of gas transportation facility	-1.	Material of gas transportation facility
Article 118.	Structure, etc. of gas facility	Article 118.	Structure, etc. of gas facility
-1.	Pipeline installed in the sea or on land	-1.	Pipeline installed in the sea or on land
-2.	Pressure part	-2.	Pressure part
-3.	Air-tightness	-3.	Air-tightness
-4.	Foundation	-4.	Foundation
Article 119.	Welding part of gas transportation facility	Article 119.	Welding part of gas transportation facility
-1.	Welding of pipeline	-1.	Welding of pipeline
-2.	Welding procedure	-2.	Welding procedure
-3.	Welding management	-3.	Welding management
Article 120.	Safety valve of gas transportation facility	Article 120.	Safety valve of gas transportation facility

Technical Regulation		Technical Guideline	
-1.	Safety valve	-1.	Safety valve
Article 121.	Instrument device, etc. for gas transportation facility	Article 121.	Instrument device, etc. for gas transportation facility
-1.	Instrument device	-1.	Instrument device
Article 122.	Warning device for transportation facility	Article 122.	Warning device for transportation facility
-1.	Warning device	-1.	Warning device
Article 123.	Fail-safe control and interlock for gas transportation facility	Article 123.	Fail-safe control and interlock for gas transportation facility
-1.	Fail-safe control	-1.	Fail-safe control
-2.	Interlock	-2.	Interlock
Article 124.	Back-up power, etc. for gas transportation facility	Article 124.	Back-up power, etc. for gas transportation facility
-1.	Back-up power	-1.	Back-up power
Article 125.	Measure of odor for gas transportation facility	Article 125.	Measure of odor for gas transportation facility
-1.	Odrization	-1.	Odrization
Article 126.	General provision for gas generation facility	Article 126.	General provision for gas generation facility
-1.	General provision	-1.	General provision
Article 127.	Off Limit to gas generation and supply facility	Article 127.	Off Limit to gas generation and supply facility
-1.	Off limit	-1.	Off limit
Article 128.	Security communication facility for gas generation and supply facility	Article 128.	Security communication facility for gas generation and supply facility
-1.	Safety communication facility	-1.	Safety communication facility
Article 129.	Off-set distance for gas generation and supply facility	Article 129.	Off-set distance for gas generation and supply facility
-1.	Separation distance from boundary	-1.	Separation distance from boundary
-2.	Separation distance from school, hospital, etc.	-2.	Separation distance from school, hospital, etc.
Article 130.	Security compartment of gas generation and supply facility	Article 130.	Security compartment of gas generation and supply facility
-1.	Security compartment	-1.	Security compartment
Article 131.	Firefighting facility for gas generation and supply facility	Article 131.	Firefighting facility for gas generation and supply facility
-1.	Firefighting facility	-1.	Firefighting facility
Article 132.	Prevention of gas accumulation for gas generation and supply facility	Article 132.	Prevention of gas accumulation for gas generation and supply facility
-1.	Prevention of gas accumulation indoor	-1.	Prevention of gas accumulation indoor
-2.	Gas detector	-2.	Gas detector
Article 133.	Explosion-proof structure of electric facility for gas generation and supply facility	Article 133.	Explosion-proof structure of electric facility for gas generation and supply facility
-1.	Distance from flammable gas facility	-1.	Distance from flammable gas facility
Article 134.	Distance from flammable gas facility of gas generation and supply facility	Article 134.	Distance from flammable gas facility of gas generation and supply facility
-1.	Distance from flammable gas facility	-1.	Distance from flammable gas facility
Article 135.	Gas displacement of gas generation and supply facility	Article 135.	Gas displacement of gas generation and supply facility

Technical Regulation		Technical Guideline	
-1.	Gas replacement	-1.	Gas replacement
-2.	Vent-stack	-2.	Vent-stack
-3.	Heat radiation	-3.	Heat radiation
Article 136.	Material of gas generation and supply facility	Article 136.	Material of gas generation and supply facility
-1.	Material	-1.	Material
Article 137.	Structures, etc. of gas generation and supply facility	Article 137.	Structures, etc. of gas generation and supply facility
-1.	Structure	-1.	Structure
-2.	Foundation	-2.	Foundation
Article 138.	Welding parts of gas generation and supply facility	Article 138.	Welding parts of gas generation and supply facility
-1.	Welding part	-1.	Welding part
-2.	Welding procedure	-2.	Welding procedure
-3.	Welding management	-3.	Welding management
Article 139.	Safety valve for gas generation and supply facility	Article 139.	Safety valve for gas generation and supply facility
-1.	Safety valve	-1.	Safety valve
Article 140.	Instrument device, etc. for gas generation and supply facility	Article 140.	Instrument device, etc. for gas generation and supply facility
-1.	Instrument device	-1.	Instrument device
Article 141.	Alarm device for gas generation and supply facility	Article 141.	Alarm device for gas generation and supply facility
-1.	Alarm device	-1.	Alarm device
Article 142.	Fail-safe control and instrument for gas generation and supply facility	Article 142.	Fail-safe control and instrument for gas generation and supply facility
-1.	Fail-safe control	-1.	Fail-safe control
-2.	Interlock	-2.	Interlock
Article 143.	Back-up power, etc. for gas generation and supply facility	Article 143.	Back-up power, etc. for gas generation and supply facility
-1.	Back-up power	-1.	Back-up power
Article 144.	Measurement of odor for gas generation and supply facility	Article 144.	Measurement of odor for gas generation and supply facility
-1.	Odorization	-1.	Odorization
Article 145.	Control room for gas generation and supply facility	Article 145.	Control room for gas generation and supply facility
-1.	Control room	-1.	Control room
Article 146.	General provision of gas storage facility	Article 146.	General provision of gas storage facility
-1.	General provision	-1.	General provision
Article 147.	Material of gas storage tank	Article 147.	Material of gas storage tank
-1.	Material	-1.	Material
Article 148.	Structure of gas storage tank	Article 148.	Structure of gas storage tank
-1	Structure	-1	Structure
-2.	Drain discharge	-2.	Drain discharge
-3.	Volume of gas storage	-3.	Volume of gas storage
Article 149.	Shut-off device for gas storage tank	Article 149.	Shut-off device for gas storage tank
-1.	Shut-off valve	-1.	Shut-off valve

Technical Regulation		Technical Guideline	
Article 150.	Indication for gas storage tank	Article 150.	Indication for gas storage tank
-1.	Indication	-1.	Indication
Article 151.	Safety valves, etc. for gas storage tank	Article 151.	Safety valves, etc. for gas storage tank
-1.	Quantity of safety valve	-1.	Quantity of safety valve
-2.	Negative pressure	-2.	Negative pressure
Article 152.	Instrument device for gas storage tank	Article 152.	Instrument device for as storage tank
-1.	Instrument device	-1.	Instrument device
-2.	Pressure detector and thermometer	-2.	Pressure detector and thermometer
Article 153.	Alarm device for gas storage tank	Article 153.	Alarm device for gas storage tank
-1.	Alarm device	-1.	Alarm device

Article 114. General provision for gas receiving and transportation facility

Article 114-1. General provision

1. Characteristics of the gas fuel

There are types of gas fuel such which is obtained by dry distillation of coal, obtained by decomposition of petroleum products, natural gas in natural state and by-products that is obtained in steel mills. Generally gaseous fuels has characteristics that it is high combustion efficiency, few excess air for complete combustion, there are features such as sulfur oxides does not occur, since it does not contain sulfur.

LNG（Liquefied Natural Gas）that was cooled down to -162°C at atmospheric pressure is composed mainly methane, ethane, propane, butane and the like. It is clean energy, since sulfur and other impurities are removed in the course of liquefaction pretreatment process. LPG（Liquefied Petroleum Gas）is the petroleum type hydrocarbon gas which is easy to liquefy under a slight pressure at room temperature, and composed mainly propane and butane and has characteristic that is high heating value and less sulfur.

COG（Coke Oven Gas）is generated during the coke production as the by-product in steel mill. It contains methane and hydrogen and is excellent to burn due to high calorific value. BFG（Blast Furnace Gas）is produced as by-product from blast furnace in the steel mill, which contains dust, carbon dioxide and nitrogen gas as an inert gas and has low calorific value. Table-2 shows an example of the properties of gaseous fuels.

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)"

2. Combustion characteristics of gas fuel

1) It is possible to burn spreading fuel mixed with air under low pressure (0.04~0.25MPa) and the combustion process will not have short flame without spraying steam such as heavy oil combustion. Flame characteristics such as reaction rate, flame temperature are governed by the condition of mixture with air.
2) Generally, the flame emissivity is low luminous flame, since low ratio of C/H of the components and there is no formation of soot in combustion process.
3) It has high water content in the combustion gases and high emissivity of the gases.
4) The combustion efficiency is high and there is no occurrence of unburned under proper combustion air ratio. However, if air lacks, unburned such as CO, etc is occurs and soot occurs in extreme cases.
5) Large turn-down of the burner, combustion is also easy to adjust. However, the shape of an improper air ratio out of range, the ignition will be instable. In extreme cases, it causes vibration combustion with resonance of the furnace natural frequencies.
6) Fuel contains little sulfur, nitrogen and impurities, there is no contamination, wear and corrosion of boiler. In addition, measure for public pollution is easy, low NOx, SOx and no dust emissions.
7) It has risk of explosion as well as other fuels in ignition failure, since flammable range is wide.

3. Flammable limit

Fuel gas and air mixture can be burn in a range of mixture. The upper and lower limit of this range is called “Flammable limit” and they are represented in concentration of fuel in the mixture. Fig-1 shows the flammable limit in mixture of each single gas at atmosphere and 25℃. The flammable limit is wider with the increase of mixture temperature and pressure, more significant changes to the cap in general. Fig-1 and 2 shows the relation between flammable limit and temperature and pressure of methane (CH_4). In addition, the production of the lower limit concentration of hydrocarbon fuel (C1) and combustion heat (Q) has a constant relation ship as shown in Fig-3. The flammable limit is important to consider safety measure such as explosion proof, anti-backfire, purging of gas piping. For example, flammable limit can be narrowed by adding an inert gas as shown in Fig-4. Generally, N^2 gas is used for purging of gas piping.

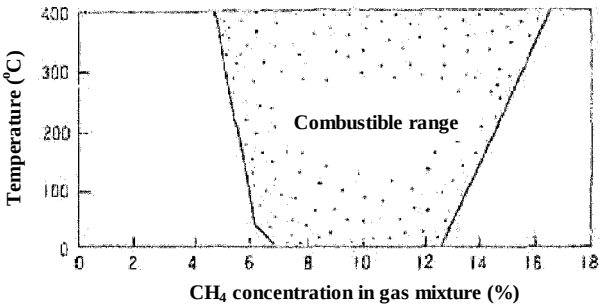


Fig- 1: Temperature dependence of flammability limit of methane-air mixture

Reference: P-106 of Journal (No.517: Oct. /1999): TENPES

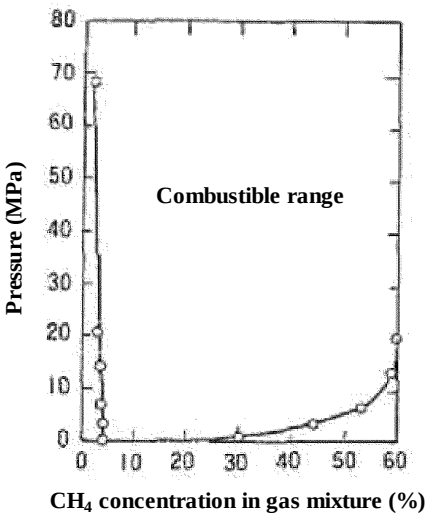


Fig- 2: Pressure dependence of flammability limit of methane-air mixture

Reference: P-106 of Journal (No.517: Oct. /1999): TENPES

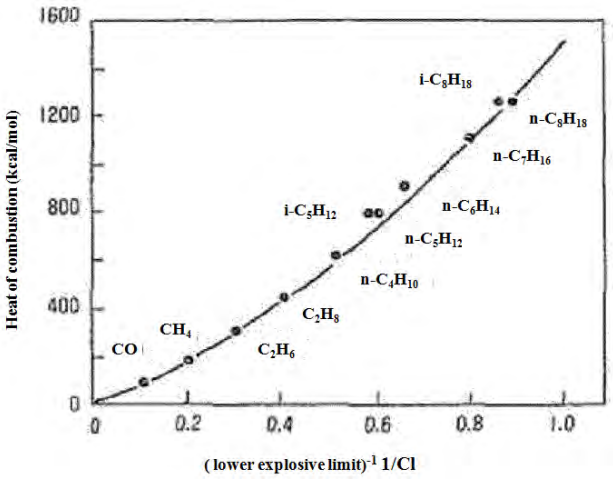


Fig- 3: Relationship between lower explosive limit and combustion heat

Reference: P-107 of Journal (No.517: Oct. /1999): TENPES

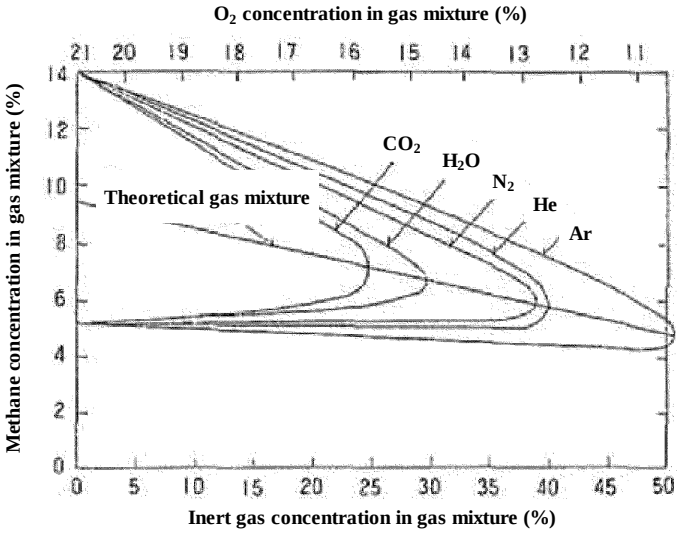


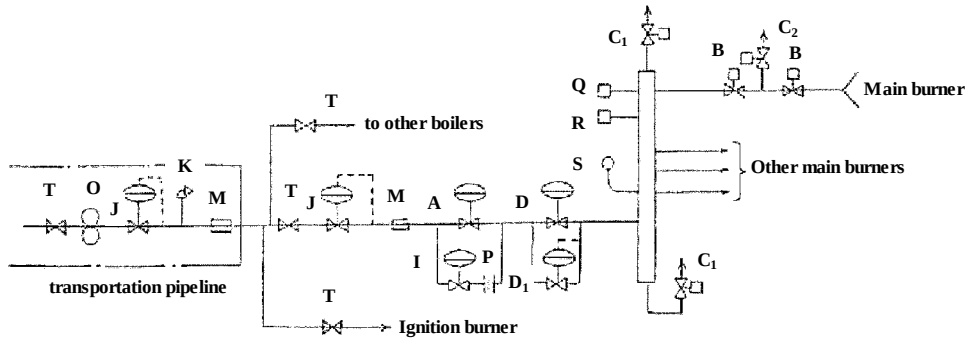
Fig- 4: Flammability limit of an gas mixture methane with air and inert gas

Reference: P-107 of Journal (No.517: Oct. /1999): TENPES

4. Fuel supply facility

Gas burner, gas shutoff valve, gas vent valve, gas flow rate measuring device and gas flow rate control device is installed in the fuel supply system for fuel gas according to NFPA (National Fire Protection Association) standard and the like. Flow rate in the gas service pipe is planned in 30~40m/s in order to reduce pressure loss in the pipe and the sound of fluid. Also, the gas fuel heater may be provided for blast furnace gas (BFG) in order to improve the efficiency of the boiler.
High calorie gas such as LNG or LPG will be injected from the tip of the burner in high speed and be burnt. Dual shutoff valves are installed for each burner and the vent valve is installed between two shutoff valves as shown in Fig-5.

By-product gas such as BFG or COG has low calorific value and low gas pressure, it is required much gas flow. Therefore, it is necessary to turn the fuel and cross gas and air alternately, to promote of gas and air to keep good combustion. When applying exhaust gas such as BFG or COD generated from steel mill as the fuel for the boiler, the U-shaped water seal valve as shown in Fig-9, 10 and Photo-12 is provided on the boundary between the steel mill and the power plant for shutoff and the emergency gas shutoff valve to separate boiler is provided in general. The highly toxic carbon monoxide (CO) has been contained in these gases; it is necessary special attention as security measures such as gas detection of leakage or remaining gas in the pipe by CO gas detector. In addition, piping purge by nitrogen gas or steam and safety arrangement of vent pipe must be pay sufficient attention for safety.



《Valves》

A: Gas shutoff valve
B: Burner inlet shutoff valve
C_1: Burner header vent valve
C_2: Burner inlet vent valve
D_1: Minimum gas pressure holding valve
I: Charge valve for leak check
J: Gas pressure reducing valve
K: Relief valve
D: Gas flow control valve
T: Manual stop valve

《Equipments》

M: Flow meter
O: Strainer
P: Orifice
Q, R: Alarm for high gas pressure, pressure switch for low trip
S: Header pressure

Fig- 5: High calorie gas fuel system (NFPA-8502-1999)

Reference: P-109 of Journal (No.517: Oct. /1999): TENPES

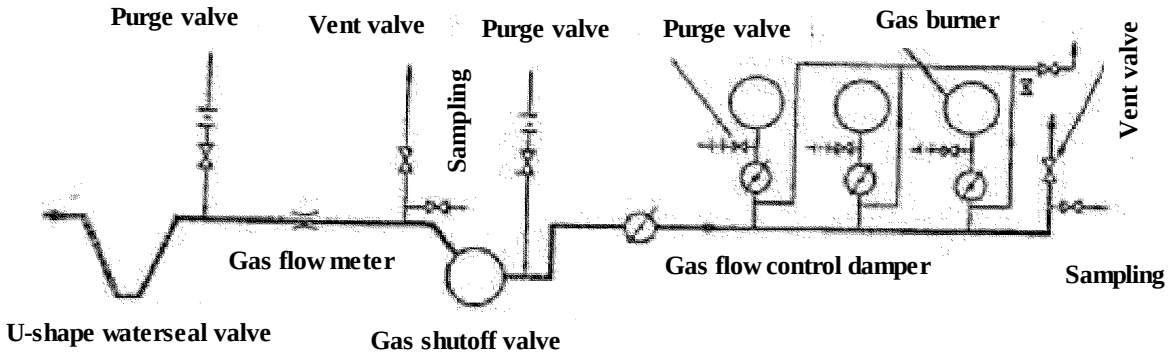


Fig- 6: Low calorie gas fuel system

Reference: P-110 of Journal (No.517: Oct. /1999): TENPES

5. Public safety and protection of the environment

National requirements which take precedence over the requirements in this International Standard must be specified by the country in which the pipeline is located. The requirements in this International Standard for public safety and protection of the environment must apply where no specific national requirements exist. On-land pipeline systems for category D and E fluids must meet the requirements for public safety of annex B where specific requirements for public safety have not been defined by the country in which the pipeline is located.

6. Requirements for operation and maintenance:

   The requirements for the operation and maintenance of the pipeline system must be established and documented for use in the design and the preparation of procedures for operations and maintenance. Aspects for which requirements must be specified may include:

   1) requirements for identification of pipelines, components and fluids transported;
   2) principles for system control, including consideration of manning levels and instrumentation;
   3) location and hierarchy of control centers;
   4) voice and data communications;
   5) corrosion management;
   6) condition monitoring;
   7) leak detection;
   8) pigging philosophy;
   9) access, sectionalizing and isolation for operation, maintenance and replacement;
   10) interfaces with upstream and downstream facilities;
   11) emergency shut-in;
   12) depressurization with venting and/or drainage;
   13) shutdowns and restart;
   14) requirements identified from the hydraulic analysis.

7. Public safety

   Pipelines conveying category B, C, D and E fluids must, where practicable, avoid built-up areas or areas with frequent human activity. In the absence of public safety requirements in a country, a safety evaluation must be performed in accordance with the general requirements of annex A for:

   1) pipelines conveying category D fluids in locations where multi-storey buildings are prevalent, where traffic is heavy or dense, and where there may be numerous other utilities underground;
   2) pipelines conveying category E fluids.

8. Environment

   An assessment of environmental impact must consider as a minimum:

   1) temporary works during construction, repair and modification;
   2) the long-term presence of the pipeline;
   3) potential loss of fluids.

