Amendments for Guidance Relating to Rules for Classification of Ships Using Low-flashpoint Fules

(Machinery Part)

Machinery Rule Development Team

- Main Amendments -

(1) Effective Date : 1 July 2018

◉ Has been Roll-back to UI GF1 New after withdrawing UI GF1 Rev.1

(2) Effective Date : 1 January 2019

◉ Has been reflected IACS Rec.146 Risk assessment for IGF code

(3) Effective Date : 1 July 2019

◉ Has been reflected request for establishment/revision of Classification Technical Rules

◉ Has been edited title number

◉ Has been reflected IACS UI GF13, 14, 15

Present	Amendment
CHAPTER 6 FUEL CONTAINMENT SYSTEM	**CHAPTER 6 FUEL CONTAINMENT SYSTEM**
Section 9 Maintaining of fuel storage condition	**Section 9 Maintaining of fuel storage condition**
901. <omitted>	**901. <omitted>**
903. Reliquefaction systems	**903. Reliquefaction systems**
1. <newly added>	**1.** If the cooling medium for heat exchanger is returned into machinery spaces, provisions are to be made to detect and alarm the presence of fuel in the medium. Any vent outlet is to be in a safe position and fitted with an effective flame screen of an approved type.
CHAPTER 11 FIRE SAFETY	**CHAPTER 11 FIRE SAFETY**
Section 3 Fire Protection	**Section 3 Fire Protection**
301. Fire protection	**301. Fire protection**
1. ~ 2. <newly added>	**1.** In applying **301. 1** of this Rules, fire protection means structural fire protection, not including menas of escape. **2.** In applying **301. 1** of this Rules, enclosed spaces containing equipment for fuel preparation such as pumps or compressors or other potential ignition sources are to be provided with a fixed fire-extinguishing system complying with **Pt 8**, **Ch 8**, **301. 1** of **Rules for the classification of steel ships,** the FSS Code and taking into account the necessary concentrations/application rate required for extinguishing gas fires.
1. <omitted>	**3.** <omitted>

Present	Amendment
CHAPTER 12 EXPLOSION PREVENTION	**CHAPTER 12 EXPLOSION PREVENTION**
Section 4 Hazardous Area Zones	**Section 4 Area classification**
401. Area classification	**401. Area classification**
1. ~ 2. <omitted>	**1. ~ 2.** <same as the present>
Section 5 Hazardous Area Zones	**Section 5 Hazardous Area Zones**
402. Area classification	**502. Zone “1”**
1. In applying **402. 2** of this Rules, measuring instruments and electrical equipment are to be capable of being used in the hazardous area zone 1.	**1.** ~~In applying **402. 2** of this Rules,~~ Measuring instruments and electrical equipment are to be capable of being used in the hazardous area zone 1.
2. In applying **402. 2** of this Rules, fuel storage hold spaces for type C tanks are normally not considered as hazardous area zone 1.	**2.** ~~In applying **402. 2** of this Rules,~~ Fuel storage hold spaces for type C tanks are normally not considered as hazardous area zone 1. For the purposes of hazardous area classification, fuel storage hold spaces containing Type C tanks with all potential leakage sources in a tank connection space and having no access to any hazardous area, is to be considered non-hazardous. Where the fuel storage hold spaces include potential leak sources, e.g. tank connections, they is to be considered hazardous area zone 1. Where the fuel storage hold spaces include bolted access to the tank connection space, they is to be considered hazardous area zone 2.
3. In applying **402. 2** (3) of this Rules, any fuel tank outlet, gas or vapour outlet means, for example, all areas within 3 m of fuel tank hatches, ullage openings or sounding pipes for fuel tanks located on open deck and gas vapour outlets.	**3.** In applying **3** of this Rules, any fuel tank outlet, gas or vapour outlet means, for example, all areas within 3 m of fuel tank hatches, ullage openings or sounding pipes for fuel tanks located on open deck and gas vapour outlets.