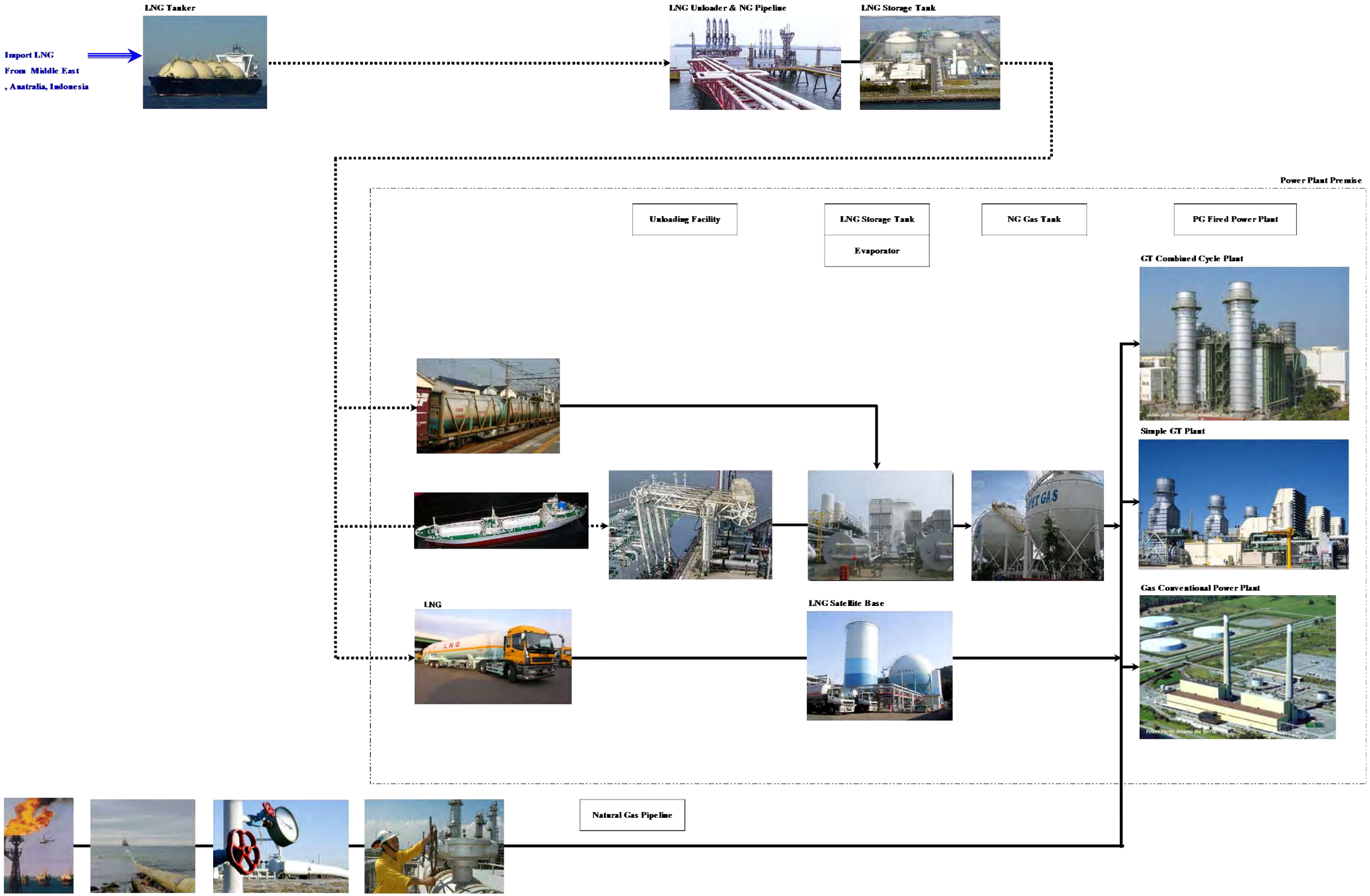


Fig- 7: Construction concept of fuel handling for gas thermal power plant (1)

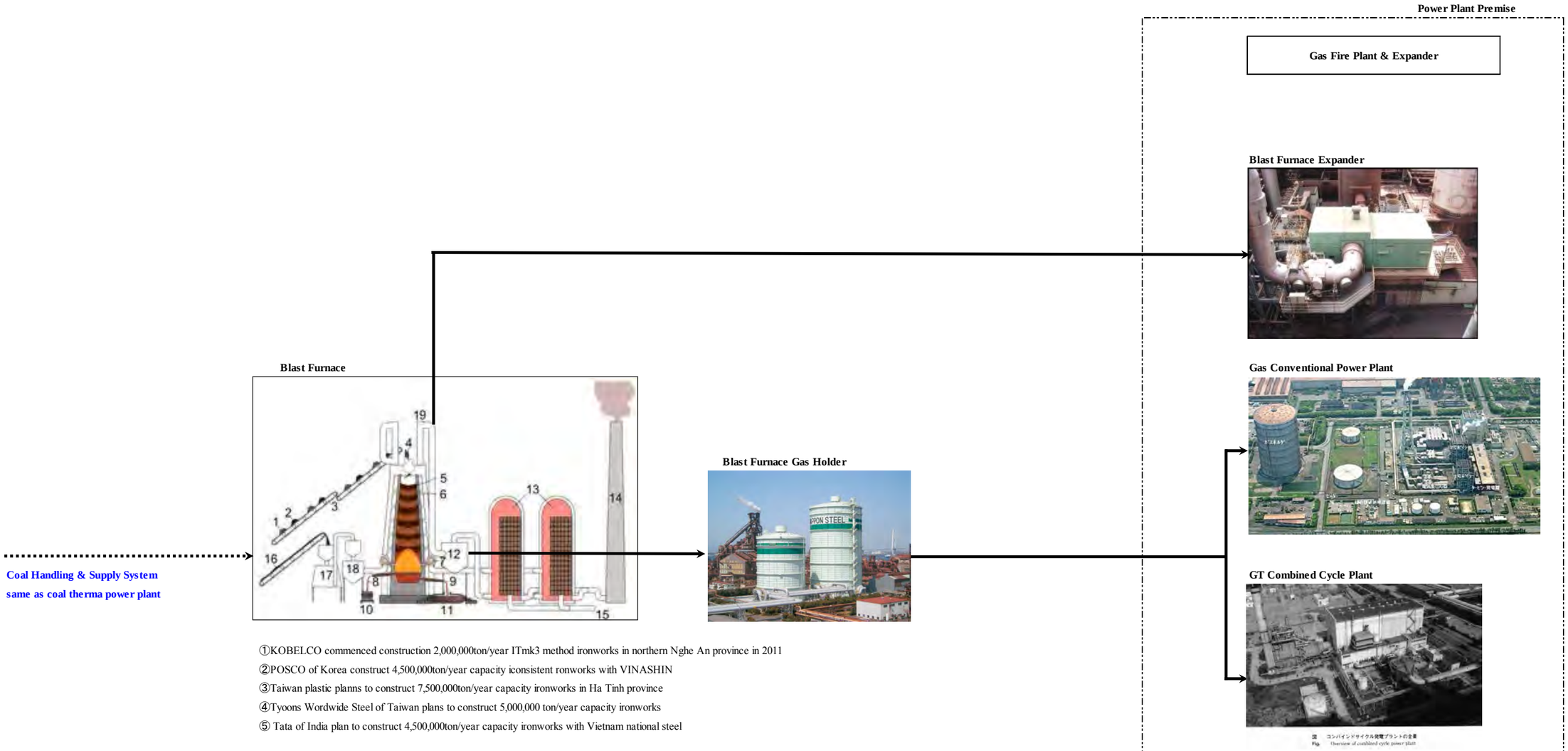


Fig- 8: Constitution concept of fuel handling for gas thermal power plant (2)

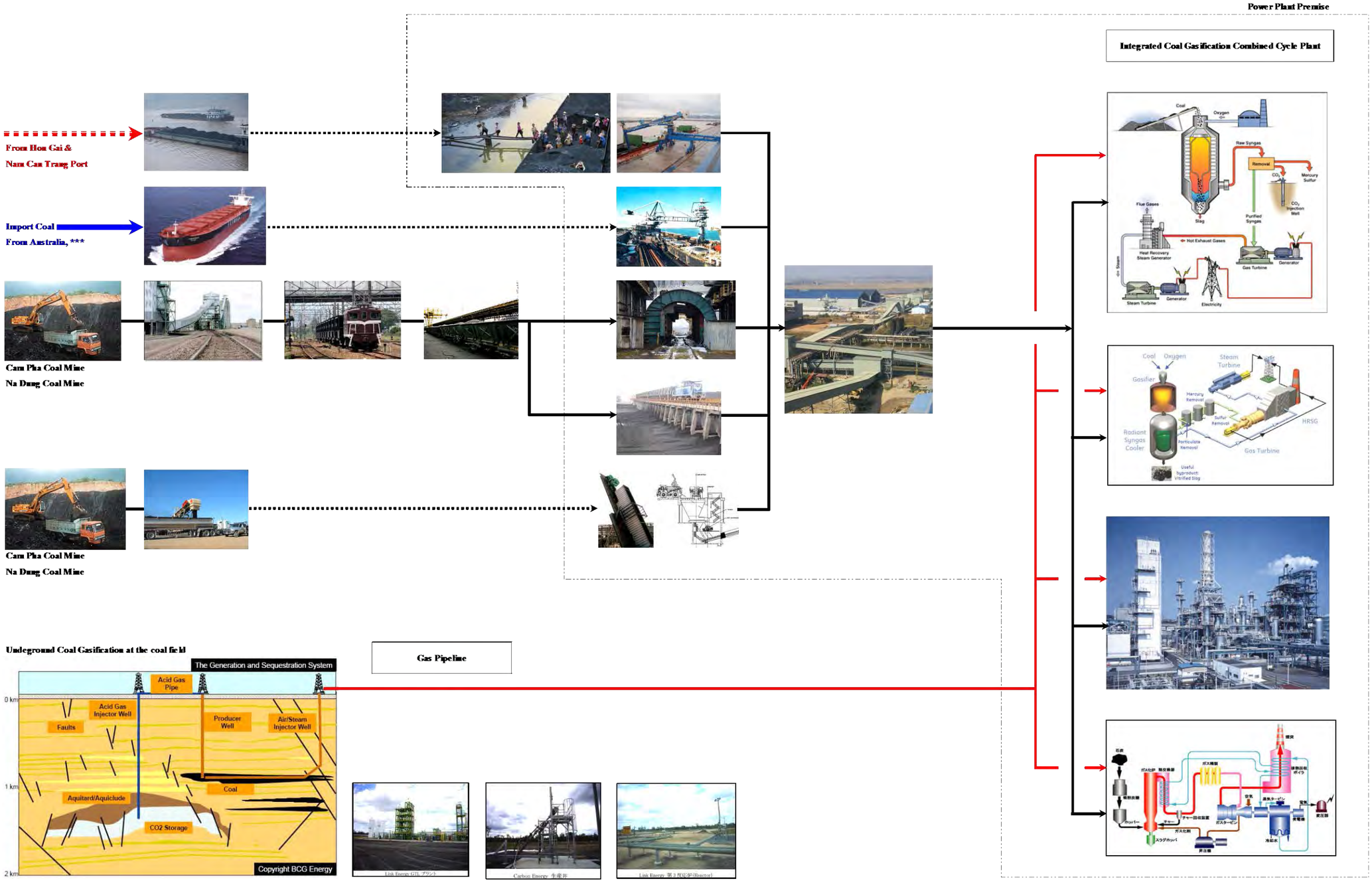


Fig- 9: Constitution concept of fuel handling for gas thermal power plant (3)

Article 115. Classification of gas pressure for gas facilities

Article 115-1. Classification of gas pressure for gas facility

1. The fluids to be transported must be placed in one of the following five categories as shown in Table-3 according to the hazard potential in respect of public safety:

Table- 3: Categorization of Fluids

Category A	Typically non-flammable water-based fluids.
Category B	Flammable and/or toxic fluids which are liquids at ambient temperature and at atmospheric pressure conditions. Typical examples are oil and petroleum products. Methanol is an example of a flammable and toxic fluid.
Category C	Non-flammable fluids which are non-toxic gases at ambient temperature and atmospheric pressure conditions. Typical examples are nitrogen, carbon dioxide, argon and air.
Category D	Non-toxic, single-phase natural gas.
Category E	Flammable and/or toxic fluids which are gases at ambient temperature and atmospheric pressure conditions and are conveyed as gases and/or liquids. Typical examples are hydrogen, natural gas (not otherwise covered in category D), ethane, ethylene, liquefied petroleum gas (such as propane and butane), natural gas liquids, ammonia and chlorine.

Reference: 5.2 of ISO 13623-2000

Gases or liquids not specifically included by name must be classified in the category containing fluids most closely similar in hazard potential to those quoted. If the category is not clear, the more hazardous category must be assumed.

2. Pressure for the gas pipeline is classified into 4 categories according to the maximum operating pressure as shown in Table-4.

Table- 4: Classification of Gas Pressure for Gas Facilities

Class	Pressure (MPag)	Object
Very High Pressure	$7.0 \leq P$	Long range transportation from gas field by pipeline
High Pressure	$1.0 \leq P < 7.0$	Middle range transportation from gas base by pipeline
Middle Pressure	$0.2 \leq P < 1.0$	Short range transportation by pipeline
Low Pressure	$P < 0.2$	For home use

Article 116. Incoming gas pipeline

1. Gas fuel for gas-fired power plant is supplied in the following major routes.

    1) Natural gas that has been mined in the onshore gas field is supplied to the power plant by pipeline.
    2) Natural gas that has been mined in the offshore gas field is supplied to the power plant by pipeline.
    3) Imported LNG or LPG is brought into power plant premise and use vaporized gas as gas fuel.
    4) Vaporized gas from imported LNG or LPG in the base is supplied to power plant by pipeline.
    5) Residual gas generated from the adjacent oil refinery plant is supplied to power plant by pipeline.
    6) Blast furnace gas, converter gas and coke oven gas that has been generated in the steel mill is supplied to the power plant by pipeline.
    7) Gas that is gasificated from coal which is brought into power plant is applied to the fuel for IGCC.
    8) Gasificated gas from coal reserved in the coal seam is extracted and supplied to the power plant by pipeline.
    9) Coal seam gas that is reserved in the underground coal seam is extracted and supplied to the power plant by pipeline.
    10) Bio-gas generated from biomass processing facility is supplied to power plant.

2. The construction concept of transportation path and combination of transportation facility are shown in Fig-5, 6 and 7.
3. Natural gas drilled in the offshore gas field as shown in Photo-1 is compressed by compressor on the platform as shown in Photo-2 and Fig-8, land on the beach and switch to the onshore pipeline as shown in Photo-3 after transporting by offshore pipeline. It is transported to inland power plant by buried pipeline or pipeline on the land as shown in Photo-4 and 5 in a long distance. It is received as shown in Photo-6 and 7, and combusted in the boiler or gas turbine after the pressure adjustment.

Photo- 1: Gas rig in Nam Con Son

http://menasassociates.blogspot.com/2010/07/mounting-interest-in-bps-nam-con-son.html

Photo- 2: Gas compression module

http://www.khi.co.jp/news/detail/20101206_1.html

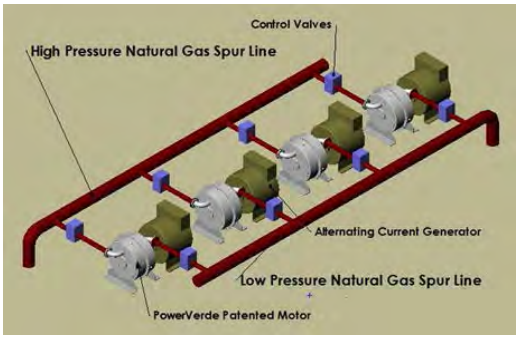


Fig- 10: Natural gas compression station

http://www.powerverdeenergy.com/natural-gas/

Photo- 3: Natural gas pipeline in Nam Con Son

http://www.aerialmarine.com/bp-nam-con-son-onshore-aerial-vietnam-BP-lan-tay

Photo- 4: Gas piprline from Nam Con son field

http://www.aerialmarine.com/bp-nam-con-son-onshore-aerial-vietnam-BP-lan-tay

Photo- 5: Natural gas pipeline in Nam Con Son

http://www.vrbank.com.vn/NewsShow1.aspx?id=131&lang=en

Photo- 6: Natural gas pipeline in Nam Con Son

http://www.uni-bros.com/en/news.php/more_than_440mil_usd_invested_in_nam_con_son_gas_pipeline_2_project/id=18264/cid=3

Photo- 7: Fuel gas for Phu My 3 power plant

http://www.vrbank.com.vn/NewsShow1.aspx?id=131&lang=en

Article 116-1. Length of pipeline

1. Route selection

(1) General

Route selection must take into account the design, construction, operation, maintenance and abandonment of the pipeline in accordance with this International Standard. To minimize the possibility of future

corrective work and limitations, anticipated urban and industry developments must be considered. Factors which must be considered during route selection include:

1) safety of the public, and personnel working on or near the pipeline;
2) protection of the environment;
3) other property and facilities;
4) third-party activities;
5) geotechnical, corrosivity and hydrographical conditions;
6) requirements for construction, operation and maintenance;
7) national and/or local requirements;
8) future exploration.

Note: Annex-C provides guidance on the planning of a route selection. Annex D provides examples of factors which must be addressed during the considerations required in 6.2.1.1 to 6.2.1.7.

(2) Public safety

Pipelines conveying category B, C, D and E fluids should, where practicable, avoid built-up areas or areas with frequent human activity. In the absence of public safety requirements in a country, a safety evaluation must be performed in accordance with the general requirements of annex A for:

1) pipelines conveying category D fluids in locations where multi-storey buildings are prevalent, where traffic is heavy or dense, and where there may be numerous other utilities underground;
2) pipelines conveying category E fluids.

(3) Environment

An assessment of environmental impact must consider as a minimum:

1) temporary works during construction, repair and modification;
2) the long-term presence of the pipeline;
3) potential loss of fluids.

(4) Other facilities

Facilities along the pipeline route which may affect the pipeline must be identified and their impact evaluated in consultation with the operator of these facilities.

(5) Third-party activities

Third-party activities along the route must be identified and should be evaluated in consultation with these parties.

(6) Geotechnical, hydrographical and meteorological conditions

Adverse geotechnical and hydrographic conditions must be identified and mitigating measures defined. In some instances, such as under arctic conditions, it may be necessary also to review meteorological conditions.

(7) Construction, testing, operation and maintenance

The route must permit the required access and working width for the construction, testing, operation and maintenance, including any replacement, of the pipeline. The availability of utilities necessary for construction, operation and maintenance must also be reviewed.

2. Surveys — Pipelines on land

Route and soil surveys must be carried out to identify and locate with sufficient accuracy the relevant geographical, geological, geotechnical, corrosivity, topographical and environmental features, and other facilities such as other pipelines, cables and obstructions, which could impact the pipeline route selection.

3. Surveys — Offshore pipelines

Route and soil surveys must be carried out on the proposed route to identify and locate:

1) geological features and natural hazards;
2) pipelines, cables and wellheads;
3) obstructions such as wrecks, mines and debris;
4) geotechnical properties.

Meteorological and oceanographical data required for the design and construction planning must be collected. Such data may include:

1) bathymetry;
2) winds;
3) tides;
4) waves;
5) currents;
6) atmospheric conditions;
7) hydrologic conditions (temperature, oxygen content, pH value, resistivity, biological activity, salinity);
8) marine growth;
9) soil accretion and erosion.

4. Spanning of valve station (shutoff device).

It is the best way to keep gas pressure high and prevent pressure drop in order to transport large amount of gas efficiently. However, the proper balance of both is required, since numbers of pumping station is required and the capital investment increases. When 2~3MPa pressure drop from discharge pressure (8~9MPa) occurs, which the pressure in the pipeline is ensured in average 6MPa, the new pumping station will be installed in general. The different system may be established due to different requirement, the method to install two pipelines instead of pumping station to avoid pressure drop is employed depending on the pipeline route. In any case, the consideration of laying space for route selection and how to set the pipeline diameter and pressure is the biggest issue in order to establish optimal pipeline system.

Table- 5: Spanning of valve station (shutoff device)

ANSI/ASME B31.8 (US)			Pipeline Business Act (JP)	
Classification	Span	Remarks	Span	Remarks
Class-1	32km (20mile)	Sparsely polluted area such as wasteland, desert, meadow	Necessary part	River crossing
Class-2	24km (15mile)	Periphery of towns and city districts, industrial zones	10km	Non-urban area
Class-3	16km (10mile)	Residential development district on outskirts	4km	Urban area
Class-4	8km (5mile)	Downtown (many high-rise buildings and large volume of traffic)	1km	House densed Area (1)

Note-(1): The population density which is calculated for each parcel of land roughly the following formatting 50ha, the area of land that have been more than 40 men/ha and the area that has population not less than 5,000.

Article 116-2. Buried pipeline

Photo- 8: Warning sign for buried pipeline

http://www.tsc.uk.net/search.php?group=1&searchtext=&start=40

Photo- 9: Buried gas pipeline

http://www.geograph.org.uk/photo/899546

Photo- 10: Buried gas pipeline

http://news.bbc.co.uk/2/hi/in_pictures/6147424.stm

Photo- 11: Buried gas pipeline

http://www.hydrocarbons-technology.com/projects/southwalesgas/southwalesgas4.html

Article 116-3. Drain slope

1. The most important consideration when building pipelines is accounting for the slope the pipeline will follow. Slope is the gradual and sustained downward angle the pipeline follows so gravity can move the media to its destination. Although some pipelines are pressurized to pump media, even in these designs, the slope is still necessary for them to successfully cover great distances.
2. A pipeline does not always have to travel downhill. It can be flat or even go uphill for some distance. The important calculation, however, is that the overall length of pipeline ends in a lower location than it begins. Accounting for the slope of just 1 foot over several thousand feet can be the difference between a well-functioning pipeline and a clogged pipe moving very little.

Article 116-4. Water seal valve

1. When large volume and low pressure BFG, COD and LDG generated in the steel mill is used as the fuel for thermal power plant, the water seal valve as shown in Fig-12m Photo-12 is installed at the boundary between steel mill and power plant, and gas is blocked reliably apart from the boiler emergency gas shutoff valve. In addition, the reverse flow from gasholder to each furnace in the steel mill is prevented by the water seal valve with check valve function as shown in Fig-11.

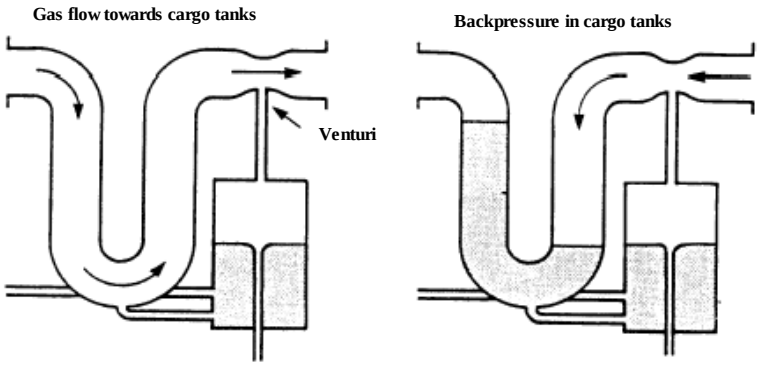


Fig- 11: Water seal valve for BFG gas

http://www.tc.gc.ca/eng/marinesafety/tp-tp4295-part-iii-2241.htm

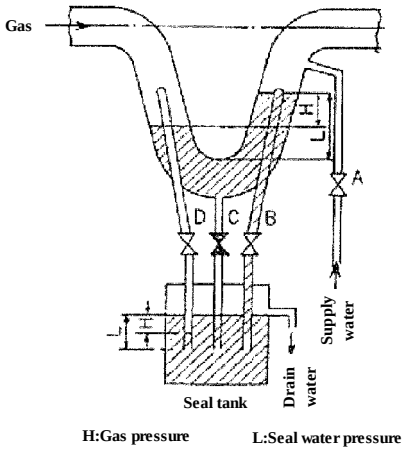


Fig- 12: U-shape water sela valve

Reference: P-51 of Journal (No.590: Nov. /2005): TENPES

Photo- 12: U-shape water sela valve

http://www.shinkoen-m.jp/product/kikai/sske/haikan.html

Article 116-5. Purge system

1. Purging of Pipelines and Mains

(1) When a pipeline or main is to be placed in service, the air in it must be displaced. The following are some acceptable methods:

1) Introduce a moderately rapid and continuous flow of gas into one end of the line and vent the air out the other end. The gas flow must be continued without interruption until the vented gas is free of air.
2) If the vent is in a location where the release of gas into the atmosphere may cause a hazardous condition, then a slug of inert gas must be introduced between the gas and air. The gas flow must then be continued without interruption until all of the air and inert gas have been removed from the facility. The vented gases must be monitored and the vent must be closed before any substantial quantity of combustible gas is released to the atmosphere.

(2) In cases where gas in a pipeline or main is to be displaced with air and the rate at which air can be supplied to the line is too small to make a procedure similar to but the reverse of that described in (a) above feasible, a slug of inert gas must be introduced to prevent the formation of an explosive mixture at the interface between gas and air. Nitrogen or carbon dioxide can be used for this purpose.

(3) If a pipeline or main containing gas is to be removed, the operation may be carried out in accordance with para.

2. The line may be first disconnected from all sources of gas and then thoroughly purged with air, water, or inert gas before any further cutting or welding is done.

(1) If a gas pipeline, main or auxiliary equipment is to be filled with air after having been in service and there is a reasonable possibility that the inside surfaces of the facility are wetted with volatile inflammable liquid, or if such liquids might have accumulated in low places, purging procedures designed to meet this situation must be used. Steaming of the facility until all combustible liquids have been evaporated and swept out is recommended. Filling of the facility with an inert gas and keeping it full of such gas during the progress of any work that might ignite an explosive mixture in the facility is an alternative recommendation. The possibility of striking static sparks within the facility must not be overlooked as a possible source of ignition.

3. Whenever the accidental ignition in the open air of gas-air mixture might be likely to cause personal injury or property damage, precautions must be taken. For example:

   1) Prohibit smoking and open flames in the area.
   2) Install a metallic bond around the location of cuts in gas pipes to be made by means other than cutting torches.
   3) Take precautions to prevent static electricity sparks.
   4) Provide a fire extinguisher of appropriate size and type, in accordance with ANSI/NFPA 10

Article 116-6. Insulation against direct sunshine

1. Natural gas is moved through a pipeline under pressure. As natural gas flows through a pipeline, it loses pressure due to friction against the inside of the pipe. To keep the natural gas moving at the desired rate, the pressure must be increased. This is accomplished with compressor stations located along a pipeline.
2. The temperature of the natural gas will slowly decrease in the pipeline, along with the pressure. The temperature decreases due to the pressure reduction. As a result, the natural gas cools. The pressure of the natural gas must be increased along the pipeline through the use of compressor stations. When compressor stations increase the pressure of the natural gas, the temperature of the natural gas rises. The natural gas must be cooled to minimize impacts on the pipeline and permafrost.
3. Design temperature and coating for gas pipeline.