Present	Amendment
4. <Newly added>	**4.** In addition to the zones defined in **502.** of this Rules, examples of hazardous area zone 1 include, but are not limited to, the following: (1) enclosures or compartments containing gas regulating and/or block and bleed valves; (2) areas on open deck or semi-enclosed spaces on deck, with 3 m of ventilation outlets of spaces: (A) tank connection spaces (B) fuel storage hold spaces (C) interbarrier spaces (D) enclosed or semi-enclosed spaces in which pipes containing fuel are located (E) enclosures or compartments defined in (1) (3) areas on open deck or semi-enclosed spaces on open deck above and in the vicinity of any vent outlet intended for the passage of large volumes of gas or vapour, within a vertical cylinder of unlimited height and 6 m radius centerd upon the centre of the outlet and within a hemisphere of 6 m radius below the outlet; (4) in applying (3), areas may be reduced up to 3 m based on a specific gas dispersion analysis
503. <newly added>	**503. Zone "2"**
4. In applying **402. 3** of this Rules, measuring instruments and electrical equipment are to be capable of being used in the hazardous area zone 2.	**1.** ~~In applying **402. 3** of this Rules,~~ Measuring instruments and electrical equipment are to be capable of being used in the hazardous area zone 2.
2. <Newly added>	**2.** In addition to the zones defined in **503.** of this Rules, examples of hazardous area zone 1 include, but are not limited to, the following: (1) areas 4 m beyond the cylinder and the sphere defined in **502. 4 (3)** of this **Guidance**. (2) airlocks protecting a non-hazardous area from hazardous area zone 1.

Present	Amendment
CHAPTER 15 CONTROL, MONITORING AND SAFETY SYSTEMS	**CHAPTER 15 CONTROL, MONITORING AND SAFETY SYSTEMS**
Section 3 <omitted>	**Section 3 <same as the present>**
Section 4 Bunkering and Liquefied Gas Fuel Tank Monitoring	**Section 4 Bunkering and Liquefied Gas Fuel Tank Monitoring**
402. Overflow control	**402. Overflow control**
1. In applying **402. 3** of this Rules, the expression "each dry-docking" refers to: (1) the survey of the outside of the ship's bottom required for the renewal of the Cargo Ship Safety Construction Certificate and or the Cargo Ship Safety Certificate, for cargo ships. (2) the survey of the outside of the ship's bottom to be carried out every 60 months according to IMO Resolution A.1104(29, paragraphs 5.10.1 and 5.10.2), for passenger ships.	**1.** In applying **402. 3** of this Rules, the expression "each dry-docking" refers to: (1) the survey of the outside of the ship's bottom required for the renewal of the Cargo Ship Safety Construction Certificate and or the Cargo Ship Safety Certificate, for cargo ships. (2) the survey of the outside of the ship's bottom to be carried out every 60 months according to IMO Resolution A.1104(29, paragraphs 5.10.1 and 5.10.2), for passenger ships.
2. In applying **402. 3** of this Rules, The expression "high-level alarms" is considered to be high liquid level alarm(s) in **1** and does not include the independent sensor(s) which activates the automatic shutdown of liquefied gas fuel tank filling and additional sensor(s) specified in **2** of this Rules.	~~**2.** In applying **402. 3** of this Rules, The expression "high-level alarms" is considered to be high liquid level alarm(s) in **1** and does not include the independent sensor(s) which activates the automatic shutdown of liquefied gas fuel tank filling and additional sensor(s) specified in **2** of this Rules.~~
3. In applying **402. 3** of this Rules, "first occasion of full loading" after "dry-docking" is considered to be the first loading of the liquefied gas fuel where conditions allow for testing provided that the position of sensors for all high-level alarm(s) additional sensor(s) specified in **2** of this Rules and independent sensor(s) which activates the automatic shutdown of liquefied gas fuel tank filling were tested by simulation at the dry-docking. The testing of the high-level alarms with liquefied gas fuel is to be recorded in the ship's logbook by the Master and verified by the Administration or recognized organisation at the first annual survey of a cargo ship, or the first renewal survey of a passenger ship, after "each dry-docking".	~~**3.** In applying **402. 3** of this Rules, "first occasion of full loading" after "dry-docking" is considered to be the first loading of the liquefied gas fuel where conditions allow for testing provided that the position of sensors for all high-level alarm(s) additional sensor(s) specified in **2** of this Rules and independent sensor(s) which activates the automatic shutdown of liquefied gas fuel tank filling were tested by simulation at the dry-docking. The testing of the high-level alarms with liquefied gas fuel is to be recorded in the ship's logbook by the Master and verified by the Administration or recognized organisation at the first annual survey of a cargo ship, or the first renewal survey of a passenger ship, after "each dry-docking".~~