Table- 6: Design temperature and coating for gas pipeline

Region	Temperature (^{o}C)			Coating type	
	Design	Actual ambient	Actual pipe surface	Type	Max. operating temperature
Desert	110	35 ~ 45	65 and more	3LPP	110 ~ 140
				3LPE	85 ~ 90
Rainforest	90	35 ~ 47	65 and more	FBE	85 ~ 90
Cold climate	X100 X120	-35 ~ -45	?	3LPE	85 ~ 90
				HPCC	85

Note: 3LPP: 3-layer polypropylene, 3PE: 3-layer polyethylene, FBE: fusion bonded epoxy, HPCC: High performance composite coating

Reference: "High temperature pipeline coatings – Fielde joint challenges in remote construction": (Wayne Hodgins and others of Canusa-CPS)

Article 116-7. Supporting system

1. Pipeline spanning

Spans in pipelines must be controlled to ensure compliance with the strength criteria in Table-13. Due consideration must be given to:

1) support conditions;
2) interaction with adjacent spans;
3) possible vibrations induced by wind, current and waves;
4) axial force in the pipeline;
5) soil accretion and erosion;
6) possible effects from third-party activities;
7) soil properties.

2. Support

The typical support of pipeline is shown in Fig-23 and Photo-60, 61

(1) Support span

Table- 7: Suggested pipe support spacing (ASME B31.1-2004)

Nominal pipe size	Suggested maximum span			
	Water service		Steam, gas or air service	
NPS	(ft)	(m)	(ft)	(m)
1	7	2.1	9	2.7
2	10	3.0	13	4.0
3	12	3.7	15	4.6
4	14	4.3	17	5.2
6	17	5.2	21	6.4
8	19	5.8	24	7.3
12	23	7.0	30	9.1
16	27	8.2	35	10.7
20	30	9.1	39	11.9
24	32	9.8	42	12.8

3. Attachment of supports or anchors

The pipeline and equipment must be adequately supported, so as to prevent or to damp out excessive vibration, and must be anchored sufficiently to prevent undue loads on connected equipment. Branch connections for pipelines on land must be supported by consolidated backfill or provided with adequate flexibility.

When openings are made in a consolidated backfill to connect new branches to an existing pipeline on land, a firm foundation must be provided for both the header and the branch to prevent both vertical and lateral movements. Braces and damping devices required to prevent vibration of piping must be attached to the carrier pipe by full encirclement members.

All attachments to the pipeline must be designed to minimize the additional stresses in the pipeline. Proportioning and welding strength requirements of attachments must conform to standard structural practice. Structural supports, braces or anchors must not be welded directly to pipelines designed to operate at a hoop stress of 50 % or more of SMYS. Instead, such devices must be supported by a full encirclement member.

Where it is necessary to provide positive support, as at an anchor, the attachment must be welded to the encircling member and not to the pipe. The connection of the pipe to the encircling member must be by continuous circumferential rather than intermittent welds.

Supports not welded to the pipeline must be designed to allow access for inspection of the pipeline underneath the supports. Design of anchor blocks to prevent axial movement of a pipeline must take into account the pipeline expansion force and any pipe-to-soil friction preventing movement. The design of the full encirclement member must include the combined stress in the carrier pipe of the functional, environmental, construction and accidental loads. Attachment of the full encirclement member may be by clamping or continuous full encirclement welds.

The axial force, F, to be resisted for fully restrained pipelines must be calculated as follows:

$$F = A \times \left[E \times \alpha \times \left(T_2 - T_1 \right) - v \times \sigma_{hp} \right]$$

Where

F	: axial force
A	: cross-section area of pipewall
E	: modulus of elasticity
α	: linear coefficient of thermal expansion
T_1	: installation temperature
T_2	: maximum or minimum metal temperature during operation
α_{hp}	: hoop stress due to internal pressure, based on nominal wall thickness
v	: poisson ratio

Significant residual installation loads shall also be taken into account when determining axial pipeline forces.

Article 116-8. Joint of gas pipeline

1. "The measure to make it possible to check the joints and to prevent spread of dangerous material" must be taken in the place where the dangerous material may scatter outside the premise when leaking from the flange joint which is installed in the premise. And it must be pursuant to as follows;

(1) The check box must have watertight, robust and durable structure with drain valve and lid.
(2) Material of the check box must be used the steel plates with at least 1.6mm thickness.
(3) Corrosion protection measures must be performed by corrosion protection coating.
(4) The check box must not interfere with the structure of piping and the effective depth (distance between bottom of joint and bottom of the check box) must be at least 10cm.
(5) The reservoir must be provided, if the distance from ground level to the lowest point of check box is more than 5cm.

2. Flanged connections

(1) Flanged connections must meet the requirements of ISO 7005-1, or other recognized codes such as ASME B16.5 or MSS SP-44. Proprietary flange designs are permissible. They must conform to relevant sections of ASME Section VIII, Division 1 as shown in Photo-44, 45 and Fig-17.

(2) Compliance with the design requirements of ASME B16.5 must be demonstrated when deviating from the flange dimensions and drillings specified in ASME B16.5 or MSS SP-44.

(3) Consideration must be given to matching the flange bore with the bore of the adjoining pipe wall to facilitate alignment for welding.

(4) Gaskets must be made of materials which are not damaged by the fluid in the pipeline system and must be capable of withstanding the pressures and temperatures to which they will be subjected in service. Gaskets for services with operating temperatures above 120 °C must be of non-combustible materials.

(5) Bolt material must be in accordance with ASTM A193 B7 or equivalent. Nut material must be in accordance with ASTM A194 2H or equivalent. Bolts or stud bolts must completely extend through the nuts.

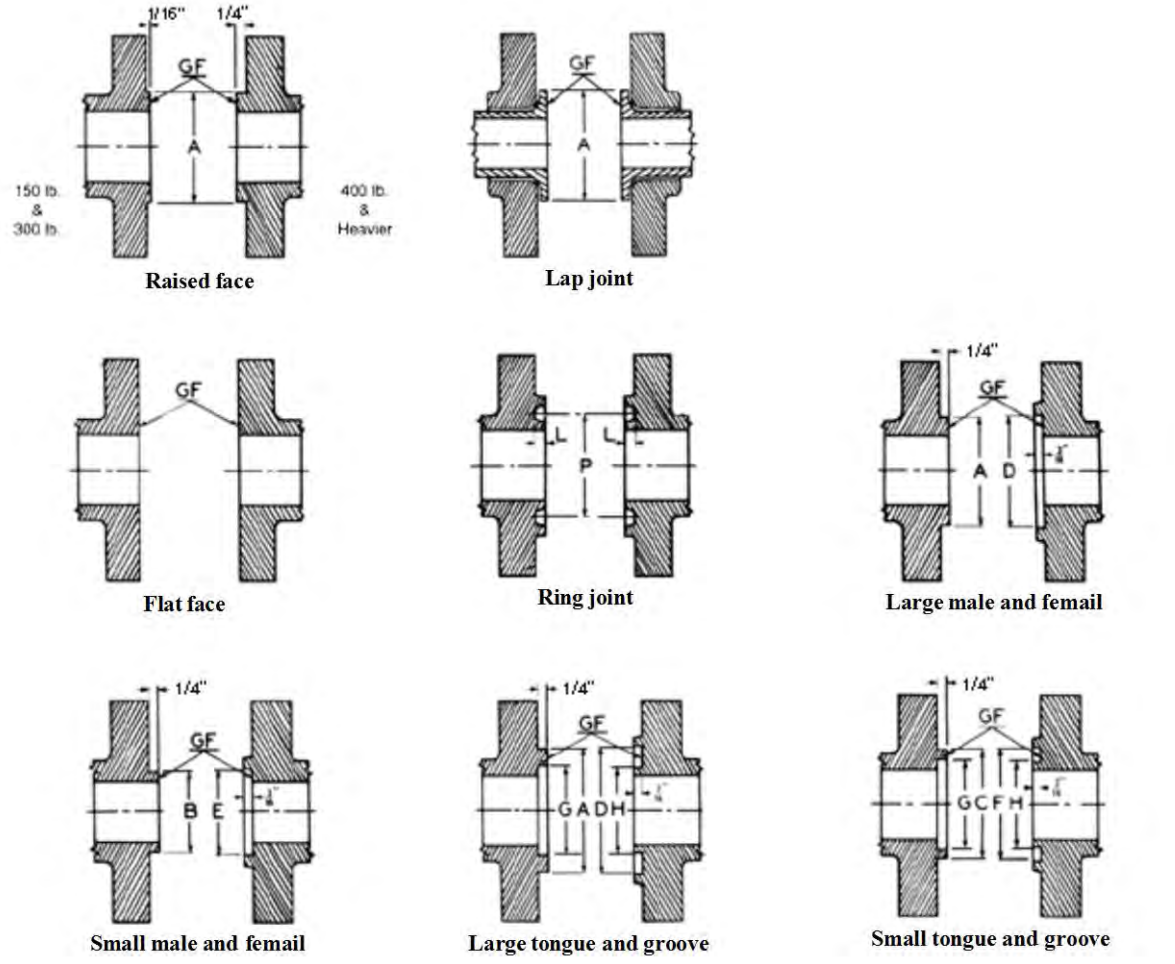


Fig- 13: Steel joint flanges

http://www.rjsales.com/products/ansi_asme_flanges/misc/b.html

Photo- 13: Flange joint

http://www.flickr.com/photos/norbar/6079336087/in/set-72157626473837695

Photo- 14: Flange joint

http://www.flickr.com/photos/norbar/6079420175/in/set-72157626473837695

Article 116-9. Trace heating for water seal valve

1. It is not necessary to consider the prevention measure for freeze of water in the seal water valve except in cold climate region.

Article 116-10. Painting

1. External coating

   All external and internal coatings must comply with a recognized standard or specification, covering the following requirements:

   1) type of coating and reinforcement, where relevant;
   2) thickness of individual layers and total thickness;
   3) composition and/or base material;
   4) mechanical properties;
   5) temperature limitations;
   6) surface preparation requirements;
   7) adhesion requirements;
   8) requirements for materials, application and curing, including possible requirements for health, safety and environmental aspects;
   9) requirements for qualification testing of coating system and personnel where relevant;
   10) requirements for testing and inspection;
   11) repair procedures where relevant.

2. Internal coatings/linings

   Internal coating must in general comply with the requirements of paragraph-3 if applied to mitigate internal corrosion. Anti-friction coatings must as a minimum comply with API RP 5L2 and have a minimum thickness of 40 μm. The coating may consist of an epoxy base and a curing agent based on epoxy aliphatic/cycloaliphatic amine or polyamide.

3. Internal coatings or linings

Coatings or linings may be applied to reduce internal corrosion provided that it is demonstrated that incomplete protection, at areas such as holidays and other defects, does not lead to unacceptable corrosion. Factors to be considered during coating or lining selection must include:

1) internal coating of field joints;
2) application methods;
3) availability of repair methods;
4) operating conditions;
5) long-term effects of the fluid(s) on the coating/lining;
6) resistance to pressure change;
7) influence of temperature gradients over the coating;
8) compatibility with pigging operations.

4. Field coating

Field-applied coatings must satisfy the requirements of paragraph-1. The preparation of the pipe surface and the application of the field joint coating must be performed in accordance with a qualified procedure that meets the requirements of the coating manufacturer's recommendations. Coating must be applied by competent operators who have received adequate instruction.

Article 116-11. Location of vent pipe

1. Pressure relief station

It consists of equipment installed to vent gas from a system being protected to prevent the gas pressure from exceeding a predetermined limit. The gas may be vented into the atmosphere or into a lower pressure system capable of safely absorbing the gas being discharged. Included in the station are piping and auxiliary devices, such as valves, control instruments, control lines, the enclosure, and ventilating equipment, installed in accordance with the pertinent requirements of this Code.

2. Purging of pipelines and mains

(1) When a pipeline or main is to be placed in service, the air in it must be displaced. The following are some acceptable methods:

1) Introduce a moderately rapid and continuous flow of gas into one end of the line and vent the air out the other end. The gas flow must be continued without interruption until the vented gas is free of air.
2) If the vent is in a location where the release of gas into the atmosphere may cause a hazardous condition, then a slug of inert gas must be introduced between the gas and air. The gas flow must then be continued without interruption until all of the air and inert gas have been removed from the facility. The vented gases must be monitored and the vent must be closed before any substantial quantity of

combustible gas is released to the atmosphere.

3. Venting

   Vent lines provided to exhaust the gas from the pressure relief valves to atmosphere must be extended to a location where the gas may be discharged without undue hazard. Vent lines must have sufficient capacity so that they will not inhibit the performance of the relief valve.

Article 116-12. Purge steam or gas

1. When pipeline segments are taken out of service for operational or maintenance purpose, it is common practice to depressurize the pipeline and vent the natural gas to the atmosphere. To prevent these emissions, partners reported using pigs and inert gas to purge pipelines.

   In implementing this practice, a pig is inserted into the isolated section of pipeline. Inert gas is then pumped in behind the pig, which pushes natural gas through the product line. At the appropriate shutoff point, the pig is caught in a pig trap and the pipeline blocked off. Once the pipeline is "gas-free" the inert gas is vented to the atmosphere.
2. For existing main:

   1) Purge line with N_2. Use detector in % Vol only (purge) mode (also measures O_2) to verify that O_2 reading is 0.5% or less, and gas reading 2% or less, to verify purge.
   2) Open line and perform service. This will introduce air into the main.
   3) Purge again with N_2. Use detector in % Vol only mode (also measures O_2) to verify that O_2 reading is 0.5% or less.
   4) Open upstream valve to charge line with gas. Use detector in % Vol only mode (also measures O_2) to verify that gas reading is 98% or more.

3. For new main:

   1) Purge line with N_2. Use detector in % Vol only mode (also measures O_2) to verify that O_2 reading is 0.5% or less, to verify purge of air from line.
   2) Open upstream valve to charge line with gas. Use detector in % Vol only mode (also measures O_2) to verify that gas reading is 98% or more.

Article 116-13. Vent pipe

1. When new natural gas mains are installed or existing mains removed from service, crews must purge the mains with an inert gas to eliminate the potential hazard of a combustible mixture. The most commonly used and preferred purge gas is nitrogen. After the purge is conducted an upstream valve is opened to allow natural gas to enter. A service valve on the line (usually a needle valve) with a stand pipe or diffuser attached is cracked to allow venting gas or nitrogen to escape.

Photo- 15: Purging of gas pipeline

http://www.csb.gov/newsroom/detail.aspx?nid=319

Photo- 16: Purging of gas pipeline

http://www.nao.com/txeasternpipeline.htm

Article 116-14. Vent valve and purge valve

1. "Blow" and "purge" are terms that have different definitions in various segment of the natural gas industry. Blow (also called "blowdown") emissions refer to the venting of natural gas contained inside a pressure vessel, pipeline, or other equipment to the atmosphere. Purge is the process of clearing air from equipment by displacing it with natural gas; in the process, some purge gas is emitted as the air is evacuated from the equipment.
2. Maintenance activities requiring blowdown provide a safe working environment when it is necessary to enter a vessel, in which case, all flammable gas must be removed. Linkewise, a reduction in the internal flammable gas inventory may be required for external equipment maintenance. Conversely, when equipment previously open to the atmosphere is placed back in cervices, air must be removed (or purged) to prevent a flammable mixture of gas and oxygen. An operation may displaced the air directly with natural gas or with an inert gas, such as nitrogen, and then displace the nitrogen with natural gas. Depending on the specific company equipment and practices, an operator may also vent some of the nitrogen and natural gas mixture to the atmosphere to reduce the inert gas concentration before the equipment is placed back in service.

Photo- 17: Purging of gas pipeline

http://www.rkiinstruments.com/pages/application_briefs/Purge_Test_Procedure.htm

Photo- 18: Venting station on natural gas pipeline

Article 116-15. Drain system

1. Installation of Service Lines

   Where there is evidence of condensate in the gas in sufficient quantities to cause interruptions in the gas supply to the customer, the service line shall be graded so as to drain into the main or to drips at the low points in the service line.

Article 117. Material of gas transportation facility

Article 117-1. Material of Gas Transportation Facility

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 so called "standard material");

   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”

Table- 8: Pipeline material stipulated in API 5L/ISO 3183

Grade	YS min. /max. (MPa)	TS min. /max. (MPa)
L245/B	245/ 450	415/ 760
L290/X42	290/ 495	415/ 760
L320/X46	320/ 525	435/ 760
L360/X52	360/ 530	460/ 760
L390/X56	390/ 545	490/ 760
L415/X60	415/ 565	520/ 760
L450/X65	450/ 600	535/ 760
L485/X70	485/ 635	570/ 758
L555/X80	555/ 705	625/ 825
L625/X90	625/ 775	695/915
L690/X100	690/ 840	760/ 990
L830/X120	830/ 1050	915/ 1145

Note: YS: Yield stress, TS: tensile strength

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.

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 Sec. Ⅷ 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 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 118. Structure, etc. of gas facility

Article 118-1. Pipeline installed in the sea or on land

1. Design principles

The extent and detail of the design of a pipeline system must be sufficient to demonstrate that the integrity and serviceability required by this International Standard can be maintained during the design life of the pipeline system.

Representative values for loads and load resistance must be selected in accordance with good engineering practice. Methods of analysis may be based on analytical, numerical or empirical models, or a combination of these methods.

Principles of reliability-based limit state design methods may be applied, provided that all relevant ultimate and serviceability limit states are considered. All relevant sources of uncertainty in loads and load resistance must be considered and sufficient statistical data must be available for adequate characterization of these uncertainties.

Reliability-based limit state design methods must not be used to replace the requirement in 10.2 for the maximum permissible hoop stress due to fluid pressure.

Note: Ultimate limit states are normally associated with loss of structural integrity, e.g. rupture, fracture, fatigue or collapse, whereas exceeding serviceability limit states prevents the pipeline from operating as intended.

2. Route selection

Route selection must take into account the design, construction, operation, maintenance and abandonment of the pipeline in accordance with this International Standard. To minimize the possibility of future corrective work and limitations, anticipated urban and industry developments must be considered. Factors which shall be considered during route selection include:

1) safety of the public, and personnel working on or near the pipeline;
2) protection of the environment;
3) other property and facilities;
4) third-party activities;
5) geotechnical, corrosivity and hydrographical conditions;
6) requirements for construction, operation and maintenance;
7) national and/or local requirements;
8) future exploration.

3. Public safety

Pipelines conveying category B, C, D and E fluids must, where practicable, avoid built-up areas or areas with frequent human activity. In the absence of public safety requirements in a country, a safety evaluation must be performed in accordance with the general requirements of Annex A for:

1) pipelines conveying category D fluids in locations where multi-storey buildings are prevalent, where traffic is heavy or dense, and where there may be numerous other utilities underground;
2) pipelines conveying category E fluids.

4. Environment

An assessment of environmental impact must consider as a minimum:

1) temporary works during construction, repair and modification;
2) the long-term presence of the pipeline;
3) potential loss of fluids.

5. Other facilities

Facilities along the pipeline route which may affect the pipeline must be identified and their impact evaluated in consultation with the operator of these facilities.

6. Surveys

6.1 Pipelines on land

Route and soil surveys must be carried out to identify and locate with sufficient accuracy the relevant geographical, geological, geotechnical, corrosivity, topographical and environmental features, and other facilities such as other pipelines, cables and obstructions, which could impact the pipeline route selection.

6.2 Offshore pipelines

Route and soil surveys must be carried out on the proposed route to identify and locate:

1) geological features and natural hazards;
2) pipelines, cables and wellheads;
3) obstructions such as wrecks, mines and debris;
4) geotechnical properties.

Meteorological and oceanographical data required for the design and construction planning must be collected. Such data may include:

1) bathymetry;
2) winds;
3) tides;
4) waves;
5) currents;

6) atmospheric conditions;
7) hydrologic conditions (temperature, oxygen content, pH value, resistivity, biological activity, salinity);
8) marine growth;
9) soil accretion and erosion.

7. Loads

7.1 General

Loads, which may cause or contribute to pipeline failure or loss of serviceability of the pipeline system, must be identified and accounted for in the design. For the strength design, loads must be classified as:

1) functional; or
2) environmental; or
3) construction; or
4) accidental.

7.2 Functional loads

(1) Classification

Loads arising from the intended use of the pipeline system and residual loads from other sources must be classified as functional.

Note : The weight of the pipeline, including components and fluid, and loads due to pressure and temperature are examples of functional loads arising from the intended use of the system. Pre-stressing, residual stresses from installation, soil cover, external hydrostatic pressure, marine growth, subsidence and differential settlement, frost heave and thaw settlement, and sustained loads from icing are examples of functional loads from other sources. Reaction forces at supports from functional loads and loads due to sustained displacements, rotations of supports or impact by changes in flow direction are also functional.

(2) Internal design pressure

The internal design pressure at any point in the pipeline system must be equal to or greater than the maximum allowable operating pressure (MAOP). Pressures due to static head of the fluid must be included in the steady-state pressures. Incidental pressures during transient conditions in excess of MAOP are permitted, provided they are of limited frequency and duration, and MAOP is not exceeded by more than 10 %.

Note: Pressure due to surges, failure of pressure control equipment, and cumulative pressures during activation of over-pressure protection devices are examples of incidental pressures. Pressures caused by heating of blocked-in static fluid are also incidental pressures, provided blocking-in is not a regular operating activity.

(3) Temperature

The range in fluid temperatures during normal operations and anticipated blowdown conditions must be

considered when determining temperature-induced loads.

7.3 Environmental loads

(1) Classification

Loads arising from the environment must be classified as environmental, except where they need to be considered as functional (see 7.2) or when, due to a low probability of occurrence, as accidental (see 7.4).

Examples: Loads from waves, currents, tides, wind, snow, ice, earthquake, traffic, fishing and mining are examples of environmental loads. Loads from vibrations of equipment and displacements caused by structures on the ground or seabed are also examples of environmental loads.

(2) Hydrodynamic loads

Hydrodynamic loads must be calculated for the design return periods corresponding to the construction phase and operational phase. The return period for the construction phase must be selected on the basis of the planned construction duration and season and the consequences of the loads associated with these return periods being exceeded. The design return period for the normal operation phase should be not less than three times the design life of the pipeline system or 100 years, whichever is shorter. The joint probability of occurrences in magnitude and direction of extreme winds, waves and currents should be considered when determining hydrodynamic loads. The effect of increases in exposed area due to marine growth or icing shall be taken into account. Loads from vortex shedding shall be considered for aerial crossings and submerged spanning pipeline sections.

(3) Earthquakes

The following effects shall be considered when designing for earthquakes;

1) direction, magnitude and acceleration of fault displacements;
2) flexibility of pipeline to accommodate displacements for the design case;
3) mechanical properties of the carrier pipe under pipeline operating pressure (conditions);
4) design for mitigation of pipeline stresses during displacement caused by soil properties for buried crossings and inertial effects for above-ground fault crossings;
5) induced effects (liquefaction, landslides);
6) mitigation of exposure to surrounding area by pipeline fluids.

(4) Soil and ice loads

The following effects shall be considered when designing for sand loads:

1) sand dune movement;
2) sand encroachment.

The following effects shall be considered when designing for ice loads:

1) ice frozen on pipelines or supporting structures;
2) bottom scouring of ice;
3) drifting ice;
4) impact forces due to thaw of the ice;
5) forces due to expansion of the ice;
6) higher hydrodynamic loads due to increased exposed area;
7) effects added on possible vibration due to vortex shedding.

(5) Road and rail traffic

Maximum traffic axle loads and frequency shall be established in consultation with the appropriate traffic authorities and with recognition of existing and forecast residential, commercial and industrial developments.

7.4 Accidental loads

Loads imposed on the pipeline under unplanned but plausible circumstances must be considered as accidental. Both the probability of occurrence and the likely consequence of an accidental load must be considered when determining whether the pipeline should be designed for an accidental load.

Examples: Loads arising from fire, explosion, sudden decompression, falling objects, transient conditions during landslides, third-party equipment (such as excavators or ship's anchors), loss of power of construction equipment and collisions.

7.5 Combination of loads

When calculating equivalent stresses (see 8.2), or strains, the most unfavorable combination of functional, environmental, construction and accidental loads which can be predicted to occur simultaneously must be considered.

If the operating philosophy is such that operations will be reduced or discontinued under extreme environmental conditions, then the following load combinations must be considered for operations:

1) design environmental loads plus appropriate reduced functional loads;
2) design functional loads and coincidental maximum environmental loads.