Present	Amendment
Section 8 <omitted>	**Section 8 <same as the present>**
Section 10 Ventilation	**Section 10 Ventilation**
1001. Ventilation	**1001. Ventilation**
1. <newly added>	**1.** In applying **1001. 1** of this Rules, acceptable means to confirm that the ventilation system has the "required ventilating capacity" in operation are, but not limited to: (1) Monitoring of the ventilation electric motor or fan operation combined with underpressure indication ; or (2) Monitoring of the ventilation electric motor or fan operation combined with ventilation flow indication ; or (3) Monitoring of ventilation flow rate to indicate that the required air flow rate is established.
Annex 1 Requirements for Equipment Used for Low-flashpoint Fuel Supply Systems	**Annex 1 Requirements for Equipment Used for Low-flashpoint Fuel Supply Systems**
Section 1 ~ 3 <omitted>	**Section 1 ~ 3 <same as the present>**
Section 4 Screw Gas Compressors	**Section 4 Screw Gas Compressors**
401. ~ 404. <omitted>	**401. ~ 404. <same as the present>**
405. Strength	**405. Strength**
1. <omitted>	**1.** <omitted>
2. Strength of screw shaft is to be in accordance with **Pt 5, Ch 3, 303.** of **Rules for the Classification of Steel Ships**.	**2.** Strength of screw shaft is to be in accordance with **Pt 5, Ch 3, 203.** of **Rules for the Classification of Steel Ships**.

<Newly added>

Annex 2 Guidance for Ships Using LPG as Fuels *(2019)*

Section 1 General

101. Application

1. This Annex applies to ships using LPG as fuel in accordance with **Ch 1, 101. 1** of the Rules. However, despite of **Ch 1, 101.1** (1) and (2) of the Rules, this Annex may apply to ships carrying liquefied gases in bulk using their LPG cargoes as fuel in addition to requirements of **Pt 7**, **Ch 5, Sec 16** of **Rules for the classification of steel ships.**

2. LPG fuels in this Annex include LPG in gas phase and liquid phase.

3. The requirements of this Annex are prescribed in addition to the requirements in the Rules. Except where specially required in this Annex, the relevant requirements in the Rules are to be applied. (The terms 'LNG' and 'natural gas' are to be construed as 'LPG' and 'PG' respectively.)

102. Definition

The definitions of terms not specified in the followings are to be as specified in the Rules.

1. LPG means liquefied petroleum gas. It is mainly composed of propane, butane or a mixture of propane (C3H8) and butane (C4H10) and contains small amounts of propylene and butylene. In this Annex, not only liquid but also gaseous petroleum gas is referred to as LPG. However, when it is necessary to distinguish between the liquid state and the gas state, LPG in the liquid state is referred to as LPG liquid, and LPG in the gaseous state is referred to as LPG gas.

2. Fuel in this Annex means LPG.

3. Critical temperature means the highest temperature at which a gas can be changed into a liquid.

4. Autoignition temperature means the lowest temperature at which it spontaneously ignites in normal atmosphere without an external source of ignition, such as a flame or spark.

5. Gas dispersion analysis means the analysis of the dispersion behavior of gases using appropriate modeling techniques such as computational fluid dynamics (CFD) analysis.

6. Ventilation analysis means the analysis of the ventilation efficiency of a space performed using appropriate modeling techniques such as computational fluid dynamics (CFD) analysis.

7. Effectiveness of ventilation mean the effectiveness on controlling the disperse and persistence of an explosive gas atmosphere due to gas leakage. This depends on the degree of dilution, the availability of ventilation and the design of the system. (See IEC 60079-10-1, 6.5.4)

8. Degree of dilution means a measure of the ability of ventilation or atmospheric conditions to dilute a release to a safe level. The degree of dilution is defined as high ventilation, medium ventilation, and low ventilation. (See IEC 60079-10-1, 6.5.4)

9. Leakage means leaking out of gas or liquid from the tank or equipment to the outside.

10. Relief refers to the release of gas into the atmosphere through a pressure relief valve for the purpose of pressure control within the tank or equipment.

11. Exhaust means exhausting the leaked gas in the dangerous area to the outside through a forced ventilation system.

12. Flash gas means to the vapor generated from the LPG liquid as the LPG liquid is depressurized or heated during the process of bunkering propane and butane respectively in the tank.

103. General

1. This Annex specifies alternative and additional requirements for that are not applicable to LPG among the detailed requirements applicable to LNG fuels, considering that LPG has different properties from those of LNG.

2. Special consideration is to be given to the fuel tank of refrigerated type other than a fully pressurized type.

<Newly added>

3. Typical difference between properties of LPG and LNG referred to in **Pare 1** are shown, but not limited to, in **Table 1**.

Table 1 Properties and related risks of LPG and LNG

properties	LNG	LPG	related risks
Vapour SG at 15 ℃ and atmospheric pressure	0.55	1.52(Propane) 2(Butane)	· unfavorable for exhaust/dispersion of leakage gas
Flammable limits in air by volume (%)	5 ~ 15	2.2~9.5(Propane) 1.8~8.4(Butane)	· formation of flammable atmosphere at lower concentrations
Autoignition temperature (℃)	595	459(Propane) 405(Butane)	· hazard of autoignition at lower temperatures · hazard of ignition of unburned gas
Boiling point at 1 bar absolute (℃)	-161	-42(Propane) -1(Butane)	· unfavorable for visual identification of gas leakage · not subject to rollover
Vapour pressure at 45 ℃ (bar)	-	15(Propane) 4(Butane)	· liquefaction by pressurizing at atmospheric temperature · various boundaries of the phase change according to the composition ratio.
Critical temperature (℃)	-82.95	96(Propane) 152(Butane)	· stored at atmospheric temperature under pressure
Critical pressure (bar)	45.99	42.6(Propane) 38(Butane)	· minimum pressure for liquefaction at critical temperature
Static pressure / static specific heat ratio k(Cp/Cv)	1.31	1.13(Propane) 1.096(Butane)	· design pressure of outer wall of double pipe
Variety of composition ratio	methane	butane and propane	· change of properties on the basis of composition ratio

4. For LPG properties listed in **Table 1**, the properties and related risks that are to be specially considered in arrangement and system design are as follows.

(1) Specific gravity of gas

(A) Since LPG gas is heavier than air, in case of leakage and relief on open decks, it may settle down at the bottom and flow through the decks with dangerous concentration. It is therefore necessary to check the floor arrangement and openings of other spaces in the way of the LPG leakage/relief source to prevent gas from accumulation and ingress into other spaces.

(B) In LPG fuelled ships, the leakage or relief sources of LPG are mainly as follows.

- vent mast
- valve and flange connection of LPG fuel piping
- equipment constituting LPG fuel supply systems
- LPG combustion equipment
- tank connections and valves
- bunkering manifolds
- damage of fuel pipe
- damage of fuel tank

(C) Since LPG gas differs from LNG in its dispersion properties, safety measures(gas detection, ventilation, distance to openings in non-hazardous areas, etc.) are to be subject to special consideration to prevent accumulation of gas.

(D) It is to be ensured that the discharged gas to the open area through the ventilation outlet of the hazardous area is not likely to be recirculated to the ventilation inlet through the floor.