Unless they can be reasonably expected to occur together, it is not necessary to consider a combination of accidental loads or accidental loads in combination with extreme environmental loads.

8. Strength requirements--Calculation of stresses

8.1 Hoop stress due to fluid pressure

The circumferential stress, due to fluid pressure only (hoop stress), must be calculated from the following

formula:

$$\sigma_{hp} = (p_{id} - p_{od})\left(\frac{D_o - t_{\min}}{2t_{\min}}\right)$$

Where

σ_{hp} : circumferential stress due to fluid pressure;
p_{id} : internal design pressure;
p_{od} : minimum external hydrostatic pressure;
D_o : nominal outside diameter:
t_{min} : specified minimum wall thickness.

Note: The specified minimum wall thickness is the nominal wall thickness less the allowance for manufacturing per the applicable pipe specification and corrosion. For clad or lined pipelines (see 8.2.3), the strength contribution of the cladding or lining is generally not included.

Carbon steel line pipe must conform to ISO 3183-1, ISO 3183-2 or ISO 3183-3. ISO 3183-2 or ISO 3183-3 line pipe must be used for applications where fracture toughness is required by ISO 13623-8.1.5 and 8.1.6. The design and internal corrosion evaluation must address whether the internal stainless steel or non-ferrous metallic layer must be metallurgically bonded (clad) or may be mechanically bonded (lined) to the outer carbon steel pipe. The minimum thickness of the internal layer must not be less than 3 mm in the pipe and at the weld. The requirement of pipe-end tolerances closer than specified in the appropriate part of ISO 3183 for welding must be reviewed and specified if deemed necessary.

8.2 Other stresses

Circumferential, longitudinal, shear and equivalent stresses must be calculated taking into account stresses from all relevant functional, environmental and construction loads. Accidental loads must be considered as indicated in 7.4. The significance of all parts of the pipeline and all restraints, such as supports, guides and friction, must be considered. When flexibility calculations are performed, linear and angular movements of equipment to which the pipeline has been attached must also be considered. Calculations must take into account flexibility and stress concentration factors of components other than plain straight pipe. Credit may be taken for the extra flexibility of such components. Flexibility calculations must be based on nominal dimensions and the modulus of elasticity at the appropriate temperature(s). Equivalent stresses must be calculated using the von Mises equation as follows:

$$\sigma_{eq} = \left(\sigma_h^2 + \sigma_i^2 - \sigma_h\sigma_i + 3\tau^2\right)^{1/2}$$

Where

σ_{eq} : equivalent stress;
σ_h : circumferential stress;
σ_i : longitudinal stress;
τ : shear stress.

Equivalent stresses may be based on nominal values of diameter and wall thickness. Radial stresses may be neglected when not significant.

9. Minimum thickness (See ASME B31.4—2006 404.1.2)

$$t = \frac{P_i \times D}{2 \times S}$$

Where

t : pressure design wall thickness ;
Pi : internal design gage pressure;
D : outer diameter of pipe
S : applicable allowable stress value; (0.72×E×SMYS)
E : weld joint factor.

$$t_n = t + A$$

Where

t_n : nominal wall thickness satisfying requirements for pressure and allowances;
t : pressure design wall thickness;
A : sum of allowances for threading, grooving and corrosion protective measure

10. Strength criteria

10.1 General

Pipelines must be designed for the following mechanical failure modes and deformations:

1) excessive yielding;
2) buckling;
3) fatigue;
4) excessive ovality.

10.2 Yielding

The maximum hoop stress due to fluid pressure must not exceed:

$$\sigma_{hp} \leq F_h \times \sigma_y$$

Where

σ_{hp} : minimum hoop stress;

Fh : hoop stress design factor, obtained from Table-6 for pipelines on land and Table-7 for offshore pipelines;

σ_y : specified minimum yield strength (SMYS) at the maximum design temperature.

Note: σ_y should be documented for design temperatures above 50 °C in accordance with 8.1.7.

The mechanical properties at the maximum operating temperature of materials for operations above 50 °C must be documented unless specified in the referenced product standard or complementary justification.

Table- 9: Hoop stress design factors F_h for pipelines on land

Location	F_h
General route (1)	0.77
Crossings and parallel encroachments (2)	
-Minor roads	0.77
-major roads, railways, canals, rivers, diked flood defenses and lakes	0.67
Pig traps and multi-pipe slug catchers	0.67
Piping in stations and terminals	0.67
Special constructions such as fabricated assemblies and pipelines on bridges	0.67
The hoop stress factors of following table must apply for category D and E pipelines to be designed to meet the requirements of annex-B.	

Location	F_h
These factors apply to pipelines pressure-tested with water. Lower design factors may be necessary when tested with air.	
(1) The hoop stress factor may be increased to 0.83 for pipelines conveying category C and D fluids at locations subject to infrequent human activity and without permanent human habitation (such as deserts and tundra regions) *(2) See ISO 13623-6.9 for the description of crossings and encroachments.*	

Reference: 6.4.2.2 of ISO 13623-2000

Table- 10: Hoop stress design factors F_h for offshore pipelines

Location	F_h
General route (1)	0.77
Shipping lanes, designated anchoring areas and harbor entrances	0.77
Landfalls	0.67
Pig traps and multi-pipe slug catchers	0.67
Risers and station piping	0.67
(1) The hoop stress factor may be increased to 0.83 for pipelines conveying category C and D fluids.	

Reference: 6.4.2.2 of ISO 13623-2000

Fluid category	D		E		D and E	
Location class	1	1	2	3	4	5
General route	0.83	0.77	0.77	0.67	0.55	0.45
Crossing and parallel encroachments (1)						
- minor roads	0.77	0.77	0.77	0.67	0.55	0.45
- major roads, railway, canals, rivers, diked, flood defenses and lakes	0.67	0.67	0.67	0.67	0.55	0.45
Pig traps and multiple slug catchers	0.67	0.67	0.67	0.67	0.55	0.45
Piping in stations and terminals	0.67	0.67	0.67	0.67	0.55	0.45
Special constructions such as fabricated assemblies and pipelines on bridges	0.67	0.67	0.67	0.67	0.55	0.45
(1) See ISO 13623-Annex B-6.9-2000 for the description of crossings and encroachments.						

Reference: Annex-B of ISO 13623-2000

The maximum equivalent stress must not exceed.

$$\sigma_{hp} \leq F_h \times \sigma_y$$

Where

σ_{hp} : minimum hoop stress;
Fh : equivalent stress design factor, obtained from Table-8.
σ_y : specified minimum yield strength (SMYS) at the maximum design temperature.

Table- 11: Equivalent stress design factors F_{eq}

Location	F_{eq}
Construction and environmental	1.00
Functional and environmental	0.90
Functional, environmental and accidental	1.00

Reference: 6.4.2.2 of ISO 13623-2000

The criterion for equivalent stress may be replaced by a permissible strain criterion where:

1) the configuration of the pipeline is controlled by imposed deformations or displacements; or
2) the possible pipeline displacements are limited by geometrical constraints before exceeding the permissible strain.

A permissible strain criterion may be applied for the construction of pipelines to determine the allowable bending and straightening associated with reeling, J-tube pull-ups, installation of a bending shoe riser and similar construction methods.

A permissible strain criterion may be used for pipelines in service for:

1) pipeline deformations from predictable non-cyclic displacement of supports, ground or seabed, such as fault movement along the pipeline or differential settlement;
2) non-cyclic deformations where the pipeline will be supported before exceeding the permissible strain, such as in case of a pipeline offshore which is not continuously supported but with sagging limited by the seabed;
3) cyclic functional loads provided that plastic deformation occurs only when the pipeline is first rose to its “worst-case” combination of functional loads and not during subsequent cycling of these loads.

The permissible strain must be determined considering fracture toughness of the material, weld imperfections and previously experienced strain. The possibility of strain localization, such as for concrete-coated pipelines in bending, must be considered when determining strains.

Note: BS 7910 provides guidance for determining the level of permissible strain.

10.3 Buckling

The following buckling modes must be considered:

1) local buckling of the pipe due to external pressure, axial tension or compression, bending and torsion, or a combination of these loads;
2) buckle propagation;
3) restrained pipe buckling due to axial compressive forces induced by high operating temperatures and pressures.

Note: Restrained pipe buckling can take the form of horizontal snaking for unburied pipelines or vertical upheaval of trenched or buried pipelines.

10.4 Fatigue

Fatigue analyses must be performed on pipeline sections and components that may be subject to fatigue from cyclic loads in order to:

1) demonstrate that initiation of cracking will not occur; or
2) define requirements for inspection for fatigue.

Fatigue analyses must include a prediction of load cycles during construction and operation and a translation of load cycles into nominal stress or strain cycles.

The effect of mean stresses, internal service, external environment, plastic prestrain and rate of cyclic loading must be accounted for when determining fatigue resistance.

Assessment of fatigue resistance may be based on either S-N data obtained on representative components or a fracture mechanics fatigue life assessment.

The selection of safety factors must take into account the inherent inaccuracy of fatigue-resistance predictions and access for inspection for fatigue damage. It may be necessary to monitor the parameters causing fatigue and to control possible fatigue damage accordingly.

10.5 Ovality

Ovality or out-of-roundness that could cause buckling or interference with pigging operations must be avoided.

(1) Stability

Pipelines must be designed to prevent horizontal and vertical movement, or must be designed with sufficient flexibility to allow predicted movements within the strength criteria of this International Standard. Factors which must be considered in the stability design include:

1) hydrodynamic and wind loads;
2) axial compressive forces at pipeline bends and lateral forces at branch connections;
3) lateral deflection due to axial compression loads in the pipelines;
4) exposure due to general erosion or local scour;
5) geotechnical conditions including soil instability due to, for example, seismic activity, slope failures, frost heave, thaw settlement and groundwater level;
6) construction method;
7) trenching and/or backfilling techniques.

Note: Stability for pipelines on land can be enhanced by such means as pipe mass selection, anchoring, and control of backfill material, soil cover, soil replacement, drainage, and insulation to avoid frost heave. Possible stability improvement measures for subsea pipelines are pipe mass, mass coating, trenching, burial (including self-burial), gravel or rock dumping, anchoring and the installation of mattresses or saddles.

11. The joint method of pipeline must be pursuant as follows;

11.1 The joint method must be pursuant to the method listed in the right column depending on the classification of maximum allowable operation pressure listed in the left column and the type of material of pipeline listed in middle column. The measure to prevent the extraction means the measure to prevent extraction by means of those which have the function by spigot, lock ring, ball band and gland, method by stay and protection n by pile and concrete.

Table- 12: Joint method of pipeline

Classification of maximum operating pressure (MPqa)	Type of material for pipeline	Joint method
Very high pressure ($7.0 \leq P$)	Steel pipe	Welding, flange joint
High pressure ($1.0 \leq P < 7.0$)	Steel pipe	Welding, flange joint or mechanical joint (limited to those that prevention measures have been taken out of the extraction.)
Middle pressure (1) $0.3 \leq P < 1.0$	Steel pipe	Welding, flange joint or mechanical joint (limited to those that prevention measures have been taken out of the extraction.)
	Cast iron pipe	Welding, flange joint or mechanical joint (limited to those that prevention measures have been taken out of the extraction.)

Classification of maximum operating pressure (MPqa)	Type of material for pipeline	Joint method
Middle pressure (2) $0.2 \leq P < 0.3$	Steel pipe	Welding, flange joint or mechanical joint (limited to those that prevention measures have been taken out of the extraction.) or gas type joint.
	Cast iron pipe	Welding, flange joint or mechanical joint (limited to those that prevention measures have been taken out of the extraction.) or gas type joint.
	Polyethylene pipe	Fusion joint, mechanical joint (limited to those that prevention measures have been taken out of the extraction.).
Low pressure ($P < 0.2$)	Steel pipe	Welding, flange joint or mechanical joint (limited to those that prevention measures have been taken out of the extraction.) or gas type joint, union joint, bite fitting or taper joint (limited to the joint of polyethylene pipe and tube or vinyl chloride).
	Cast iron pipe	Welding, flange joint or mechanical joint (limited to those that prevention measures have been taken out of the extraction.) or gas type joint.
	Hard vinyl chloride pipe or polyethylene pipe	Fusion joint, mechanical joint (limited to those that prevention measures have been taken out of the extraction.) or gas type joint.
	Steel or brass pipe	Flange joint, mechanical joint, union joint, brazing, bite fitting or flair joint.
	Lead pipe	Mechanical joint.

Reference: Article 41 of guideline for gas facility Japan

12. Support for pipeline

(1) The pipeline which is installed on a dedicated bridge, etc. must be supported by the safety supporting structure against wind force and earthquake, etc.

(2) The pipeline installed in the building must be supported by safety support methods against earthquake.

13. Measures for prevention damage due to uneven settlement

(1) The pipeline installing in the soft ground and installing in the place to penetrate outer wall of building must be taken the measures to prevent damage due to uneven settlement pursuant to the following about entire piping system of pipeline and by the way how to combine two or more appropriately.

1) The method to absorb the displacement by the flexibility using a steel pipe jointed by welding or a polyethylene pipe jointed by fusion joint.
2) The method to absorb the displacement by the flexibility in the strait part using a mechanical joint having a displacement absorption capacity.
3) The method to absorb the displacement by the flexible combination of bends by means of screw joint, mechanical joint or welding joint.
4) The method to use expansion joint.
5) The method to absorb the displacement by the gap between pipeline and sheath tube by means of installing pipeline in the sheath tube.

14. Supports for Buried Piping

In pipelines, especially those that are highly stressed from internal pressure, uniform and adequate support of the pipe in the trench is essential. Unequal settlements may produce added bending stresses in the pipe. Lateral thrusts at branch connections may greatly increase the stresses in the branch connection itself, unless the fill is thoroughly consolidated or other provisions are made to resist the thrust. Rock shield shall not be draped over the pipe unless suitable backfill and padding are placed in the ditch to provide a continuous and adequate support of the pipe in the trench.

Photo- 19: Natural gas pipeline on land

http://theuglytruth.wordpress.com/2011/07/30/us-israeli-mercenaries-blow-up-iran-turkey-gas-line/

Photo- 20: Natural gas pipeline on land

http://www.txchnologist.com/2011/the-clean-fossil-fuel-natural-gas-under-fire

Photo- 21: Natural gas wellhead

http://www.mjpaintingcontractor.com/gaswellheads.htm

Photo- 22: Shutoff valve for Natural gas pipeline

http://www.exponent.com/gas_processing_monetization/

15. Measures to absorb expansion

(1) The pipeline other than those which is buried underground (except that is installed in the culvert and exposed by drilling) must be taken measure to absorb expansion due to the change in temperature by the either method listed in the following items or in combination.

1) The measure to absorb the change in length by a flexible piping system such as expansion joint (bellows type, dresser type and including telescopic tube), loop pipe, bend pipe, etc.
2) The measure to absorb thermal stress generated in the pipeline in the allowable stress.

16. Stability of the pipeline to be installed on the seabed

(1) It is deemed that the pipeline designated based on DNV RP W305 “On-bottom stability design of submarine pipelines” does not move.

(2) The pipeline must have harmful vibration. In addition, it is deemed that the pipeline designated based on DNV Guideline14 “Free spanning pipelines” have no harmful vibration.

17. Construction of submarine pipeline

(1) The construction standard of pipeline which is installed deeper than 50m water depth (herein after so called “submarine pipeline”) must be pursuant to follows;

1) The upper limit of the stress generated by the assumed combination load must not exceed 90.0% of the yield point of the material.
2) The design factor (percentage of the material yield point of circumferential stress occurs when it took pressure) must not exceed 0.72.
3) The thickness of pipe must be more than equal to 12.5mm.
4) The high-speed ductile fracture must be capable to stop.

(2) The method to joint pipeline must be welding.

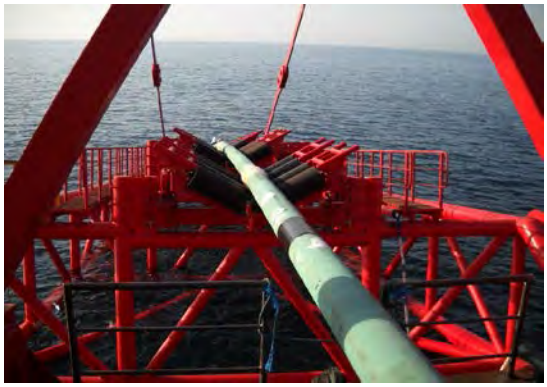


Photo- 23: Laying off-sore pipeline

http://maritimecollectibles.prestigious-hosting.com/2011/07/12/nigeria-brass-lng-opens-bid-for-subsea-pipeline-construction/

Photo- 24: Welding of off-shoe pipeline

http://www.sciencephoto.com/media/153281/enlarge

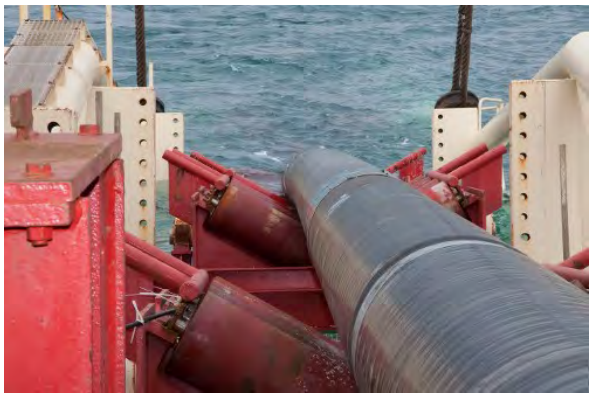


Photo- 25: Laying off-sore pipeline

http://www.gazprom.com/press/news/2010/april/article97626/

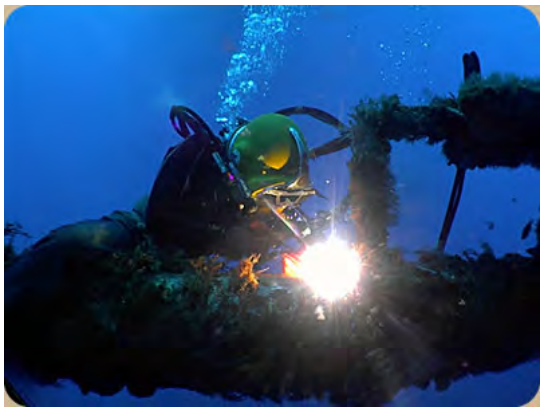


Photo- 26: Welding of subsea pipeline

http://rangeroffshoreinc.com/pipeline_subsea_construction.htm

Article 118-2. Pressure part

1. The "pressure part" of the gas pipeline must be pursuant the definition in the design technical regulation Article 118-1.

Article 118-3. Air-tightness

1. General

   Pipeline systems must be pressure-tested in place after installation but before being put into operation to demonstrate their strength and leak-tightness. Prefabricated assemblies and tie-in sections may be pretested before installation provided their integrity is not impaired during subsequent construction or installation. The requirements for pressure testing can govern the necessary pipe wall thickness and/or steel grade in terrain with significant elevations.

2. Test medium

   Test medium available, when disposal of water is not possible, when testing is not expedient or when water contamination is unacceptable. Pneumatic tests (when necessary) may be made using air or a non-toxic gas as shown in Photo-85, 86.

Photo- 27: Compressor for pressure test

http://www.aabbxair.com/about.html

Photo- 28: Compressor for pressure test

http://www.atlascopco.us/hurricane/applications/pipeline/

3. Pressure test requirements

Pressure tests shall be conducted with water (including inhibited water), except when low ambient temperatures prevent testing with water, when sufficient water of adequate quality cannot be made.

Note: Rerouting of short pipeline sections or short tie-in sections for pipelines in operation are examples of situations for which pressure tests with water may not be expedient.

4. Pressure levels and test durations

The pipeline system must be strength-tested, after stabilization of temperatures and surges from pressurizing operations, for a minimum period of 1h with a pressure at any point in the system of at least:

1) 1.25 × MAOP for pipelines on land; and
2) 1.25 × MAOP minus the external hydrostatic pressure for offshore pipelines.

If applicable, the strength test pressure must be multiplied by the following ratios:

1) the ratio of σ_y at test temperature divided by the derated value for σ_y at the design temperature in case of a lower specified minimum yield strength σ_y at the design temperature than exists during testing; and
2) the ratio of t_{min} plus corrosion allowance divided by t_{min} in case of corrosion allowance.

The strength test pressure for pipelines conveying category C and D fluids at locations subject to infrequent human activity and without permanent habitation may be reduced to a pressure of not less than 1.20 times MAOP, provided the maximum incidental pressure cannot exceed 1.05 times MAOP.

Following a successful strength test, the pipeline system shall be leak-tested for a minimum period of 8h with a pressure at any point in the system of at least:

1) 1.1 × MAOP for pipelines on land; and
2) 1.1 × MAOP minus the external hydrostatic pressure for offshore pipelines.

The strength and leak test may be combined by testing for 8 h at the pressure specified above for strength testing. The requirement for a minimum duration of a leak test is not applicable to pipeline systems completely accessible for visual inspection, provided the complete pipeline is visually inspected for leaks following a hold-period of 2h at the required leak-test pressure. The additional test requirements of clause B.6 must apply for category D and E pipelines to which Annex B of ISO 13623-2000 applies.

5. Acceptance criteria

Pressure variations during strength testing must be acceptable if they can be demonstrated to be caused by factors other than a leak. Pressure increases or decreases during leak testing must be acceptable provided

they can be demonstrated through calculations to be caused by variations in ambient temperature or pressure, such as tidal variation for offshore pipelines. Pipelines not meeting these requirements must be repaired and retested in accordance with the requirements of this International Standard.

Article 118-4. Foundation

1. When openings are made in a consolidated backfill to connect new branches to an existing line, care must be taken to provide firm foundation for both the header and the branch to prevent vertical and lateral movements.

Article 119 Welding part of gas transportation facility

Article 119-1. Welding of pipeline

1. Welding of pipeline must be performed according to the proven and reliable international standards such as ISO 13847, API 1104, JIS Z3104, ASME Section-9 or EN 3480.

   Photo-29, 30 and 31 shows the arc welding procedure, Photo-34 shows the Tig welding procedure and Photo-33 shows the flash-butt welding procedure.

Photo- 29: Arc welding of buried pipeline

http://teeic.anl.gov/er/transmission/activities/act/index.cfm

Photo- 30: Arc welding of pipeline on the land

http://www.gazprom.com/press/news/2011/july/article115149/

Photo- 31: Mig welding

http://www.indiazooms.com/?p=2896

Photo- 32: Arc welding

http://rattlestan.com/projects.html

Photo- 33: Flash butt welding

http://www.pskovelectrosvar.ru/pages_en.html?id=28

Photo- 34: Tig welding

http://newsroom.lincolnelectric.com/Image/Awards+Events/

Article 119-2. Welding procedure

1. "Welding" must be pursuant to as follows;

(1) Welding of pipeline must be performed according to the appropriate WPS.

(2) Welding equipment such as the welding machine, dryer, and windbreak must conform to the welding method or welding conditions specified in WPS.

(3) Welding or consumables such as the welding rod, welding wire, flux, electrode and seal gas must conform to WPS.

(4) A butt weld must be applied for the mains. And V-shape or U-shape groove must be applied to welding joint shape.

Article 119-3. Welding management

1. The appropriate measure to obtain good circumstance for welding such as wind break, waterproof, lighting, worming equipment must be provided as shown in Photo-35 and 36.

Photo- 35: Welding house

http://www.gazprom.com/production/projects/pipelines/shvg/

Photo- 36: Welding tent

http://www.weldcrawler.com/pipeline-welding/

Article 120. Safety valve of gas transportation facility

Article 120-1. Safety valve

1. The following formulae extracted from API Recommended Practice 520 are provided to enable the selection of effective discharge areas. The effective discharge areas will be less than the actual discharge areas, therefore these formulae must no be used for calculating certified discharge capacities. After determining the required effective area selected from Table-16 the orifice with an area equal to or greater then the required effective discharge area.

$$A = \frac{W}{0.00759 \times C \times K_d \times P_1 \times K_b} \times \sqrt{\frac{T \times Z}{M}}$$

Where

		(Metric units)
A	: required effective discharge area of the valve	mm^2
W	: flow rate	kg/h
C	: Coefficient determined from an expression of the ratio of the specific heats of the gas or vapour at standard conditions. (see Table-**)	—
k	:ratio of specific heats for an ideal gas	
K_d	: effective coefficient of discharge related to the effective flow areas acc. To API 526; for steam, gases and vapours (=0.975)	—
P_1	: relieving pressure: for liquids (=set pressure+allowable overpressure)	bar
K_b	: capacity correction factor due to back pressure (for balanced bellows values and gases vapour only) with back pressure < 20% P1 (=1)	—
T	:Relieving temperature	K
Z	:Compressibility factor for the deviation of the actual gas from a perfect gas (Z=1 for a perfect gas)	—
M	: Molecular weight of the gas or vapour	—

Table- 13: Effective areas acc. to API 526

Orifice	Effective areas (mm^2)
D	71
E	126
F	198
G	324
H	506
J	830
K	1,185
L	1,840
M	2,322
N	2,800
P	4,116
Q	7,129
R	10,322
T	16,774

Table- 14: Values of coefficient C

k	C
1.01	317
1.05	321
1.10	327
1.15	332
1.20	337
1.25	342
1.30	347
1.35	352
1.40	356
1.45	360
1.50	365
1.55	369
1.60	373
1.65	376
1.70	380
1.80	387
1.90	394
2.00	400

Article 121. Instrument device, etc. for gas transportation facility

Article 121-1. Instrument device

1. "Appropriate instrumentation equipment to measure and check" stipulated in design technical regulation Article 121-1 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 122. Warning device for transportation facility

Article 122-1. Warning device

1. "Appropriate warning device" stipulated in design technical regulation Article 122-1 means those pursuant as follows. However, if the equipment doesn't be such state, this must not be applied.

(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 has 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 is 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 gas pressure raises abnormally, with regard to the gas purification facility that the maximum operation pressure is high or medium.
(3) 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).
(4) 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).

Article 123. Fail-safe control and interlock for gas transportation facility

Article 123-1. Fail-safe control

1. "Measures to prevent mistake and to ensure the operation" stipulated in design technical regulation Article 123-1 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 123-2. Interlock

1. Many routine pipeline operating procedures are potentially dangerous if executed incorrectly or in unsafe conditions, with the scope for injury and/or damage significantly increased when high temperature, high pressure or toxic/flammable product is present.

   Key interlock systems are dual-keyed mechanical locking devices which operate on a 'key transfer' principle to control the sequence in which process equipment may be operated. They are widely accepted as an effective safety management tool and are being adopted by many of the world's oil, gas and chemicals majors. Interlocks are also recommended in a number of internationally recognized standards for specific process applications including:

   1) API RP 14E - Design & Installation of Offshore Production Platform Piping Systems (Para. 5.8. b2) - Relief Device Piping.
   2) API RP 520 - Pressure Relieving Systems for Refinery Services (Part II: Section 4 - Isolation Valve Requirements).
   3) NFPA 12 - National Fire Protection Association (USA) - Carbon Dioxide Extinguishing Systems - 1993 Edition.
   4) BS 5306 - British Standard - Part 4 1986 - Specification for Carbon Dioxide Systems.
   5) BS 8010 - Code of Practice for Pipelines (Part 2 1992 - Sect. 2.8).
   6) BS 8010 - Code of Practice for Pipelines (Part 3 1993 - Sect. 6.6).
   7) 1996 No. 825 - (UK) The Pipelines Safety Regulations (Section 6 - Para. 37 of Guidance on Regulations - published by UK Health & Safety Executive).

   Key interlocks date back to the 1890's where they were first used in the French railway system to control track switching operations. Modern key interlock systems for oil and gas, chemical processing and pipelines systems did not emerge until the early 1980's. Since then, acknowledgement of their effectiveness

has led to increasing levels of usage and growing recommendations within international standards and codes of practice. The hardware is relatively simple and is based on specialized mechanical locks designed as integral-fit attachments to the host equipment.

Typically they are applied to valves, closures, switches or any form of equipment which is operated by human intervention. The 'open' or 'closed' status of an interlocked valve, or the 'on' or 'off' status of an interlocked switch can only be changed by inserting a unique coded key; inserting the key unlocks the operating mechanism (e.g. handwheel or push-button) enabling operation of the valve or switch.

Operating the unlocked equipment immediately traps the initial (i.e. inserted) key; when the operation is complete, a secondary (previously trapped) key may then be released thereby locking the equipment in the new position. This secondary key will be coded in common with the next lock (item of equipment) in the sequence. By this simple coded key transfer principle a 'mechanical logic' system is created which denies any scope for operator error.

While padlocks and chains provide a lock-off capability, they do not provide any control over the sequence of operations, nor do they assure or confirm the status of the equipment to which they are fixed. So, removing a key from a padlock ensures neither that the equipment is locked nor its 'open/closed' or 'on/off' status. While a padlock and chain may be suitable and sufficiently robust in low risk applications, they have virtually no mechanical integrity and are a minimal solution offering (at best) a visual restriction against unauthorized operation.

Mechanical key interlock systems are ideally suited for integration with Permit-to- Work (PtW) procedures; indeed, the Cullen Report on the public inquiry into the Piper Alpha offshore rig disaster (1990) strongly recommends the use of locking systems integrated with PtW procedures, especially where routine procedures cannot be accomplished in the time-scale of a single work shift.

In the same vein, ongoing surveillance of the UK chemicals industry by the Health & Safety Executive (HSE) found that one third of all accidents in the chemical industry were maintenance related – the most significant factor being the absence of, or an inadequacy in, PtW systems.

In addition to the standards referred to earlier, the Technical Guidance Notes (published by the HSE) supporting interpretation of the UK Pipeline Safety Regulations (1996) Act [PSR 1996] recommend interlocks as a suitable safety system in the operation of pig traps.

http://www.smithflowcontrol.com/new/Downloads/news/SFC02-06-Pipeline-article.pdf

Article 124. Back-up power, etc. for gas transportation facility

Article 124-1. Back-up power

1. "Safety apparatus needed to safely close the incoming gas and transportation facility" stipulated in design technical regulation Article124-1 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 125. Measure of odor for gas transportation facility

Article 125-1. Confirmation of odor

1. "Odor in order for easy detection" and "it is possible to detect odor" stipulated in design technical regulation Article 125-1 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/m3) that is measured by either of the following methods. 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- 15: 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).

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.

Article 126. General provision for gas generation facility

Article 126-1. General provision

1. Natural gas which is drilled in the onshore or offshore gas field is used directly for the gas-fired thermal power plants or GTCC plants. In addition, natural gas as shown in Table-2 is imported in the state of liquefied gas after desulfurization for the country where does not produce natural gas.
2. City gas is produced at gas production plant from natural gas, liquefied natural gas, liquefied petroleum gas, naphtha and coal, and is used as household fuel. Also, city gas is used as the main fuel for small power generation facilities or emergency power generation facilities, if they don’t have a fuel storage facility.

Table- 16: Classification of city gas

Classification of gas		Heating value	
		(kcal/m^3)	(kJ/m^3)
City gas	13A	10,000 ~15,000	41,861 ~ 62,791
	12A	9,070 ~11,000	37,967 ~ 46,047
	6A	5,800 ~7,000	24,279 ~ 29,302
	5C	4,500 ~5,000	18,837 ~20,930
	L1 (6B, 6C, 7C)	4,500 ~5,000	18,837 ~ 20,930
	L2 (5A, 5B, 5AN)	4,500 ~5,000	18,837 ~ 20,930
	L3 (4A, 4B, 4C)	3,600 ~4,500	15,070 ~18,837
LP gas	—	—	—

Reference: http://home.tokyo-gas.co.jp/userguide/shurui.html

3. On the other hand, it is believed that the use of coal seam gas (CBM: Coalbed Methane) or gasified gas from coal or underground coal such as Fig-9 in future.

Photo- 37: Reactor (Link energy)

http://www.brain-c-jcoal.info/worldcoalreport/S03-02-03.html

Photo- 38: GTLplant (Link energy)

http://www.brain-c-jcoal.info/worldcoalreport/S03-02-03.html

Photo- 39: Production well (Carbon energy)

http://www.brain-c-jcoal.info/worldcoalreport/S03-02-03.html

Article 127. Off limit to gas generation and supply facility

Article 127-1. Prevention of off limit

1. "Appropriate measures" stipulated in design technical regulation Article127-1 means to provide fence , wall, barbed wire and hedge (referred to as "fence") and to display prohibiting to close to gas facility in the gas production and supply premises. However, it deemed appropriate measures have been taken, if the sea, rivers, lakes, cliffs, etc. has become a boundary.

2. "Appropriate measures" must be as follows;

(1) To provide fence, etc. and display prohibiting to close to gas facility, in case of the large mobile gas generation facility.

(2) To provide fence, etc., in case of the mobile gas generation facility (excluding the large mobile gas generation facility). In addition, when installing in the garden such as a person other than the home demand individual and providing cover that cannot be operated facility, it may be deemed to have provided such fence.

(3) The following measures, in case of pressure regulator;

1) Measures to install pressure regulator in the room (including box, etc.).
2) Measures to install pressure regulator in the underground manhole or pit, etc.
3) Measures to install pressure regulator in the height that the public cannot operate without good reason.
4) Measures to install pressure regulator with construction which public cannot operate without good reason.

3. Security

Access to stations and terminals must be controlled. They must be fenced, with gates locked or attended. Permanent notices must be located at the perimeter indicating the reference details of the station or terminal and a telephone number at which the pipeline operating company may be contacted. Security requirements for pipeline facilities within a station, terminal or installation must be established in conjunction with the requirements for the station, terminal or installation.

Photo- 40: Gas generation plant

http://jointfukuoka.seesaa.net/category/7241665-5.html

Photo- 41: Coal gasification plant

http://www.jpower.co.jp/news_release/news070507_1.html

Article 128. Security communication facility for gas generation and supply facility

Article 128-1. Safety communication facility

1. "Appropriate communication facility" stipulated in design technical regulation Article128-1 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 129. Off-set distance for gas generation and supply facility

Article 129-1. Separation distance from boundary

1. "Separation distance required for safety" stipulated in design technical regulation Article 129-1 means the distance as follows;

(1) Separation distance required for safety must be at least 1m.

(2) Open space must be provided around stations and terminals for the free movement of fire-fighting equipment. Sufficient access and clearance must be provided at stations and terminals for movement of fire-fighting and other emergency equipment. Layouts of stations and terminals must be based on minimizing the spread and consequences of fire. Areas within stations and terminals with possible explosive gas mixtures must be classified in accordance with IEC 60079-10 and the requirements for plant and equipment defined accordingly.

(3) Spacing of tankage must be in accordance with NFPA 30. Piping must be routed such that trip or overhead hazards to personnel are avoided, and access to piping and equipment for inspection and maintenance is not hindered. Requirements for access for replacement of equipment must also be considered when routing primary piping. Vent and drain lines to atmosphere must be extended to a location where fluids may be discharged safely. Particular attention must be paid to safety in locating vent and drain lines near living quarters on offshore installations.

Article 129-2. Separation distance from school, hospital, etc.

1. When installing the gas generation facility above a certain size, it is necessary to prevent danger to the surrounding security properties such as critical facilities and homes and the like when the accident occurred in it.

1) Elementary school, middle school, high school, secondary school, vocational high school, special needs schools and kindergarten.
2) Hospital (which has a facility for patients to be hospitalized for more than 20 peoples).
3) Theater, cinema, hall, auditorium and similar facilities to accommodate more than 300 peoples.
4) Protecting living facility, child welfare facilities, welfare facilities for the aged, nursing home care facilities, welfare aid for persons with disabilities, maternal and child welfare facilities and the like which has admission capacity more than 20 peoples.
5) Important cultural building properties, Important tangible folk cultural properties, building and museums that is designated as historic sites, scenic natural monument or important cultural monuments.
6) Main building of the station and platform which more than 20,000 passengers per day by an average

are getting on and off.

Content of separation distance	Separation distance
Between gas generation facility and other gas generation facility of flammable gas	5 m and more
Between gas generation facility and facility to dwal with fire	8 m and more
Between gas generation equipment and boundary of premise	20 m and more
Between gas generation facility and above security property	50 m and more

Article 130. Security compartment of gas generation and supply facility

Article 130-1. Security compartment

1. "Appropriate security compartment for security" 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 131. Firefighting facility for gas generation and supply facility

Article 131-1. Firefighting facility

1. "An appropriate firefighting facility *** in the proper location" stipulated in design technical regulation Article 131-1 means those facility which installed according to the followings;

(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.

7) 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-** 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- 17: 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 132. Prevention of gas accumulation for gas generation and supply facility

Article 132-1. Prevention of gas accumulation indoor

1. "Structure shall allow for no accumulation of gas" stipulated in design technical regulation Article 132-1 means those which conform to followings;

(1) One which has following structures considering the nature of the gas, the amount of gas processing or storage, the characteristics of equipment and the size of room an the like.

1) The structure with an opening of at least two directions with sufficient area for ventilation.
2) The structure which is capable to ventilate effectively and mechanically.

2. "Suitable place where gas may be possible to accumulate in the gas manufacturing works" stipulated in design technical regulation Article132-2 means the place where it is considered the circumstances surrounding placement of equipment, properties of gas, draft, ventilation and the like.

Article 132-2. Gas detector

1. "Suitable place where gas may be possible to accumulate in the gas manufacturing works" stipulated in design technical regulation Article 132-2 means those which can be secure security measures equivalent to odorization.

Article 133. Explosion-proof structure of electric facility for gas generation and supply facility

Article 133-1. Explosion-proof of electric facility

1. "Explosion-proof type depending on the conditions of place and the kind of gas" stipulated in design technical regulation Article133 means those which are conform to the appropriate standards for explosion-proof electrical equipment, are considered the selection of electrical equipment and wiring depending on the classification to type of flammable gas and explosion risk and are installed.
2. Electrical equipment and wiring installed in stations must conform to the requirements of IEC 60079-14. Electrical installations which are to remain in operation during an emergency must be based on the zone applicable during the emergency.

Article 134. Distance from flammable gas facility of gas generation and supply facility

Article 134-1. Distance from flammable gas facility

1. "Sufficient distance" stipulated in design technical regulation Article 134-1 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 135. Gas displacement of gas generation and supply facility

Article 135-1. Gas replacement

1. "To replace gas safely" stipulated in design technical regulation Article 135-1 means to replace flammable gas with an inert gas such as nitrogen in order to prevent accident in halt, corrosion protection and secure environment during repair work (to prevent gas explosion and poisoning). The methods are divided into following ;

    1) To supply liquefied nitrogen from outside to installed vaporizer for liquid nitrogen and supply nitrogen gas to gas pipeline.
    2) To supply nitrogen gas directly to gas pipeline by nitrogen pipe.
    3) To supply inert gas that is generated by inert gas generator.

Article 135-2. Vent-stack

1. "Appropriate measures" stipulated in design technical regulation Article 135-2 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.

Article 135-3. Heat radiation

1. "Keep from damaging its surroundings due to heat radiation and to be able to release gas safely" stipulated in design technical regulation Article 135-3 must be pursuant as follows;

(1) The material must withstand the generated heat on that flairstack.

(2) Its height and location must not give failure to surroundings from the radiation heat generated on the flairstack.

(3) The flair stack must be taken measures to prevent explosions.

Photo- 42: Flaire stack

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

Photo- 43: Landfill gas flaire stack

http://www.ukexportnews.co.uk/news/1269/Landfill-Gas-Analysis-Telematics-In-Slovenia-On-Line-In-UK

Photo- 44: Flaire stack

http://www.dreamstime.com/royalty-free-stock-photos-gas-plant-flare-stack-2-image3157278

Photo- 45: Flaire stackignition nozzle

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

Article 136. Material of gas generation and supply facility

Article 136-1. Material

1. See Article 117-1.

Article 137. Structures, etc. of gas generation and supply facility

Article 137-1. Structure

1. The construction of vessel and piping for the gas generation facility and gas purifier must be pursuant to the provision for gas generation facility and gas purification facility stipulated in the interpretation of technical regulation for gas facility or JIS B8265-2008 “Construction of pressure vessel—General”. And the allowable stress for gas generation facility must be pursuant the allowable stress stipulated in stipulated in the interpretation of technical regulation for gas facility.

Article 137-2. Foundation

1. See Article118-4.

Article 138. Welding parts of gas generation and supply facility

Article 138-1. Welding part

1. “Welded part” is the generic part that includes the welded metal and heat affected zone. Generally, the part subjected to welding consists of continuous set with different nature, the base metal which is not heat affected zone out of heat affected zone and the heat affected zone which consist of welded metal and heat affected part.

Article 138-2. Welding procedure

1. “Welding” must be pursuant to as follows;

(1) Welding of pipeline must be performed according to the appropriate WPS.
(2) Welding equipment such as the welding machine, dryer, and windbreak must conform to the welding method or welding conditions specified in WPS.
(3) Welding or consumables such as the welding rod, welding wire, flux, electrode and seal gas must conform to WPS.
(4) A butt weld must be applied for the mains. And V-shape or U-shape groove must be applied to welding joint shape.

Article 138-3. Welding management

1. The appropriate measure to obtain good circumstance for welding such as wind break, waterproof, lighting, worming equipment must be provided as shown in Photo-35 and 36.

Article 139. Safety valve for gas generation and supply facility

Article 139-1. Safety valve

1. See Article 120-1.

Article 140. Instrument device, etc. for gas generation and supply facility

Article 140-1. Instrument device

1. "Appropriate instrumentation equipment to measure and check" stipulated in design technical regulation Article 140-1 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 141. Alarm device for gas generation and supply facility

Article 141-1. Alarm device

1. "Appropriate warning device" stipulated in design technical regulation Article 141-1 means those pursuant as follows. However, if the equipment doesn't be such state, this must not be applied.

(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 has 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 is 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 gas pressure raises abnormally, with regard to the gas purification facility that the maximum operation pressure is high or medium.
(3) 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).
(4) 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).

Article 142. Fail-safe control and instrument for gas generation and supply facility

Article 142-1. Fail-safe control

1. "Measures to prevent mistake and to ensure the operation" stipulated in design technical regulation Article 142-1 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 142-2. Interlock

1. The interlock mechanism must be provided on the generation facility of flammable gas or the important place of instrumentation circuit of these facility where is necessary for security to prevent the abnormal operation other than normal operation or to cut off the supply of raw materials for generation facility automatically when equipment is deviated from the normal condition in order to control the production in the generation facility.

Article 143. Back-up power, etc. for gas generation and supply facility

Article 143-1. Back-up power

1. "For the safety apparatus needed to safety stop the gas generation facility" stipulated in the design technical regulation Article 143-1 means 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 144. Measurement of odor for gas generation and supply facility

Article 144-1. Odorization

1. See Article 125-1.

Article 145. Control room for gas generation and supply facility

Article 145-1. Control room

1. "Shall be capable of controlling the gas safely in an emergency" stipulated in the design technical regulation Article 145 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.

Article 146. General provision of gas storage facility

Article 146-1. General provision

1. The gasholder is installed in the factory or gas production plant in order to storage gas in time s of low demand and to supply gas in high demand, which acts to regulate the transmission of gas. Gasholder is made of steels plates with together and has enough strength to withstand a big earthquake. The foundation has a structure that piling until firm ground according to a survey basis for ground for gasholder and struts or body is permanently fixed on the basis on reinforced concrete. In addition, Oil damper and the emergency shutoff valve that can be remote control and the expansion that absorb vibration at the junction of gasholder and gas piping.
2. The gasholder occur explosion or fire even heating from outside or putting the ignition source inside in the gasholder without air, since gas explosion can be occurred with certain mixture percentage of air. If gas blow out from hole on the holder, gas is only burn without immediate explosion, since there is no oxygen required for combustion.
3. There were water seal type, cylindrical type and spherical type, what were once almost cylindrical, but has

now been placed almost spherical.

Article 147. Material of gas storage tank

Article 147-1. Material

1. See Article 117-1.

Article 148. Structure of gas storage tank

Article 148-1 Structure of gasholder

1. The structure of the gasholder must be pursuant by any of followings. In addition, the shape of must be spherical in case of the high maximum operating pressure, spherical or cylindrical in case other cases. However, it must not be the cylindrical with flat bottom in case of those of medium pressure or high pressure of maximum operating pressure. In addition, standard pertaining to seismic safety are limited to more than 300m^3 of storage capacity.

(1) The structure of gasholder must conform to following 1) to 5);

1) The foundation of gasholder must withstand gross weight of gasholder filled with gas and including supports and wind load stipulated in 2).
2) The gasholder and its support must withstand wind load calculated according to "4.5.2 (5) of Guideline for spherical gas holder: JGA (Japan Gas Association) 104-03".
3) Earthquake resistance of gasholder (including supports) must conform to the provision of "Seismic Design Guidelines for gas production facility: JGA (Japan Gas Association) 101-01.
4) The gasholder which has high and medium maximum operating pressure must be pursuant to the following provision a. to h. In addition, the allowable stress of materials stipulated in Article 117-1 must be applied.

a. Measures for incoming and outgoing piping to absorb expansion due to change in temperature and pressure must be taken.
b. Inspection hole or manhole must be provided according to standard.
c. The thickness of gasholder must be conformed to the minimum thickness according to standard.
d. The thickness of nozzle neck must be conformed to the minimum thickness according to standard.
e. The thickness of dished head plate must be conformed to the minimum thickness according to standard.
f. The stiffener of hole must be conformed to the minimum thickness according to standard.
g. The installation procedure of piping on the gasholder must be conformed to the minimum thickness according to standard.
h. The installation procedure of flanges on the gasholder must be conformed to the minimum

thickness according to standard.

5) The minimum thickness limit excluding corrosion allowance of the gasholder which has low maximum operation pressure must be 1.6mm.

(2) The structure of spherical gasholder must conform to the provision“4.4.7 (3): design, 8.1: general, 8.4: design criteria, 8.5: structure and design, incoming and outgo piping of Guideline for spherical gas holder: JGA (Japan Gas Association) 104-03”. However, the allowable tensile stress for pressure part of gasholder body must conform to the provision Article 117-1.

2. The structure of membrane gasholder must conform to the provision “Design: Guideline for membrane gasholder (Nuclear Safety Agency Japan No.1).

Photo- 46: Gas holder for BFG

http://en.wikipedia.org/wiki/File:Lazarus_Thick_Shell_Gasholder.jpg

Photo- 47: Spherical gas holder

http://pinktentacle.com/2011/03/decorated-gas-tanks/

Photo- 48: Bio gas hoilder

http://www.thewatertreatmentplant.com/gas-holder.html

Photo- 49: Membrane gas holder

http://www.esi.info/detail.cfm/The-Utile-Engineering-Co-Ltd/Sattler-double-membrane-gas-holder/_/R-25867_NN95UG

3. Storage and working tankage (ISO 13623-7.11 2000)

(1) Tanks for storage or handling of fluids shall be designed and constructed in accordance with the following

standards:

1) API 650 “Welded steel tanks for oil storage-10th edition ” for fluids with a vapour pressure less than 0.035 bar(g);
2) API 620 “Design and construction of large, welded, low-pressure storage tanks. - 11th edition.” for fluids with a vapour pressure higher than 0.035 bar(g) but not more than 1 bar(g);
3) this International Standard for pipe-type holders used for fluids with a vapour pressure of more than 1 bar(g);
4) applicable standards for holders other than pipe-type holders for fluids with a vapour pressure of more than1 bar (g).

Foundations shall be designed and constructed in accordance with plans and specifications which shall take into account local soil conditions, type of tank, usage and general location.

Article 148-2. Drain discharge

1. It is possible that the separation of heavy minutes in the material which passes through the bottom of piping, storage vessel or tank and accumulation. The work to extract this heavy fraction and condensate is referred to as “work down”. The drain of LPG or light hydrocarbons is often accompanied water and condensation and freezing is likely to occur. Valve must be duplicated, the upstream side valve must be fully open and the degree of opening of the downstream side secondary valve must be adjusted.