(2) Autoignition temperature

(A) The autoignition temperature is to be specially considered in that the unburned gas can ignite without ignition sources at high temperatures such as the high temperature of the exhaust and surfaces of the machinery.

(B) The autoignition temperatures of propane and butane, as the main components of LPG, are 459 ℃ and 405 ℃ respectively which are relatively low compared to LNG(595 ℃). Therefore, the possibility of spontaneous combustion of unburned gas in the exhaust system is to be considered.

(3) Critical temperature

(A) Since the LNG has a critical temperature of -83 ℃ the inside of the tank is to be kept at a cryogenic temperature to store the LNG in a liquid state. However, LPG has a critical temperature of 96 ℃ to 152 ℃ depending on the composition ratio of butane and propane, so it can be stored in a liquid state using a pressurized tank at atmospheric temperature.

(B) The pressure of the tank is to be higher than the vapor pressure of LPG at the working temperature to store LPG only in a pressure type. The working temperature is to be determined in consideration of the heat ingress from the outside into LPG.

(4) Vapor pressure at 45 ° C and variation of composition ratio

(A) LPG has a vapor pressure of 4 bar to 15 bar at 45 ° C, which is the reference temperature of the engine room, and the liquid phase and gas pressure conditions of the fuel are determined according to the composition ratio of propane and butane. Therefore, when the fuel supply pressure is close to the vapor pressure, the possibility of an unintended phase change in the fuel supply system is to be considered.

(B) The requirements for purging and venting systems of the Rules are specified for gaseous fuels, so that those systems for fuel supply systems in liquid state are to be designed and arranged suitably for liquid fuels.

(C) Since LPG has different properties depending on the composition ratio of propane and butane, the composition ratio of LPG is to be suitable for normal operation of the fuel consumption device.

4. For the purposes of **Rule 1, 103.**, a risk assessment of **105.** is to be carried out to demonstrate satisfaction of the goal and the functional requirements of the Rules and the equivalent level of safety of LNG fuel.

104. Functional Requirements

1. For the purposes of **Ch 2**, **201. 2** of **the Rules**, the ventilation, detection and safety measures for LPG leakage are to be equivalent to those for LNG leakage.

2. The fuel consumers are to suitable for the properties of all possible composition of the LPG.

3. For the purposes of **Ch 2**, **201.** of the Rules, means to maintain the pressure and temperature of fuel tanks as required by **Ch 6**, **901.** of the Rules are to be provided. Unless the tank is designed to withstand the maximum gauge vapour pressure corresponding to the maximum temperature of the fuel which may reach to at the upper ambient design temperature, pressure and temperature control measures are be provided also for Type C independent tanks.

4. LPG is to be considered that the phase may change depending on the pressure at room temperature. When the design pressure of the fuel supply system is close to the vapor pressure, it is to be designed so as not to adversely affect the function of the fuel consumer and the flow in the pipe due to the phase change.

5. Designed to prevent unburned gases from igniting the exhaust in fuel consumer.

6. Ensure that LPG liquid is not released to the atmosphere through vent pipe.

105. Risk Assessment

1. A risk assessment is to be conducted to ensure that risks arising from use of LPG fuel affecting the person on board, the environment and the ship are addressed. Consideration is to be given to the hazards associated with physical layout, operation and maintenance, following any reasonably foreseeable failure.

2. The risk assessment is to address the possible leakage of the fuel and the consequences thereof. In particular, considering the properties of LPG gas heavier than air, consideration is to be given to the possibility of gas accumulation at the bottom and escape of gas into other space.

3. Risk assessment is to be conducted in accordance with **Annex 4**. However, since **Sec.2** of **Annex 4** deals with the properties and risk of LNG, the properties of LPG and the related risk are to be applied to the risk assessment.

4. In risk assessment, in addition to **Ch 3, 201.** of the Rules, the followings are to be as a minimum considered, but not limited to,:

<Newly added>

(1) Leakage potential of LPG and its consequence
(2) Dispersion characteristics of leaked LPG in ship
(3) For the following areas/spaces, but not limited to, the HAZID is to be performed to address the possibility of leakage gas entering the non-hazardous area and its consequence. If necessary, analysis of dispersion and/or ventilation is to be conducted to demonstrate the dispersion characteristics and ventilation characteristics of the leakage gas in the area/space.
 (A) tank connection space
 (B) fuel tank
 (C) fuel preparation room
 (D) bunkering station
 (E) a space where single walled fuel pipes are installed.
 (F) gas valve unit room
 (G) in the way of vent mast
(4) The risk of LPG in accordance with **103. 4**
(5) Leakage detection in the drip tray according to **305. 1**
(6) Ignition of unburned gas in the exhaust system according to **701. 2**,
(7) The gas leakage in the gas turbine space according to **703. 1**
(8) Possibility of staying of the LPG fuel in the vent pipe
(9) the purging and venting of the LPG liquid in the fuel pipe where high pressure liquid fuel is supplied to the engine,
(10) The pressure rise inside the tank due to the generation of flash gas where propane and butane are filled into the fuel tank respectively.
(11) Possibility of recirculation of hazardous gas in accordance with **1001. 4**
(12) The effectiveness of ventilation in hazardous spaces in accordance with **1001. 5**
(13) Installation of gas detectors according to **1201. 1** (1) and (2)
(14) Hazards for passenger ships according to **1301. 2**

Section 2 Classification and Survey

201. Classification

1. Class notation

Ships satisfying the requirements of this Annex may be given a notation LFFS (LPG duel fuel, LPG only) as additional special feature notations.

2. Classification Survey during Construction

In addition to **Ch 4, 203. 3** of **the Rules**, the following plans and documents are to be submitted.
(1) Plan and data for approval
 (A) detailed drawings of vent mast including head
 (B) arrangement of ventilation duct in hazardous area
 (C) detailed layout of the gas detector
 (D) route of outer pipes and ducts of fuel pipe and location of their ventilation outlets and outlets
 (E) risk assessment data according to **105.**
(2) Plan and documents for reference
 (A) approval data of the combustion engine
 (B) ventilation analysis and dispersion analysis data
 (C) design pressure calculation formula for pressurize type of fuel tank where temperature control measures are not provided

<Newly added>

Section 3 Ship Design and Arrangement

301. Functional Requirements

1. In applying **Ch 5, 201. 2** of **the Rules**, locations of the vent mast and the ventilation outlet of the hazardous area are to be determined considering the surrounding arrangement so as to minimize the possibility of accumulation of the gas released on the open space and to facilitate dispersion into the atmosphere .

2. In applying **Ch 5, 201. 3** of **the Rules**, openings are to be arranged so that gas can not escape to the openings of non-hazardous spaces, taking into account the specific gravity and dispersion characteristics of LPG gas.

302. Arrangement of machinery space

1. A single failure of fuel systems is not to lead to a gas release in the machinery space. I.e, gas safe machinery space concept may be accepted.

2. In the case of gas turbines installed in a enclosed space of independent gas-tight, ESD protected machinery space concept is acceptable. In this case, in addition to **Ch 5, Sec 6** of **the Rules**, a pressure sensor is to be installed in the space to ensure that the negative pressure in the space is maintained. In addition, when the negative pressure is not maintained in the space, it is to give an audible and visual alarm on the navigation bridge, continuously manned central control station or onboard safety centre.

303. Location and protection of fuel piping

1. In applying **Ch 1, 701. 3**, where LPG gas from leakage or spill is likely to accumulate or escape to non-hazardous areas such as accommodation areas, machinery spaces, etc., based on the risk assessment in accordance with **105. 4**, all LPG fuel piping on open decks is to be protected by double pipes. However, double pipes are not required when is demonstrated that LPG does not accumulate or does not escaped into non-hazardous areas.