Article 148-3. Volume of gas storage

1. The storage capacity of gas must be calculated according to the following formula.

Table- 18: 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 149. Shut-off device for gas storage tank

Article 149-1. Shut-off valve for gasholder

1. "Appropriate equipment to promptly shutoff the inflow and outflow of gas shall be provided" stipulated in design technical regulation Article 149 means the followings;

(1) In case of the gasholder with low maximum operating pressure, it means to provide the remote control valve or water seal valve adjacent to the connection of gasholder and pipes (limited those which are use gas discharge or incoming). In addition, such remote control valve must be capable to operate at a distance of more than 5m (0m in case of buried pipe and water seal gasholder) from the outside surface of piping (limited to such remote control valve from the gasholder) and the gas holder.

(2) In case of the gasholder with high or medium maximum operating pressure, it must conform to following 1) and 2);

1) In case of such gasholder, it means to provide the emergency shutoff valve adjacent to the connection of gasholder and pipes (limited those which are use gas discharge or incoming). In addition, such emergency shutoff valve must be capable to operate at a distance of more than 5m (10m in case of large scale site and 0m in case of buried pipe and water seal gasholder) from the outside surface of piping (limited to such remote control valve from the gasholder) and the gas holder.
2) It means to provide the manual valve or the remote control valve adjacent to the connection of gasholder and pipes (limited those from such gasholder to the emergency shutoff valve). However, this is not applied, if installing the emergency shutoff valve stipulated in 1) between gasholder and expansion part which absorb changes in thermal expansion due to temperature and pressure.

2. Each blower or compressor station must be provided with an emergency shutdown system that is readily accessible, locally and/or remotely operated, and which will shut down all prime movers. Consideration must also be given to isolating the station from the pipeline and to relieving or venting the piping system when required. Operation of the emergency shutdown system must also permit the shutdown of any gas-fired equipment that could jeopardize the safety of the site provided it is not required for emergency purposes. Uninterrupted power supply must be provided for personnel protection and those functions that are necessary for protection of equipment.

3. Gas shutoff valve on the main or branch of pipeline

(1) "The appropriate equipment which is capable to shutoff gas immediately" means the equipment to stop gas immediately in emergency case.

(2) "The proper location" is the turning point or other the place where it is necessary to maintain pipeline, the riser part in case of offshore pipeline.

Article 150. Indication for gas storage tank

Article 150-1.Indication for gas storage tank

1. Signs must be placed to identify hazardous, classified and high-voltage areas. Access to such areas must be controlled. Fences must not hinder the escape of personnel to a safe location. Escape gates must open outward and be capable of being opened from the inside without a key when the enclosure is occupied.

Adequate exits and unobstructed passage to a safe location must be provided for each operating floor of main pump and compressor buildings, basements, and any elevated walkway or platform. Exits must provide a convenient possibility of escape. Appropriate fire and gas detection and fire-fighting facilities must be provided. For stations and terminals on land, the requirements for such facilities must be established in consultation with the local fire authorities. Tanks, dikes and firewalls must meet the requirements of NFPA 30.

Ventilation must be provided to prevent the exposure of personnel to hazardous concentrations of

flammable or noxious liquids, vapours or gases in enclosed areas, sumps and pits during normal and abnormal conditions such as a blown gasket or packing gland. Equipment for the detection of hazardous concentrations of fluids must be provided. Hot and cold piping which may cause injury to personnel must be suitably insulated or protected.

Photo- 50: Warning board for gas tank

http://www.megacoolstuff.com/GasStorageArea.asp

Photo- 51: Warning board for gas tank

http://www.prosportstickers.com/products/Natural-Gas-Danger-Sign.html

Article 151. Safety valves, etc. for gas storage tank

Article 151-1. Quantity of safety valve

1. "Safety valve" stipulated in design technical regulation Article 151 must be provided pursuant to the followings in addition to Article 120-1;

(1) Two or more safety valves that are configured to operate at pressure below maximum allowable working pressure of gasholder. However, it may be less than 1.07 times of the maximum operating pressure, if there is a device which automatically stops gas flow at pressure below maximum allowable operating pressure of gas going into the holder.

(2) The total capacity of blowing of safety valves must be greater than the maximum amount of discharge gas when the pressure of gasholder equal to the maximum operating pressure, even if any one of the safety valve provided on the gasholder is omitted.

Article 151-2. Negative pressure

1. This article is not applied to the gasholder, since the negative pressure id particular for the liquefied gas storage tank.

Article 152. Instrument device for gas storage tank

Article 152-1. Instrument device

"Instrumentation equipment to measure the operation conditions" stipulated in design technical regulation Article 152-1 means those which is capable to measure and confirm following matters.

(1) Those which is capable to measure the stored gas capacity, in case of the gasholder which maximum operating pressure is low.
(2) Those which are capable to measure the stored gas pressure, in case of the gasholder which maximum operating pressure is middle and high.
(3) Following matters, in case of 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.

1. 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 152-2. Pressure detector and thermometer

1. Provisions such as pressure control valves or automatic shutdown of pressurizing equipment must be installed, or procedures implemented, if the operating pressure can exceed the maximum allowable operating pressure anywhere in the pipeline system. Such provisions or procedures must prevent the operating pressure exceeding MAOP under normal steady-state conditions. Overpressure protection, such as relief or source isolation valves, must be provided if necessary to prevent incidental pressures exceeding the limits anywhere in the pipeline system.

Article 153. Alarm device for gas storage tank

Article 153-1. Alarm device

1. "Warning equipment" stipulated in design technical regulation Article 153 means those alarming in following cases. Furthermore, this is not applied, if these states will not happen due to structural reason.

(1) When the volume of stored gas decreased abnormally, in case of gasholder which maximum operating pressure is low (limited to those deliver gas by blower and compressor).

(2) When lubrication oil pressure decrease abnormally, in case of blower and compressor (limited to those that has the external forced lubricating oil system).

Chapter-3. Technical Standards for pipeline

The comparison table of technical standard for gas and oil pipeline is shown in Table-19.

Table- 19: 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, 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. (...	SP-44-2006	Steel Pipe Line Flanges	2006 Edition	§192.147(a).

SDO acronomy	Standards	Title	Latest edition	Federal reference
Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (...	SP–75–2004	Specification for High Test Wrought Butt Welding Fittings	2004 Edition	§195.118(a).
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

SDO acronomy	Standards	Title	Latest edition	Federal reference
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
(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

SDO acronomy	Standards	Title	Latest edition	Federal reference
(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 gas fuel handling facility are organized in Table-20.

Table- 20: Reference International Technical Standards

Number	Rev.	Title	Content
ISO 13623	2009	Petroleum and natural gas industries—Pipeline transportation systems	ISO 13623:2009 specifies requirements and gives recommendations for the design, materials, construction, testing, operation, maintenance and abandonment of pipeline systems used for transportation in the petroleum and natural gas industries. ISO 13623:2009 applies to pipeline systems on land and offshore, connecting wells, production plants, process plants, refineries and storage facilities, including any section of a pipeline constructed within the boundaries of such facilities for the purpose of its connection. A figure shows the extent of pipeline systems covered by ISO 13623:2009. ISO 13623:2009 applies to rigid, metallic pipelines. It is not applicable for flexible pipelines or those constructed from other materials, such as glass-reinforced plastics. ISO 13623:2009 is applicable to all new pipeline systems and can be applied to modifications made to existing ones. It is not intended that it apply retroactively to existing pipeline systems. ISO 13623:2009 describes the functional requirements of pipeline systems and provides a basis for their safe design, construction, testing, operation, maintenance and abandonment.
ISO 15649	2001	Petroleum and natural gas industries—Piping	**1.1** This International Standard specifies the requirements for design and construction of piping for the petroleum and natural gas industries, including associated inspection and testing. **1.2** This International Standard is applicable to all piping within facilities engaged in the processing or handling of chemical, petroleum, natural gas or related products. EXAMPLE Petroleum refinery, loading terminal, natural gas processing plant (including liquefied natural gas facilities), offshore oil and gas production platforms, chemical plant, bulk plant, compounding plant, tank farm. **1.3** This International Standard is also applicable to packaged equipment piping which interconnects individual pieces or stages of equipment within a packaged equipment assembly for use within facilities engaged in the processing or handling of chemical, petroleum, natural gas or related products. **1.4** This International Standard is not applicable to transportation pipelines and

Number	Rev.	Title	Content
			associated plant.
ISO 13628	2011	Petroleum and natural gas industries -- Design and operation of subsea production systems -- Part 15: Subsea structures and manifolds	ISO 13628-15:2011 addresses recommendations for subsea structures and manifolds, within the frameworks set forth by recognized and accepted industry specifications and standards. As such, it does not supersede or eliminate any requirement imposed by any other industry specification. ISO 13628-15:2011 covers subsea manifolds and templates utilized for pressure control in both subsea production of oil and gas, and subsea injection services.
ISO 13628-1	2005	Petroleum and natural gas industries -- Design and operation of subsea production systems -- Part 1: General requirements and recommendations	ISO 13628-1:2005 provides general requirements and overall recommendations for development of complete subsea production systems, from the design phase to decommissioning and abandonment. ISO 13628-1:2005 is intended as an umbrella document to govern other parts of ISO 13628 dealing with more detailed requirements for the subsystems which typically form part of a subsea production system. However, in some areas (e.g. system design, structures, manifolds, lifting devices, and color and marking) more detailed requirements are included herein, as these subjects are not covered in a subsystem standard. The complete subsea production system comprises several subsystems necessary to produce hydrocarbons from one or more subsea wells and transfer them to a given processing facility located offshore (fixed, floating or subsea) or onshore, or to inject water/gas through subsea wells. ISO 13628-1:2005 and its related subsystem standards apply as far as the interface limits described in Clause 4. Specialized equipment, such as split trees and trees and manifolds in atmospheric chambers, are not specifically discussed because of their limited use. However, the information presented is applicable to those types of equipment.
ISO 13628-2	2006	Petroleum and natural gas industries -- Design and operation of subsea production systems -- Part 2: Unbonded flexible pipe systems for subsea and marine applications	ISO 13628-2:2006 defines the technical requirements for safe, dimensionally and functionally interchangeable flexible pipes that are designed and manufactured to uniform standards and criteria. Minimum requirements are specified for the design, material selection, manufacture, testing, marking and packaging of flexible pipes, with reference to existing codes and standards where applicable. ISO 13628-2:2006 applies to unbonded flexible pipe assemblies, consisting of segments of flexible pipe body with end fittings attached to both ends. ISO 13628-2:2006 applies to both static and dynamic flexible pipes used as flowlines, risers and jumpers. The applications addressed by this ISO 13628-2:2006 are sweet and sour service production, including export and injection applications for production products including oil, gas, water and injection chemicals. ISO 13628-2:2006 does not cover flexible pipes

Number	Rev.	Title	Content
			of bonded structure or flexible pipe ancillary components or to flexible pipes for use in choke-and-kill line applications.
ISO 13628-3	2000	Petroleum and natural gas industries -- Design and operation of subsea production systems -- Part 3: Through flowline (TFL) systems	—
ISO 14556	2000	Steel -- Charpy V-notch pendulum impact test -- Instrumented test method	—
ISO 148	2009	Metallic materials -- Charpy pendulum impact test -- Part 1: Test method	ISO 148-1:2009 specifies the Charpy pendulum impact (V-notch and U-notch) test method for determining the energy absorbed in an impact test of metallic materials.
ISO 3183	2007	Petroleum and natural gas industries -- Steel pipe for pipeline transportation systems	ISO 3183:2007 specifies requirements for the manufacture of two product specification levels (PSL 1 and PSL 2) of seamless and welded steel pipes for use in pipeline transportation systems in the petroleum and natural gas industries.
ISO 7005-1	2011	Pipe flanges -- Part 1: Steel flanges for industrial and general service piping systems	ISO 7005-1:2011 establishes a base specification for pipe flanges suitable for general purpose and industrial applications including, but not limited to, chemical process industries, electric power generating industries, petroleum and natural gas industries. It places responsibility for the selection of a flange series with the purchaser. It is applicable to flanges within facilities engaged in the processing or handling of a wide variety of fluids, including steam, pressurized water and chemical, petroleum, natural gas or related products. ISO 7005-1:2011 is also applicable to packaged equipment piping, which interconnects individual pieces or stages of equipment within a packaged equipment assembly for use within facilities engaged in the processing or handling of a variety of fluids, including steam and chemical, petroleum, natural gas or related products
ISO 10474	1991	Steel and steel products _Inspection documents.	Defines the different types of inspection documents supplied to the purchaser. Shall be used in conjunction with: ISO 404 for steel and steel products; ISO 4990 for steel castings.
ISO 13847	2000	Petroleum and natural gas industries _ Pipeline transportation systems _ Field and shop welding of pipelines.	—
ISO 14313	2007	Petroleum and natural gas industries _Pipeline transportation systems _Pipeline valves	ISO 14313:2007 specifies requirements and provides recommendations for the design, manufacturing, testing and documentation of ball, check, gate and plug valves for application in pipeline systems meeting the requirements of ISO 13623 for the petroleum and natural gas industries. ISO 14313:2007 is not applicable to subsea pipeline valves, as they are covered by a separate International Standard (ISO 14723).

Number	Rev.	Title	Content
ISO 14723	2009	Petroleum and natural gas industries _Pipeline transportation systems _Subsea pipeline valves.	ISO 14723:2009 specifies requirements and gives recommendations for the design, manufacturing, testing and documentation of ball, check, gate and plug valves for subsea application in offshore pipeline systems meeting the requirements of ISO 13623 for the petroleum and natural gas industries.
ISO 15761	2002	Steel gate, globe and check valves for sizes DN 100 and smaller, for the petroleum and natural gas industries	ISO 15761 specifies the requirements for a series of compact steel gate, globe and check valves for petroleum and natural gas industry applications. It is applicable to valves of nominal sizes (DN) 8, 10, 15, 20, 25, 32, 40, 50, 65, 80 and 100, to corresponding nominal sizes, to nominal pipe sizes (NPS) of a quarter, three eighths, half, three quarters, one, one and a quarter, one and a half, two, two and a half, three and four, and to pressure designation classes 150, 300, 600, 800 and 1500. It includes provisions for a wide range of valve characteristics and is applicable to valve end flanges in accordance with ASME B16.5 and valve body ends having tapered pipe threads to ISO 7-1 or ASME B1.20.1.
ISO 17292	2004	Metal ball valves for petroleum, petrochemical and allied industries	ISO 17292:2004 specifies the requirements for a series of metal ball valves suitable for petroleum, petrochemical, natural gas plants, and related industrial applications. It covers valves of the nominal sizes DN 8, 10, 15, 20, 25, 32, 40, 50, 65, 80, 100, 150, 200, 250, 300, 350, 400, 450 and 500, corresponding to nominal pipe sizes NPS 1/4, 3/8, 1/2, 3/4, 1, 1 1/4, 1 1/2, 2, 2 1/2, 3, 4, 6, 8, 10, 12, 14, 16, 18 and 20, and is applicable for pressure designations of Class 150, 300, 600 and 800 (the last applicable only for valves with reduced bore and with threaded and socket welding end), and PN 16, 25 and 40.
ISO 16708	2006	Petroleum and natural gas industries -- Pipeline transportation systems -- Reliability-based limit state methods	ISO 16708:2006 specifies the functional requirements and principles for design, operation and re-qualification of pipelines in the petroleum and natural gas industries using reliability based limit state methods as permitted by ISO 13623. Reliability-based limit state methods provide a systematic way to predict pipeline safety in design and operation. ISO 16708:2006 supplements ISO 13623 and can be used in cases where ISO 13623 does not provide specific guidance and where limit states methods can be applied, such as, but not limited to - qualification of new concepts, e.g. when new technology is applied or for design scenarios where industry experience is limited, - re-qualification of the pipeline due to a changed design basis, such as service-life extension, which can include reduced uncertainties due to improved integrity monitoring and operational experience, - collapse under external pressure in deep water, - extreme loads, such as seismic loads (e.g. at a fault crossing), ice loads (e.g. by impact from

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			ice keels), - situations where strain-based criteria can be appropriate. ISO 16708:2006 applies to rigid metallic pipelines on-land and offshore used in the petroleum and natural gas industries.
ISO 13628	2011	Petroleum and natural gas industries -- Design and operation of subsea production systems -- Part 15: Subsea structures and manifolds	ISO 13628-15:2011 addresses recommendations for subsea structures and manifolds, within the frameworks set forth by recognized and accepted industry specifications and standards. As such, it does not supersede or eliminate any requirement imposed by any other industry specification. ISO 13628-15:2011 covers subsea manifolds and templates utilized for pressure control in both subsea production of oil and gas, and subsea injection services.
IEC 60079-10	1995	Electrical apparatus for explosive gas atmospheres _ Part 10: Classification of hazardous areas.	Is concerned with the classification of hazardous areas where flammable gas or vapor risks may arise, in order to permit the proper selection and installation of apparatus for use in such hazardous areas.
IEC 60079-14	1996	Electrical apparatus for explosive gas atmospheres _ Part 14: Electrical installations in hazardous areas (other than mines).	This part of IEC 60079 contains the specific requirements for the design, selection and erection of electrical installations in hazardous areas associated with explosive atmospheres. Where the equipment is required to meet other environmental conditions, for example, protection against ingress of water and resistance to corrosion, additional methods of protection may be necessary. The method used should not adversely affect the integrity of the enclosure. The requirements of this standard apply only to the use of equipment under normal or near normal atmospheric conditions. The significant technical changes with respect to the previous edition are: Equipment Protection Levels (EPLs) have been introduced and are explained in the new Annex I and dust requirements included from IEC 61241 14, Ed. 1.0.
ASME B31.3	1996	Process piping.	Rules for piping typically found in petroleum refineries; chemical, pharmaceutical, textile, paper, semiconductor, and cryogenic plants; and related processing plants and terminals. This code prescribes requirements for materials and components, design, fabrication, assembly, erection, examination, inspection, and testing of piping. This Code applies to piping for all fluids including: (1) raw, intermediate, and finished chemicals; (2) petroleum products; (3) gas, steam, air and water; (4) fluidized solids; (5) refrigerants; and (6) cryogenic fluids. Also included is piping which interconnects pieces or stages within a packaged equipment assembly.
ASME B31.4	2006	Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids	The B31.4 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,

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			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 Requirements for offshore pipelines are found in Chapter IX. Also included within the scope of this Code are: (A) Primary and associated auxiliary liquid petroleum and liquid anhydrous ammonia piping at pipeline terminals (marine, rail and truck), tank farms, pump stations, pressure reducing stations and metering stations, including scraper traps, strainers, and prover loop; (B) Storage and working tanks including pipe-type storage fabricated from pipe and fittings, and piping interconnecting these facilities; (C) Liquid petroleum and liquid anhydrous ammonia piping located on property which has been set aside for such piping within petroleum refinery, natural gasoline, gas processing, ammonia, and bulk plants; (D) Those aspects of operation and maintenance of liquid pipeline systems relating to the safety and protection of the general public, operating company personnel, environment, property and the piping systems.
ASME B16.5	1996	Pipe flanges and flanged fittings _NPS 1/2 through NPS 24.	This Standard covers pressure-temperature ratings, materials, dimensions, tolerances, marking, testing, and methods of designating openings for pipe flanges and flanged fittings. Included are: flanges with rating class designations 150, 300, 400, 600, 900, and 1500 in sizes NPS 1/2 through NPS 24 and flanges with rating class designation 2500 in sizes NPS 1/2 through NPS 12, with requirements given in both metric and U.S. Customary units with diameter of bolts and flange bolt holes expressed in inch units flanged fittings with rating class designation 150 and 300 in sizes NPS 1/2 through NPS 24, with requirements given in both metric and U.S. Customary units with diameter of bolts and flange bolt holes expressed in inch units flanged fittings with rating class designation 400, 600, 900, and 1500 in sizes NPS 1/2 through NPS 24 and flanged fittings with rating class designation 2500 in sizes 1/2 through NPS 12 that are acknowledged in Nonmandatory Appendix E in which only U.S. Customary units are provided
ASME B16.9	2007	Factory-Made wrought butt-welding fittings	This Standard covers overall dimensions, tolerances, ratings, testing, and markings for wrought carbon and alloy steel factory-made buttwelding fittings of NPS 1/2 through 48. It

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			covers fittings of any producible wall thickness. This standard does not cover low pressure corrosion resistant buttwelding fittings. See MSS SP-43, Wrought Stainless Steel Butt-Welding Fittings. Short radius elbows and returns, which were previously included in ASME B16.28-1994, are included in this standard. B16.9 is to be used in conjunction with equipment described in other volumes of the ASME B16 series of standards as well as with other ASME standards, such as the Boiler and Pressure Vessel Code and the B31 Piping Codes.
ASTM A193A/193M	1998	Standard specification for alloy-steel and stainless steel bolting materials for high temperature service.	This specification covers alloy steel and stainless steel bolting material for pressure vessels, valves, flanges, and fittings for high temperature or high pressure service, or other special purpose applications. Ferritic steels shall be properly heat treated as best suits the high temperature characteristics of each grade. Immediately after rolling or forging, the bolting material shall be allowed to cool to a temperature below the cooling transformation range. The chemical composition requirements for each alloy are presented in details. The steel shall not contain an unspecified element for ordered grade to the extent that the steel conforms to the requirements of another grade for which that element is a specified element. The tensile property and hardness property requirements are discussed, the tensile property requirement is highlighted by a full size fasteners, wedge tensile testing.
ASTM A194A/194M	1998	Standard specification for carbon and alloy steel nuts for bolts for high pressure or high temperature service, or both.	This specification covers a variety of carbon, alloy, and martensitic and austenitic stainless steel nuts. These nuts are intended for high-pressure or high-temperature service, or both. Bars from which the nuts are made shall be hot-wrought. The material may be further processed by centerless grinding or by cold drawing. Austenitic stainless steel may be solution annealed or annealed and strain-hardened. Each alloy shall conform to the chemical composition requirements prescribed. Hardness tests, proof of load tests, and cone proof load tests shall be made to all nuts to meet the requirements specified.
ASTM A350M	2007	Standard specification for carbon and low-alloy steel forgings, requiring notch toughness testing for piping components.	This specification covers several grades of carbon and low alloy steel forged or ring-rolled flanges, forged fittings and valves for low-temperature service. The steel specimens shall be melt processed using open-hearth, basic oxygen, electric furnace or vacuum-induction melting. A sufficient discard shall be made to secure freedom from injurious piping and undue segregation. The materials shall be forged and shall undergo heat treatment such as normalizing, tempering, quenching and precipitation heat treatment. Heat analysis and product analysis shall be performed wherein the steel materials shall conform to the required chemical compositions of carbon, manganese,

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			phosphorus, sulfur, silicon, nickel, chromium, molybdenum, copper, columbium, vanadium, and nitrogen. The materials shall also undergo tension tests and shall conform to the required values of tensile strength, yield strength and elongation. Impact tests shall also be performed and the steel materials shall conform to the required values of minimum impact energy, temperature, and minimum equivalent absorbed energy. Hardness and hydrostatic tests shall also be performed.
API RP 5L1	2002	Railroad transportation of line pipe	The recommendations provided herein apply to the transportation on railcars of API Specification 5L steel line pipe in sizes 23/8 and larger in lengths longer than single random. These recommendations cover coated or uncoated pipe, but they do not encompass loading practices designed to protect pipe coating from damage.
API RP 5L2	2002	Recommended practice for internal coating of line pipe for non-corrosive gas transmission service.	This Recommended Practice provides for the internal coating of line pipe used for non-corrosive natural gas service. It is limited to the application of internal coatings on new pipe prior to installation.
API RP 1102	2007	Steel pipelines crossing railroads and highways	This recommended practice, Steel Pipelines Crossing Railroads and Highways, gives primary emphasis to provisions for public safety. It covers the design, installation, inspection, and testing required to ensure safe crossings of steel pipelines under railroads and highways. The provisions apply to the design and construction of welded steel pipelines under railroads and highways. The provisions of this practice are formulated to protect the facility crossed by the pipeline, as well as to provide adequate design for safe installation and operation of the pipeline.
API RP5LW		Transportation of line pipe on barges and marine vessels	The recommendations in this document apply to transportation of API Specification 5L steel line pipe by ship or barge on both inland and marine waterways, unless the specific requirement of a paragraph in this document references only marine or only inland waterway transport. Inland waterways are defined as those waterways with various degrees of protection, such as rivers, canals, intracoastal waterways, and sheltered bays. These waterways can be fresh or saltwater but are usually traversed by barges. Marine waterways are defined as waterways over open seas with limited or no protection from wind, current, waves, and the like. These areas are normally traversed by sea-going vessels. These recommendations apply to steel line pipe that has $2\ ^{3}/_{8}$-in. outside diameter (OD) and larger. These recommendations cover coated or uncoated pipe, but they do not encompass loading practices designed to protect pipe coating from damage. These recommendations are not applicable to pipe-laying vessels or supply vessels. They must be considered as supplementary to the existing rules of governing