2. Outer pipes or ducts of fuel systems are not to have openings in non-hazardous spaces. Where a gas valve unit are located in a gas safety machinery space, the means of access to the gas valve unit is permissible only though bolted hatch which can withstand the maximum leakage pressure.

304. Bilge systems

1. Bilge systems in hazardous areas are not to be lead to machinery spaces or other non-hazardous areas.

2. The bilge systems in the hazardous area are to be arranged separately for each space and discharged overboard or to an enclosed tank fitted with a gas detector. Where bilge piping of two or more hazardous area is connected, means are to be provided to prevent the gas in one area from entering through bilge pipes the connected bilge pipes into other areas.

305. Drip tray

1. Drip trays containing fuel spill are to be equipped with means to detect leakage and shut off the fuel if required by the risk assessment.

2. Drip trays which may be exposed to low temperature due to fuel leakage are to be made of materials suitable for low temperatures.

306. Arrangement of entrances and other openings in enclosed spaces

1. In applying **Ch 5, 1101. 3** of the Rules, the access from the non-hazardous area to the tank connection space is to be as shown in **Fig 1**.

<Newly added>

307. Outlet of vent pipe and pressure relieving systems

1. LPG gas line from the followings is to be led to a vent mast.

(1) the pressure relief valve of the tank
(2) vent lines and bleed lines for gas fuel systems

2. LPG liquid line from the followings is to be led to a fuel tank. However, where it is not practicable, the line may be led to a vent mast.

(1) the pressure relief valve of the liquid fuel supply pipe
(2) vent line and bleed line of liquid fuel supply piping
(3) pressure relief valve in bunkering line

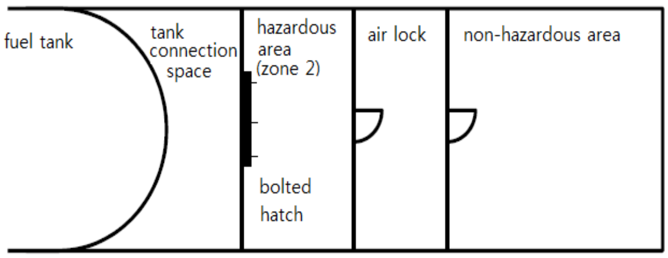


Fig 7.5.1 the access from the non-hazardous area to the tank connection space

Section 4 Fuel Containment System

401. General

1. In applying **Ch 6, 301. 1** of the Rules, LPG may be stored with a maximum allowable relief valve setting (MARVS) of over 1.0 MPa.

2. In applying **Ch 6, 301. 1** of the Rules, for the fuel tank located in enclosed space, a tank connection space is to be provided separately from a fuel storage hold space. For the fuel tank located on open deck, a tank connection space is also to be provided where escaped gas may accumulate on open deck or enter in non-hazardous area such as accommodation space and machinery space based on the risk assessment required in **105. 4.**

3. **Ch 6, Sec 6** of the Rules is not applied.

402. Liquefied gas fuel containment

1. In applying **Ch 6, 402. 1** of the Rules, no secondary barrier is required where the fuel temperature at atmospheric pressure is at or above -10°C.

2. In applying **Ch 6, 402. 1** of the Rules, where the fuel temperature at atmospheric pressure is not below -55°C, the hull structure may act as a secondary barrier.

403. Design load

1. In applying **Ch 6, 409. 3** (3) (A) (b) of the Rules, design vapour pressure P_0 is not to be less than the gauge vapour pressure corresponding to a maximum temperature of fuel that may be increased due to heat ingress from the upper ambient design temperatures.

404. Pressure relief system

1. In applying **Ch 6, 409. 3** (3) (A) (b) of the Rules, the vapour discharge is to be directed vertically upwards in the form of unimpeded jets. Vent exits are to be arranged based on the gas dispersion analysis required in 105. 4 (3) (G) and the followings are to be confirmed;

(1) escaped gas does not escape to non-hazardous area through the opening around the vent exit,
(2) escaped gas does not accumulated on open deck and,

<Newly added>

(3) escaped gas does not form flammable atmosphere in the way of exhaust gas outlet and other ignition source.