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			agencies. These recommendations are supplemental to shipping rules for the convenience of purchasers and manufacturers in the specification of loading and shipping practices and are not intended to inhibit purchasers and manufacturers from using other supplemental loading and shipping practices by mutual agreement.
API/ANSI 600	2009	Bolted Bonnet Steel Gate Valves for Petroleum and Natural Gas Industries - Modified National Adoption of ISO 10434	This International standard specifies the requirements for a heavy-duty series of bolted bonnet steel gate valves for petroleum refinery and related applications where corrosion, erosion and other service conditions would indicate a need for full port openings, heavy wall sections and large stem diameters.
API Std 620	1996	Design and construction of large, welded, low-pressure storage tanks.	This standard covers the design and construction of large, welded, low-pressure carbon steel above ground storage tanks (including flat-bottom tanks) that have a single vertical axis of revolution. This standard does not cover design procedures for tanks that have walls shaped in such a way that the walls cannot be generated in their entirety by the rotation of a suitable contour around a single vertical axis of revolution. The tanks described in this standard are designed for metal temperatures not greater than 250°F and with pressures in their gas or vapor spaces not more than 15 lbf/in.2 gauge. The basic rules in this standard provide for installation in areas where the lowest recorded 1-day mean atmospheric temperature is –50°F. Appendix S covers stainless steel low-pressure storage tanks in ambient temperature service in all areas, without limit on low temperatures. Appendix R covers low-pressure storage tanks for refrigerated products at temperatures from +40°F to –60°F. Appendix Q covers low-pressure storage tanks for liquefied hydrocarbon gases at temperatures not lower than –270°F. The rules in this standard are applicable to tanks that are intended to (a) hold or store liquids with gases or vapors above their surface or (b) hold or store gases or vapors alone. These rules do not apply to lift-type gas holders. Although the rules in this standard do not cover horizontal tanks, they are not intended to preclude the application of appropriate portions to the design and construction of horizontal tanks designed in accordance with good engineering practice. The details for horizontal tanks not covered by these rules shall be equally as safe as the design and construction details provided for the tank shapes that are expressly covered in this standard.
API Std 650	1993	Welded steel tanks for oil storage.	API Std 650 establishes minimum requirements for material, design, fabrication, erection, and testing for vertical, cylindrical, aboveground, closed- and open-top, welded carbon or stainless steel storage tanks in various sizes and capacities for internal pressures approximating

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			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.
API Std 1104		Welding of pipeline and related facilities	This standard 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 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. The values stated in either inch-pound units or SI units are to be regarded separately as standard. Each system is to be used independently of the other, without combining values in any way. Processes other than those described above will be considered for inclusion in this standard. Persons who wish to have other processes included shall submit, as a minimum, the following information for the committee's consideration:
MSS SP-25	1998	Standard marking system for valves, fittings, flanges and unions.	American standard by Manufacturers Standardization Society for valve, fitting, flange and union.
MSS SP-44	1996	Steel pipeline flanges.	American standard by Manufacturers Standardization Society for steel pipeline flange.
MSS SP-75	2008	Specification for high-test, wrought, butt-welding fittings	Covers factory-made, seamless and electric welded carbon and low alloy steel, butt-welding fittings for use in high pressure gas and oil transmission and distribution systems, including pipelines, compressor stations, metering and regulating stations, and mains. Governs dimensions, tolerances, ratings, testing, materials, chemical and tensile properties, heat treatment, notch toughness properties, manufacture and marking for

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			high-test, butt-welding fittings NPS 60 and smaller. Dimensional requirements for NPS 14 and smaller are provided by reference to ASME B16.9. The term "welding fittings" applies to buttwelding fittings such as elbows, segments of elbows, return bends, caps, tees, single or multiple-outlet extruded headers, reducers, and factory-welded extensions and transition sections.(1) Fittings may be made to special dimensions, sizes, shapes, and tolerances, or of wrought materials other than those covered by this Standard Practice by agreement between the manufacturer and the purchaser. When such fittings meet all other stipulations of this Standard Practice they shall be considered as being in partial compliance there with, providing they are appropriately marked. Fittings manufactured in partial compliance, as provided in Section 1.4, shall be identified with "Part" following the respective grade designation.
CSA Z245.20	2002	External fusion bonded epoxy coating for steel pope	This Standard covers the qualification, application, inspection, testing, handling, and storage of materials required for plant-applied fusion bond epoxy (FBE) coating applied externally to bare steel pipe. The coated pipe is intended primarily for buried or submerged service for oil or gas pipeline systems. This Standard does not cover dual powder FBE coating systems or high temperature (a glass transition temperature higher than 110 °C) FBE coating systems.
BS 4164	2002	Specification for coal tar based hot applied coating materials for protecting iron and steel , including a suitable primer	Coatings, Protective coatings, Corrosion protection, Primers (paint), Coal tar, Coal products, Fillers, Packaging, Marking, Sampling methods, Determination of content, Volatile matter determination, Density, Test equipment, Testing conditions, Softening point, Softening-point determination, Penetration tests, Viscosity, Sag (deformation), Cracking, Bend testing, Specimen preparation, Impact testing, Peeling tests, Mechanical testing, Low-temperature testing, Viscosity measurement, Density measurement, Grades (quality), Adhesion tests, Ignition-loss tests, Distillation methods of analysis
BS 5353	1989	Specification for steel plug valves	Design, materials, dimensions, pressure/temperature ratings, wall thicknesses, testing and marking of lubricated, and soft seated and lined valves. Gives requirements for anti-static features plus the option of a fire tested design.
BS 6651	1999	Code of practice for the protection of structures against lightning	This British Standard provides guidance on the design of systems for the protection of structures against lightning and on the selection of materials. Recommendations are made for special cases such as explosives stores and temporary structures, e.g. cranes and spectator stands constructed of metal scaffolding. Guidance is also provided on the protection of

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			electronically stored data. This British Standard outlines the general technical aspects of lightning, illustrating its principal electrical, thermal and mechanical effects. Guidance is provided on how to assess the risk of being struck and how to compile an index figure as an aid to deciding whether a particular structure is in need of protection.
BS 7430	1998	Code of practice for earthing	This British Standard gives guidance on the methods that may be adopted to earth an electrical system for the purpose of limiting the potential (with respect to the general mass of the earth) of current-carrying conductors forming part of the system, and non-current-carrying metalwork associated with equipment, apparatus, and appliances connected to the system. This standard applies only to land-based installations; it does not apply to ships, aircraft or offshore installations, nor does it deal with the earthing of medical equipment or the special problems encountered with solid state electronic components and equipment due to their sensitivity to static electricity.
49CFR195	2012	Transportation of hazardous liquid by pipeline	US federal regulation This part prescribes safety standards and reporting requirements for pipeline facilities used in the transportation of hazardous liquids or carbon dioxide.
NFPA 30	2008	Flammables and combustible liquids code.	This code shall apply to the storage, handling, and use of flammable and combustible liquids, including waste liquids, as herein defined and classified. 1.1.2 This code shall not apply to the following: (1)* Any liquid that has a melting point of 100°F (37.8°C) or greater (2)* Any liquid that does not meet the criteria for fluidity given in the definition of liquid in Chapter 3 and in the provisions of Chapter 4 (3) Any cryogenic fluid or liquefied gas, as defined in Chapter 3 (4)* Any liquid that does not have a flash point, but which is capable of burning under certain conditions (5)* Any aerosol product (6) Any mist, spray, or foam (7)* Transportation of flammable and combustible liquids as governed by the U.S. Department of Transportation (8)* Storage, handling, and use of fuel oil tanks and containers connected with oil-burning equipment A.1.1.1 This code is recommended for use as the basis for legal regulations. Its provisions are intended to reduce the hazard to a degree consistent with reasonable public safety, without undue interference with public convenience and necessity, of operations that require the use of flammable and combustible liquids. Compliance with this code does not eliminate all hazards in the use of flammable and combustible liquids. (See the Flammable and Combustible Liquids Code Handbook for additional explanatory information.) A.1.1.2(1) Liquids that are solid at 100°F (37.8°C) or above, but are handled, used, or stored at temperatures above their flash points, should be reviewed against pertinent sections of this code. A.1.1.2(2) The information in A.1.1.2(1) also

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			applies here. A.1.1.2(4) Certain mixtures of flammable or combustible liquids and halogenated hydrocarbons either do not exhibit a flash point using the standard closed-cup test methods or will exhibit elevated flash points. However, if the halogenated hydrocarbon is the more volatile component, preferential evaporation of this component can result in a liquid that does have a flash point or has a flash point that is lower than the original mixture. In order to evaluate the fire hazard of such mixtures, flash point tests should be conducted after fractional evaporation of 10, 20, 40, 60, or even 90 percent of the original sample or other fractions representative of the conditions of use. For systems such as open process tanks or spills in open air, an open-cup test method might be more appropriate for estimating the fire hazard. A.1.1.2(5) See NFPA 30B, Code for the Manufacture and Storage of Aerosol Products. A.1.1.2(7) Requirements for transportation of flammable and combustible liquids can be found in NFPA 385, Standard for Tank Vehicles for Flammable and Combustible Liquids, and in the U.S. Department of Transportation's Hazardous Materials Regulations, Title 49, Code of Federal Regulations, Parts 100–199. A.1.1.2(8) See NFPA 31, Standard for the Installation of Oil-Burning Equipment.
NFPA 220	2012	Standard on types of building construction.	This standard defines types of building construction based on the combustibility and the fire resistance rating of a building's structural elements. Fire walls, nonbearing exterior walls, nonbearing interior partitions, fire barrier walls, shaft enclosures, and openings in walls, partitions, floors, and roofs are not related to the types of building construction and are regulated by other standards and codes, where appropriate.
AS 2885	2003	A modern standard for design, construction, operation and maintenance of high integrity petroleum pipelines.	The suite of Standards that makes up the Australian Standard AS2885 "Pipelines – Gas and liquid petroleum" has been benchmarked against equivalent international and national Standards including ASME B31.8, CSA Z662, ISO 13623, API 1104, and ISO 13847. The benchmarking shows that AS2885 is superior in many detailed technical respects to its counterparts elsewhere, and that it better represents the current international state of the art in the design, construction, testing, operation and maintenance of petroleum pipelines. It is accepted by all of the stakeholders as the single and sufficient set of technical requirements . It uses an integral risk assessment and threat mitigation process in design and for the whole of the life of the pipeline in operation and maintenance. It has explicit requirements for the design, documentation, and approval of key processes such as prevention of external interference, control of fracture, and welding procedure qualification. And it assigns responsibility for the key processes to suitably qualified, experienced, and trained people who take

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			responsibility for their actions in writing. Amongst other reasons that has allowed the development of a worlds best practice Standard in Australia is the relatively small and agile committee process, and the involvement of many of the key contributors to the Standard in industry sponsored research projects. This involvement has simultaneously ensured that they are abreast of the latest developments, and that they are able to incorporate those developments in the Standard as and when they happen.
BS PD8010	2009	Code of practice for pipelines	PD 8010-2:2004 gives recommendations for and guidance on the design, use of materials, construction, installation, testing, commissioning and abandonment of carbon steel subsea pipelines in offshore, nearshore and landfall environments. Guidance on the use of flexible composite pipelines is also given. It is not intended to replace or duplicate hydraulic, mechanical or structural design manuals. This part of PD 8010 is applicable to subsea pipelines intended for the conveyance of hydrocarbon liquids, hydrocarbon gases and other gases, liquids and gases in two-phase flow, fluid-based slurries and water. UK standard.
CSA Z662	2011	Oil and gas pipeline systems	The 2011 edition of CSA Z662 provides guidance in the design, operation and maintenance of Canada's oil and gas pipeline systems. The sixth edition addresses relevant industry changes related to legislation, regulation, management systems and technology. It is a Canadian national standard and is incorporated in federal and provincial pipeline safety legislation.
DNV OS-F101	2010	Submarine Pipeline Systems	Norway standard. The revised Submarine Pipeline Standard complies now with the new ISO 3183 on line pipe material, with additional and modified requirements. This is the only pipeline standard in the world in compliance with ISO 13623 on pipeline design. The DNV standard also has increased focus on pipeline integrity during the operational phase. Further, the document is easier to follow and gives improved guidance and interpretations compared with the previous revision. The ISO requirements are repeated, with any additional or modified requirements clearly marked. DNV's intention is therefore to get the best out of two worlds; in compliance with ISO but still self-contained. In addition to the line pipe section, the component section has been updated to reflect new ISO standards. A list of other relevant standards, although not compulsory, has been included. DNV’s intention is for this document to now stipulate most of the additional requirements that purchasers normally specify regarding ISO/API.

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DVGW G463	2009	Gas supply systems—Pipelines for maximum operating pressure over 16 bar	German standard.
IGE/TD/1	2001	Steel pipelines for high-pressure gas transmission (provisional section on pipeline sleeving).	UK standard.
SNiP 2.05.06-85	1985	Construction regulation and rules. Trunk pipelines	This Code covers design and engineering of new mainline cross-country pipelines, as well as those under construction, and bran¬ches from these pipelines, the nominal pipe size being up to 1400 mm inclusive, with the gauge pressure of the carried fluid ranging from 1.2 MPa (12 kgf/cm2) to 10 MPa (100 kgf/cm2) (in the case of laying a single pipeline or parallel pipelines along a single lane), which pipelines are intended for transporting the following products: a) crude oil, petroleum products (including stable condensate and stable gasoline), natural, associated petroleum and manufac¬tured hydrocarbon gases from the areas of recovery (from the oil and gas fields or storage sites, to the consumers (petroleum storage , transfer tank farms, filling stations, gas distributing stations, individual industrial or agricultural enterprises, and terminals); b) liquefied hydrocarbon gases of fractions C3 and C4 and mixtures of these, unstable gasoline and associated gas condensate, as well as other liquefied hydrocarbons having saturated vapor pressure at a temperature of plus 40°C not exceeding 1.6 MPa (16 kgf/ cm2), from the areas of their recovery (producing fields) or production (from the origin pump stations) to the consumers; c) commodity products within the area of compressor stations (CS), and pump stations (PS), underground gas storage stations (UGSS),. booster compressor stations (BCS), gas distributing stations (GDS), and gas meter stations (GMS); d) control, fuel and starting gas for CSs, UGSSs, BCSs, GDSs, GMSs, and city gate stations (CGS) or pressure reducing stations (PRS).
SNiP 3.42-80	1981	Construction code and guidelines. Trunk pipelines	Russian standard. This code shall govern construction of new and reconstruction of working trunk pipelines and their branches having a nominal diameter up to 1400 mm, inclusive, and access pressure not exceeding 10 MPa (100 kgf/cm2.)

Chapter-5. Reference Japanese Technical Standards

The reference Japanese industrial standards for designing gas fuel handling facility are organized in Table-21.

Table- 21: Reference Japanese Technical Standards

Number	Rev.	Title	Content
JIS K0091	2008	Method for determination of carbon disulfide in fuel gas	This stipulates how to analyze the carbon disulfide in the exhaust gas.
JIS K0804	2008	Gas detector tube measurement system (length-of-strain type)	This stipulates about the tube-shaped gas measuring detector for a short period time.
JIS G3476	2011	Petroleum and natural gas industries—Steel pipe for pipeline transportation systems	This stipulates about seamless steel pipe and welded steel pipe products (Grade PSL1 and PSL2) used for transportation in oil and gas industry.
JIS Z3050	2010	Method of nondestructive examination for weld of pipeline	This stipulates the non-destructive testing methods of for circumferential butt weld joint with its diameter is more than 100mm and less than 2,000mm, with its thickness more than 6mm and less than 40mm for the pipeline to transport oil and gas by using pipe in normal operation pressure 0.98MPa and more.
JIS Z2300	2008	Terms and definitions of nondestructive	This stipulates major terms and definitions used in industrial non-destructive testing.
JIS Z2306	2009	Radiographic image quality indicators for non-destructive testing	This stipulates about penertometer to be used for X-ray or γ-ray radiographic testing.
JIS Z2343-1	2010	Non-destructive testing － Penetrant testing－Part 1 : General principles－Method for liquid penetrant testing and classification of the penetrant indication	This stipulates penetrant testing method and classification method of indication patterns which is used detect crack opening the surface such as crack, overlapping, wrinkles, porosity and incomplete fusion.
JIS Z2343-2	2006	Non-destructive testing---Penetrant testing—Part2: Testing of penetrant materials	This stipulates technical requirement for type testing and lot testing of liquid penetrant, procedure of testing, management and method on site.
JIS Z2343-3	2010	Non-destructive testing---Penetrant testing—Part3: Reference test blocks	This stipulates 3 types of specimen of comparison tests. Type-1 is used to determine the sensitivity levels of both penetrant and fluorescent dye penetrant products. Type-2 and 3 specimens are used to periodically examine the performance of equipment and agents for penetrant and fluorescent dye penetrant.
JIS Z2343-4	2010	Non-destructive testing---Penetrant testing—Part4: Equipment	This stipulates the characteristics of test equipment used for liquid penetrant examination.
JIS Z2345	2010	Standard test blocks for ultrasonic testing	This stipulates the standard specimens which is used to calibration, adjustment of ultrasonic test equipment and the sensitivity adjustment.
JIS Z3060	2011	Method for ultrasonic examination for welds of ferritic steel	This stipulates detection method, measurement of location and dimension defects of the full penetrated weld for ferritic steel with more than 6mm thickness by ultrasonic test using pulse-echo technique by manual.

Number	Rev.	Title	Content
JIS Z3104	2010	Methods of radiographic examination for welded joints in steel	This stipulates the radiographic transmission testing of steel welding joint by direct shooting method and by using X-ray or γ-ray using industrial X-ray film.
JIS Z4560	2008	Industry γ-ray apparatus for radiography	This stipulates about industrial γ-ray equipment used for γ-ray transmission testing.
JIS Z4561	2008	Viewing illuminators for industrial radiograph	This stipulates industrial observation instruments for grading of radiographic photos obtained by X-ray or γ-ray transmission testing.
JIS Z4606	2000	Industrial---X-ray apparatus for radiographic testing	This stipulates about industrial X-ray equipment used for X-ray transmission testing.
JIS K2251	2007	Crude petroleum and petroleum products---Sampling	This stipulates method to sample specimens of crude oil, petroleum products, semi-finished products, residue in the tank and sediment from static tank, tank lorry, drum, oil tanker, barge and pipeline.
JGA-104-03	2004	Guideline for spherical gas storage tank	—
	2006	Guideline for high pressure gas pipeline	—
	2008	Check point of the welding procedure	—
	1998	Guideline for cylindrical gasholder	—
	1982	Guideline for water seal gasholder	—
JGA-106-05	1992	Guideline for LPG storage tank	—
	2011	Guideline of seismic design for gas generation facility	—

Chapter-6. Reference TCVN

The reference Vietnamese national standards for designing gas fuel handling facility are organized in Table-22.

Table- 22: Reference TCVN

Number	Rev.	Title	Content
TCVN 3745-2	2008	System for design documentation. Rules of making drawings of pipes, pipelines and pipe line systems	Lập những quy tắc lập bản vẽ ống, đường ống và hệ thống đường ống nằm trong bộ tài liệu thiết kế của sản phẩm thuộc tất cả các ngành công nghiệ
TCVN 4090	1985	Main pipelines for transporting oil and oil products. Design standard	Áp dụng khi thiết kế mới, thiết kế cải tạo, phục hồi và mở rộng các công trình đường ống chính dẫn dầu và sản phẩm dầu và đường ống nhánh bằng thép có đường kính không lớn hơn 1400 mm
TCVN 4606	1988	Main pipeline used for transportation of petrol and petrol products. Rules for implementation and acceptance	Áp dụng để thi công và nghiệm thu các đường ống chính và đường ống nhánh bằng thép có đường kính không lớn hơn 1000 mm, có áp suất bơm chuyển không lớn hơn 1000 N/cm2, dùng để vận chuyển dầu mỏ, sản phẩm dầu mỏ và khí đốt
TCVN 5066	1990	Underground pipelines transferring gases, petroleum and petroleum products. General requirements for design and corrosion protection	áp dụng cho việc thiết kế mới phục hồi cải tạo, mở rộng đường ống chính dẫn khí đốt, dầu mỏ và sản phẩm dầu mỏ đặt ngầm dưới đất
TCVN 5422	1991	System of design documents. Symbols of pipelines	Qui định ký hiệu qui ước và đơn giản của đường ống và các phần tử của đường ống
TCVN 6022	1995	Petroleum liquids. Automatic pipeline sampling	Qui định các qui trình lấy mẫu tự động để nhận được các mẫu đại diện của dầu thô và các sản phẩm dầu mỏ lỏng chuyên chở đường ống
TCVN 6475-1	2007	Rules for Classification and Technical Supervision of Subsea Pipeline Systems. Part 1: General Requirement	Tiêu chuẩn này quy định các yêu cầu về phân cấp và giám sát kỹ thuật trong quá trình thiết kế, chế tạo và khai thác các hệ thống đường ống biển, kể cả các hệ thống đường ống đặt ở các cửa sông và vùng biển Việt Nam dùng để vận chuyển riêng lẻ hoặc hỗn hợp các chất hydrô cácbon ở trạng thái lỏng hoặc khí, như dầu thô, các sản phẩm của dầu, các loại khí.
TCVN 6475-2	2007	Rules for Classification and Technical Supervision of Subsea Pipeline Systems. Part 2: Classification of Subsea Pipeline Systems	Tiêu chuẩn này quy định các yêu cầu về phân cấp và giám sát kỹ thuật trong quá trình thiết kế, chế tạo và khai thác các hệ thống đường ống biển, kể cả các hệ thống đường ống đặt ở các cửa sông và vùng biển Việt Nam dùng để vận chuyển riêng lẻ hoặc hỗn hợp các chất hydrô cácbon ở trạng thái lỏng hoặc khí, như dầu thô, các sản phẩm của dầu, các loại khí.
TCVN 6475-3	2007	Rules for Classification and Technical Supervision of Subsea Pipeline Systems. Part 3: Requalification	Tiêu chuẩn này quy định các yêu cầu về phân cấp và giám sát kỹ thuật trong quá trình thiết kế, chế tạo và khai thác các hệ thống đường ống biển, kể cả các hệ thống đường ống đặt ở các cửa sông và vùng biển Việt Nam dùng để vận chuyển riêng lẻ hoặc hỗn hợp các chất hydrô cácbon ở trạng thái lỏng hoặc khí, như dầu thô, các sản phẩm của dầu, các loại khí.

Number	Rev.	Title	Content
TCVN 6475-4	2007	Rules for Classification and Technical Supervision of Subsea Pipeline Systems. Part 4: Design Philosophy	Tiêu chuẩn này quy định các yêu cầu về phân cấp và giám sát kỹ thuật trong quá trình thiết kế, chế tạo và khai thác các hệ thống đường ống biển, kể cả các hệ thống đường ống đặt ở các cửa sông và vùng biển Việt Nam dùng để vận chuyển riêng lẻ hoặc hỗn hợp các chất hydrô cácbon ở trạng thái lỏng hoặc khí, như dầu thô, các sản phẩm của dầu, các loại khí. Tiêu chuẩn này đưa ra các quy định về các nguyên tắc thiết kế một hệ thống đường ống biển.
TCVN 6475-5	2007	Rules for Classification and Technical Supervision of Subsea Pipeline Systems. Part 5: Design Premises	Tiêu chuẩn này quy định các yêu cầu mấu chốt, cần thiết trong việc thiết kế, lắp đặt, vận hành và chứng nhận lại các hệ thống đường ống biển.
TCVN 6475-6	2007	Rules for Classification and Technical Supervision of Subsea Pipeline Systems. Part 6: Loads	Tiêu chuẩn này đưa ra các quy định về điều kiện tải trọng và hiệu ứng tải trọng đặc trưng được sử dụng trong thiết kế các hệ thống đường ống biển tổng cả giai đoạn xây lắp và giai đoạn vận hành.
TCVN 6475-7	2007	Rules for Classification and Technical Supervision of Subsea Pipeline Systems. Part 7: Design Criteria	Tiêu chuẩn này quy định các chỉ tiêu thiết kế và các chỉ tiêu chấp nhận các dạng phá huỷ kết cấu có thể xảy ra đối với hệ thống đường ống biển.
TCVN 6475-8	2007	Rules for Classification and Technical Supervision of Subsea Pipeline Systems. Part 8: Linepipe	Tiêu chuẩn này quy định các yêu cầu đối với vật liệu, quá trình chế tạo, thử nghiệm và hồ sơ của hệ thống đường ống về các tính chất đặc trưng của vật liệu sau khi nhiệt luyện, giãn nở và tạo dáng lần cuối.
TCVN 6475-9	2007	Rules for Classification and Technical Supervision of Subsea Pipeline Systems. Part 9: Component and Assemblies	Tiêu chuẩn này quy định những yêu cầu về thiết kế, chế tạo, lắp đặt, thử nghiệm và hồ sơ của các bộ phận đường ống và các hạng mục kết cấu. Ngoài ra, tiêu chuẩn này còn quy định những yêu cầu về chế tạo và thử nghiệm các ống đứng, các vòng dãn nở, các đoạn ống dùng để cuộn ống và kéo ống.
TCVN 6475-10	2007	Rules for Classification and Technical Supervision of Subsea Pipeline Systems. Part 10: Corrosion Protection and Weight Coating	Phạm vi áp dụng của phần này bao gồm chống ăn mòn bên trong và bên ngoài đường ống và ống đứng cũng như lớp bọc bê tông gia tải để chống nổi đường ống.
TCVN 6475-11	2007	Rules for Classification and Technical Supervision of Subsea Pipeline Systems. Part 11: Installation	Tiêu chuẩn này được áp dụng cho việc lắp đặt và kiểm tra các đường ống và ống đứng cứng được thiết kế và chế tạo theo các yêu cầu của tiêu chuẩn này.
TCVN 6475-12	2007	Rules for Classification and Technical Supervision of Subsea Pipeline Systems. Part 12: Weldings	Tiêu chuẩn này áp dụng cho tất cả các quá trình chế tạo trong xưởng hoặc ngoài hiện trường, bao gồm cả quá trình xử lý nhiệt sau khi hàn.
TCVN 6475-13	2007	Rules for Classification and Technical Supervision of Subsea Pipeline Systems. Part 13: Non Destructive Testing	Tiêu chuẩn này quy định các yêu cầu đối với các phương pháp, thiết bị, quy trình, chỉ tiêu chấp nhận, chứng nhận các chứng chỉ cho các nhân sự thực hiện kiểm tra bằng mắt thường và kiểm tra không phá huỷ (NDT) vật liệu thép C-Mn, thép duplex, các loại thép không gỉ khác và các vật liệu thép có lớp phủ chống ăn mòn, các đường hàn được sử dụng trong các hệ thống đường ống.

Chapter-7. Comparison table of regislation related to pipeline.

Table- 23: Comparison table of legislations related to pipeline

Act	Gas Business Act (JP)	Mining Act (JP)	High Press. Gas Safety Act (JP)	Electric Business Act (JP)	Oil pipeline Business Act (JP)	Act of each countries	
Technical Regulation	Technical regulation for gas facility	Technical regulation for facilities used for mining activity	Schedule of high press. Gas ordinance	Technical regulation for power generation facility	Technical regulation for oil pipeline facility	49 CFR 192 “Transportation of natural and other gas by pipeline”	
Standard	Interpretation for technical regulation for gas facility	Guideline for technical regulation for facilities used for mining activity	KHK standard, JIS standard, etc.	Interpretation for technical regulation for power generation facility	—	**ASME B31.8-1999**	**ISO 13623-2000**
Material	・Main material for gas facility must have the safety mechanical property under the maximum and minimum operating temperature. ・**JIS, API, etc are quoted.**	・ The steel pipe for oil transportation must withstand the maximum operating pressure and load applied at the installed point. ・Gas is included in the oil. ・ **No specific quotation from standard.**	・Same as the item of structure. ・**JIS is quoted.**	・Main material for pressure part must have the safety mechanical property under the maximum and minimum operating temperature. ・**JIS, API are quoted.**	・Material for pipe, fitting and valve (hereinafter called “pipeline, etc.”) must conform to the standards prescribed by notice or must have mechanical properties equivalent them. ・**JIS is quoted according to notice.**	・Specification names of main materials are listed in main body, available standard name are listed in annex. ・**ASTM, API are quoted.**	・Materials used for pipeline system must have necessary mechanical properties to satisfy the design requirements such as strength and toughness. ・To be suitable for assembly and construction methods.
Structure	・The structure must be proper under the working load, maximum pressure at maximum working temperature and minimum temperature.	・ The steel pipe for oil transportation must withstand the maximum operating pressure and load applied at the installed point. ・Gas is included in the oil.	・ The structure must have sufficient strength for maximum stress generated in the normal operation pressure or temperature depending on the shape, dimension, allowable stress on material at normal operation temperature and welding efficiency, etc. of such pipeline, or must have sufficient strength corresponding to the normal operating pressure and is produced by the producer who is allowed as appropriate producer who has the production technical or inspection technology of pipe by METI .	・The structure must be proper under the working load, maximum pressure at maximum working temperature and minimum temperature.	・The structure of pipeline, etc. must be safe against stress caused by the weight of oil to be transported, inner pressure and the like. ・ The minimum thickness is stipulated for every pipe diameter.	・Design must be performed in consideration with following fracture mode properly; (1) yield (2) Buckling (3) Fatigue, etc.	・Load that may cause destruction of pipeline or loss of function must be identify are design stage and be considered. ・ Functional, environmental, construction, accidental load and their combination must be considered.

Act	Gas Business Act (JP)	Mining Act (JP)	High Press. Gas Safety Act (JP)	Electric Business Act (JP)	Oil pipeline Business Act (JP)	Act of each countries	
Calculation of piping thickness	・The equation for minimum wall thickness against inner pressure and the calculation formula for minimum wall thickness against earth pressure and road load is set forth and the greater one is adopted. ・(Outer pressure) $t=\sqrt{\frac{2.5\left(K_f W_f+K_t W_t\right)}{\sigma}}D_o+C$	・No provision.	・The calculation formula for minimum wall thickness against inner pressure is set forth.	・The calculation formula for minimum wall thickness against inner pressure, earth pressure and road load is set forth.	・Expected load such as inner pressure, soil pressure, hydraulic pressure, train and vehicle is prescribed by the ordinance. Generated stress by the load is; Primary load, etc. $\leqq 0.5\sigma_y$ Pressure load $\leqq 0.4\sigma_y$ There is the regulation equation; Combination of primary load and secondary load $\leqq 0.9\sigma_y$	・The minimum wall thickness against inner pressure (wall thickness varies with coefficients designed by Location Class). ・To be thicken, if a large force such as scour, landslides, earthquake and liquefaction is possible to apply.	・Formula of the minimum wall thickness in the circumferential direction against inner pressure (wall thickness varies with coefficients designed by Location Class) and composite stress.
	・(Inner pressure) (1) When the ratio between outer diameters to inner diameter is 1.5 or less. $t=\frac{PD_o}{2\sigma_a\eta+0.8P}+C$ (2) When the ratio between outer diameters to inner diameter is more than 1.5. $t=\frac{D_o}{2}\left[1-\sqrt{\frac{\alpha_a\eta-P}{\alpha_a\eta-P}}\right]+C$	・No provision.	・(Inner pressure) (1) When the ratio between outer diameters to inner diameter is 1.5 or less. $t=\frac{PD_o}{2\sigma_a\eta+0.8P}+C$ (2) When the ratio between outer diameters to inner diameter is more than 1.5. $t=\frac{D_o}{2}\left[1-\sqrt{\frac{\alpha_a\eta-P}{\alpha_a\eta-P}}\right]+C$	・(Inner pressure) (1) When the ratio between outer diameters to inner diameter is 1.5 or less. $t=\frac{PD_o}{2\sigma_a\eta+0.8P}+C$ (2) When the ratio between outer diameters to inner diameter is more than 1.5. $t=\frac{D_o}{2}\left[1-\sqrt{\frac{\alpha_a\eta-P}{\alpha_a\eta-P}}\right]+C$	・(Inner pressure) ・The formula is provided.	・(Inner pressure) $P=\frac{2S_t}{D}FET$ F=0.4～0.8	・(Inner pressure) $\sigma_{hp}=\left(p_{id}-p_{od}\right)\frac{\left(D_0-t_{\min}\right)}{2\times t_{\min}}$
Earthquake resistant	・Quoted seismic design of gas facility. Middle and low pressure: Guideline for seismic design of middle and low pressure gas pipeline. High pressure: Guideline for seismic design of high pressure pipeline and guideline for liquefaction seismic design of high gas pipeline. ・ Level-2 earthquake is	・No provision. ・Allowable stress design method Level-1	・No stipulation in the general rule. (Complex rule: The construction of pipeline must be safe against the stress caused by earthquake *** and other secondary load.) ・Allowable stress design method Level-1	・Refer to safety rule related the complex rule (No.717/1987/ Environmental Protection and Industrial Location Bureau ・Allowable stress design method Level-1	・Provision by notice. ・Consideration based on stress.	・No specific provision.	・ The formula has not been shown, though earthquake has been to consider as environmental load.

Act	Gas Business Act (JP)	Mining Act (JP)	High Press. Gas Safety Act (JP)	Electric Business Act (JP)	Oil pipeline Business Act (JP)	Act of each countries	
	considered in case of high pressure pipeline.						
Pressure test	・Pressure test for pressure part must be performed by appropriate method. (excluding those that have passed RT ・1.5 times of maximum operating pressure.	・To pass the pressure test under at least 1.5 times of maximum operating pressure. ・Pressure test or air tightness test must be performed.	・To withstand pressure test under at least 1.5 times of normal operation pressure. ・At least 1.25 times in case of gas.	・Pressure test for pressure part must be performed by appropriate method. ・1.5 times of maximum operating pressure.	・Hydro pressure test for pipeline, etc. must be performed 1.5 times of operating pressure by the method specified in the notice.	・ Different with each class locations. (design factor, location) Class1, Dev.1 : more than 1.25 times by water Class1, Dev.2 : more than 1.1 times by water or air Class2 : more than 1.25 times by water or air Class3&4 : more than 1.4 times by water	・More than 1.25 times, at least one hour by water, or air when water is unavailable. (1.20 times is possible for C, D fluid that does not exceed 1.05 times.) ・More than 1.1 times, at least 8 hours as leak test after the strength test.
Air tightness test	・No leakage when performing air-tight examination in appropriate method. ・ Air-tight examination under maximum operating pressure or normal operating pressure must be performed.	・To pass the air-tight examination more than 1.1 times of maximum operation pressure. ・ Air-tight examination or pressure test must be performed.	・To pass the air-tight examination more than normal operation pressure.	・No leakage when performing air-tight test. ・1.1 times of the maximum operating pressure.	・No provision.	・No provision.	・No provision.
Welding part	・Welding part of the gas facility where gas passing through and bear 0MPa and more must have good melting, no harmful defects due to crack by welding and have strength at least as required as design strength. ・Confirmation of WPS, welder test, appropriate non-destructive testing and criteria for RT in case of high pressure and middle pressure pipeline with 150mm diameter and more must be pursuant to **JIS Z3104**.	・Pipe joint must be made by welding method that has equivalent effect of other than arc welding. However, it may be other safety method that has necessary strength for safety when welding is not proper.	・ Non-destructive testing is required when testing by gas pressure only.	・Welding part of the electric facilities where gas passing through and bear 0.98MPa and more must have safety shape. (liquefied gas pipeline) ・Welding part must not have cracking and could arise cracks. ・Confirmation of WPS, welder test, appropriate non-destructive testing and criteria for RT must be pursuant to **JIS Z3104**.	・The welding of pipeline, etc. must be performed by the welding method such as arc welding stipulated in notice. ・The welding equipment, welding consumables used for welding of pipeline must have performance equivalent or more than standard stipulated in notice. ・The welding method and other necessary matter for welding must be stipulated in notice.	・Welding procedure and welder must be pursuant to **API 1104.**	・Welding procedure and welder must be pursuant to **ISO 13847.**

Act	Gas Business Act (JP)	Mining Act (JP)	High Press. Gas Safety Act (JP)	Electric Business Act (JP)	Oil pipeline Business Act (JP)	Act of each countries	
Gas drip box	・Gas drip box must be provided on pipeline which may accumulate water.	・Measure to remove moisture between natural gas pipeline and its connected compressor must be taken.	・Measure to remove water must be taken.	・No provision.	・No provision.	・No provision.	・No provision.
Corrosion protection	・Measure to prevent corrosion must be taken, if there is risk of corrosion.	・Appropriate measures for corrosion protection must be taken for pipeline that installed in the place where the much risk of corrosion is.	・Measure to prevent corrosion must be taken when burring underground.	・The appropriate measures must be taken if there is a risk of corrosion.	・The painting, coating and electrical corrosion protection must be applied the pipeline installed underground or on seabed.	・Must be painted or covered inconsideration with installation conditions, operation environment and cathodic protection condition.	・Corrosion control must be performed to prevent the risk of non-operation due to destruction by corrosion during design life. ・The outer electricity supply method is stipulated.
Protection measures	・Measure to prevent damage due to contact exposed pipeline on the road with vehicles must be taken.	・Protective equipment and sign must be provided if there is a risk of damage due to collision to vehicle when installing on a ground. ・Protective measure to prevent damage of the riser pipe by vessel must be taken and must be provided sign when installing on the seabed, etc.	・Signs must be installed when installing pipeline on the ground, pipeline must be buried under more than 0.6m and provided signs when installing pipeline buried under the ground surface. ・When installing in the water, appropriate depth that no affect by vessel and wave. ・（Complex rule stipulates to install pipeline in the protective structure when burying it raid across the road, railroad, river or waterway.	・Appropriate protective measures must be taken if there is a risk of damage.	・The protection equipment must be installed according to notice if there is a risk of damage on pipeline or support due to the collision of vehicle, vessel and the like.	・Pipeline must be protected from damage or accidents by vehicles in exposed places such as intersection with pipe-rack or bridge by means of separation or barrier.	・No provision.
Interrupting device	・Emergency shutoff device for pipeline that are buried in alongside the road such as gas shutoff device.	・Gas shutoff device must be provided in the junction point of pipeline. Pipeline must be placed in a suitable position when pipeline across the city, etc.	・No stipulation in general rule.(Complex rule: Emergency shutoff device must be provided in every 4km for pipeline crossing urban area, etc. At the same time, measure that can transport gas to every section and be replaced by an inert gas must be taken.)	・Shutoff equipment to block the inflow and outflow of gas must be provided at the main entrance of gas equipment. ・（The last place entering the common culvert and junction point and other point where necessary for maintenance of pipeline.）	・Every 4km for an specified area in an ordinance. ・Specified in notice; Every 4km for back and forth of river and channel crossing, necessary place for safety management of mountain slope and city area, every 10km for outside town.	・The interval between section shutoff valves must be less than following; (1) Class1：20mile (2) Class2：15mile (3) Class3：10mile (4) Class4：5mile	・Section shutoff valves must be provided at start, end and the points for following items on pipeline; (1) Operation and maintenance (2) Emergency control (3) Limit of runoff
Leak detection	・No provision.	・Leak detection equipment or leak detection hole must be	・No provision in general rule. (Complex rule: gas leak detection	・Appropriate measures to prevent harm must be taken in case of gas	・Leak detection equipment and leak detection hole must be	・No provision.	・Testing and recording must be performed periodically to confirm

Act	Gas Business Act (JP)	Mining Act (JP)	High Press. Gas Safety Act (JP)	Electric Business Act (JP)	Oil pipeline Business Act (JP)	Act of each countries	
device		provided where necessary.	alarm equipment or leak detection mouth must be provided on the flammable gas pipeline.)	leak. ・（ Ventilation equipment in common duct, leak detection alarm equipment must be provided where gas may leak. ）	provided on pipeline system.		the suitability of operation requirements.
Protection device	・No provision.	・To provide operation condition monitoring equipment. ・To provide alarm system in the event of abnormal fluctuation of pressure and flow rate.	・No provision in general rule. (Complex rule: alarm device must be provided for abnormal pressure and flow on pipeline.)	・No provision.	・Monitoring device to monitor the operating status of equipment such as compressor and valves must be provided on pipeline. ・Warning device to indicate in the event of an abnormal situation such as unusual changes in pressure or flow rate must be provided according to notice.	・ No specific provision. (The provision of emergency shutoff device that can isolate and dissipate gas is stipulated in the item of compressor station.)	・Emergency shutdown system, pressure regulating system, monitoring system and communication system must be provided in station.
Installation condition for pipeline (except seabed)	・	・	・	・Protection measure for buried under road must be taken. （ 0.15m when crossing with underground object and at least 0.3m in parallel case.）	・To be buried underground. ・To keep clearance at least 0.3m. ・Distance with ground level. (1) Forest wilderness：at least 0.9m (2) Other area：at least 1.2m	・ Stipulated according to classification rules; 【Piping cover：item-841.142】 (1) Class1 ：24inch (2) Class2 ：30inch (3) Calss3&4：30inch	・With little human activity：0.8m Farmland：0.8m Road, railroad：0.8m
Safety device, etc.	・No provision for pipeline.	・Safety valve and other safety device to avoid exceeding the maximum working pressure.	・ Measure to avoid exceeding normal operation temperature and measure that can be returned to reduce pressure to below normal operation pressure, if the pressure exceeds the normal operating pressure.	・No provision for pipeline.	・ Control device to control pressure due to normal operation or oil hammering must be provided so as not to exceed 1.1 times of normal operating pressure. ・Pressure safety device must have enough capacity to fully absorb pressure fluctuation of pipeline.	・(The provision of pressure safety device is stipulated in the item of compressor station.)	・ The equipment to prevent overpressure such as relief valve, isolation valve must be provided in order to prevent the occurrence of incidental pressure.
Items provided specifically	・No provision.	・Pressure sensing devices and backflow prevention devices for the marine pipeline must be provided in the appropriate location.	・No provision in the general rule. (Complex rule: Seismic sensor must be provided in the necessary place along the pipeline and measures to prevent disaster must	・No provision.	・ Seismic sensor and strong motion seismograph must be provided along the pipeline pursuant to the notice.	・No provision.	

Act	Gas Business Act (JP)	Mining Act (JP)	High Press. Gas Safety Act (JP)	Electric Business Act (JP)	Oil pipeline Business Act (JP)	Act of each countries	
			be taken.)				
Safety control device	・No provision for pipeline. (Stipulated in ordinance Article 23, 26 and 27 related to production)	・Control function that compressor or pump does not work without ensuring that the control circuit for the safety equipment such as monitoring equipment of operating condition is normal for pipeline which is installed in the complex area. ・Control function to gracefully shut down compressor and pump or close emergency shutoff equipment by automatic or manual in the event of abnormal conditions.	・No provision in general rule. (Control function that compressor or pump does not work without ensuring that the control circuit for the safety equipment such as monitoring equipment of operating condition is normal for pipeline which is installed in the complex area. Control function to gracefully shut down compressor and pump or close emergency shutoff equipment by automatic or manual in the event of abnormal conditions.)	・No provision for pipeline.	・Pipeline must be provided safety control device that has following function. (control function that blower does not work without ensuring that the control circuit for the safety equipment such as pressure safety equipment, automatic oil leak detection equipment, emergency shutoff valve, seismoscope, and other safety equipments is normal and control function to gracefully shut down blower or close emergency shutoff equipment by automatic or manual in the event of abnormal conditions.)	・Stipulated in item about compressor station.	
Protective grounding	・No provision.	・Earthling must be provided, if required for safety.	・No provision in the general rule. (Complex rule: Earthing must be provided for safety, if necessary.)	・No provision.	・Earthling must be provided if required for safety.	・No specific provision.	・No specific provision.
Insulation	・No provision.	・Measure must be taken such as insulation from support or other structure, application of insulating fittings and necessary measure for insulation when installing pipeline in close proximity to location of the arrester must be taken if necessary for safety.)	・No stipulation in general rule. (Complex rule: Measures must be taken such as insulation from support or other structures, application of insulating fittings and necessary measure for insulation must be taken if necessary for safety.)	・No provision.	・Pipeline system must be insulated from other structure such as support, if there is necessity for safety. ・The insulated joint must be applied to pipeline system, if there is necessity for safety. ・Necessary insulation measure must be taken when installing pipeline in close proximity to location of the arrester.	・No specific provision.	・The following items must be taken into account for the selection of the insulation; (1) Risk for fluid (2) Insulation systems and other safety requirements (requirement as operation management)
Lightning protection system	・No provision.	・To be provided, if required for safety.	・No provision in the general rule.(Complex rule: measures to avoid the effects of lightning must be taken , if necessary.)	・No provision.	・The lightning protection system must be provided for the part that are placed on the ground pursuant to notice.	・No specific provision.	・No specific provision.

Act	Gas Business Act (JP)	Mining Act (JP)	High Press. Gas Safety Act (JP)	Electric Business Act (JP)	Oil pipeline Business Act (JP)	Act of each countries	
Others	・No provision.	・No provision.	・ Complex rule: Power for security, patrol vehicle and equipment storage must be provided.	・No provision.	・Emergency reporting equipment and a facility to notify fire authority must be provided along the pipeline. ・ Chemical fire engine, patrol vehicle and equipment storage must be provided along pipeline pursuant to notice.	・No specific provision.	・No specific provision.
Leak test	・HP : once every 14 months ・Others：once every 40 months	・ No provision. (according to safety manual)	・No provision.（Airtight test is required as a security check）	・ No provision. （ Inspection frequency must be done in accordance with Gas Business Act.）	・No provision.	・No specific provision.	・No specific provision.
Pressure regulator	・Prevention measures due to fire caused by gas leakage (high pressure), shutoff device and impurity removal equipment at entrance, prevention apparatus for pressure rise, flood protection device, anti-icing system, support to withstand earthquake and overhaul maintenance for if gas is supplied to one user.	・Pressure regulator at appropriate location, gas isolating equipment at the entrance of regulator and safety device at the outlet must be provided for pipeline if necessary.	・No provision.	・No provision.	・No provision.	・No specific provision.	・No specific provision.

Chapter-8. Referenced Literature and Materials

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

1. Interpretation of technical regulation for thermal power facility(10/Jul/1007): NISA (Nuclear and Industrial Safety Agency) of METI (Ministry of Economy, Trade and Industry)
2. Guideline for gas facility Japan (Mar /2010): NISA (Nuclear and Industrial Safety Agency) of METI (Ministry of Economy, Trade and Industry)
3. Gas combustion technology (Lournal: A.Fujimoto and others: No.517: Oct/1999) TENPES (Thermal and Nuclear Engineering Society of Japan)
4. The outline—boiler (Journal: No.583: Apr/2006): TENPES (Thermal and Nuclear Engineering Society of Japan)
5. Fuel and combustion (Journal: No. 590: Nov/2005): TENPES (Thermal and Nuclear Engineering Society of Japan)
6. Management of fuel (Fuel for therma; power plant) (Journal: No.611: Aug/2007): TENPES (Thermal and Nuclear Engineering Society of Japan)
7. "High temperature pipeline coatings – Fielde joint challenges in remote construction": (Wayne Hodgins and others of Canusa-CPS)