2. In applying **Ch 6, 702. 10** of the Rules, The drain line is to be fitted with two self closing valves near the vent line and these valves are to be opened sequentially to prevent gas from escaping through the drain line.

3. In applying **Ch 6, 702.** of the Rules, vent lines from fuel tank relief valves are to be fitted with means of purging with inert gas when gas is detected.

405. Maintaining of fuel storage condition

1. In applying **Ch 6, 901. 1** of the Rules, for the pressurized tank, 'the full gauge vapour pressure of the fuel under conditions of the upper ambient design temperature' is to apply the gauge vapour pressure corresponding to a maximum temperature of fuel that may be increased due to heat ingress from the upper ambient design temperatures.

2. With the exception of **Par 1**, control means of tank pressure and temperature in accordance with **Ch 6, 901. 1** of the Rules are to be provided.

Section 5 Bunkering

501. Functional requirements

In addition to **Ch 8, 201.** of the Rules, the followings are to be applied;

1. Bunkering systems are to be suitable temperature, pressure and composition of all expected LPG.

2. Means are to be provided to manage vapour generated during bunker transfer. Where means of vapour management are not provided in accordance with **Ch 8, 201.** of the Rules, vapour return connection is to be fitted at bunkering manifold.

502. Bunkering stations

1. In applying **Ch 6, 901. 1** of the Rules, gas detectors are to be fitted below bunkering manifolds even though manifolds are located in open spaces and to be fitted under 30 cm height from the bottom at an proper interval. Where gas is detected, gas detectors are to activate alarm and emergency shutdown.

2. Bunkering manifolds are to be observable from bunkering control station by providing permanent watch or CCTV during bunker transfer.

Section 6 Fuel Supply to Consumers

601. Functional requirements

In addition to **Ch 9, 201.** of the Rules, the followings are to be applied;

1. Fuel supply systems are to be able to supply fuel at the required pressure, temperature and flow rate.

2. Where fuel supply systems supply LPG in the liquid phase, purging, drain, vent and leakage are to be subject to special consideration to provide an equivalent level of safety of fuel in the gas phase.

3. Fuel supply systems are design to be prevent unintended phase changes in processing of fuel supply to consumers considering vapour pressure at the working temperature as the followings;

(1) Where fuel is supplied in the gaseous state, measures are to be taken so that the temperature of fuel is not lowered to the dew point at the working pressure.

(2) Where fuel is supplied in the liquid state, measures are to be taken so that the pressure of fuel is not lowered to the vapour pressure at the working temperature.

<Newly added>

602. Safety functions of gas supply system

1. In applying **Ch 9, 401. 4** (1) of the Rules, where fuel supply systems supply LPG in the liquid phase, bleed lines are to be led to the fuel tank.

2. In applying **Ch 9, 401. 4** (1) of the Rules, a purging line is to be connected between two block valves to prevent heavy gas from remaining in bleed line by automatically purging bleed line when a bleed valve is open.

3. In applying **Ch 9, 401. 7** of the Rules, where fuel supply systems supply LPG in the liquid phase, vent lines are to be led to the fuel tank.

4. In applying **Ch 9, 401. 10** of the Rules, excess flow valve may be used, as appropriate, as means for rapid detection of a rupture in the gas line. Gas detection systems are not to be accepted as means for rapid detection of a rupture in the gas line.

603. Design of ventilated duct, outer ppipe against inner pipe gas leakage

1. In applying **Ch 9, 802. 1** (2) of the Rules, most conservative value is to be selected for k considering expected composition of fuel. (propane: 1.13, butane : 1.096)

Section 7 Power Generation Including Propulsion and Other Gas Consumers

701. Functional requirements

In addition to **Ch 10, 201.** of the Rules, the followings are to be applied;

1. Fuel consumers are to be suitably designed for operation with possible composition of intended LPG fuel.

2. The temperature of exhaust gas is be subject to special consideration to prevent self-ignition of unburned gas in exhaust systems. However, where reducing the temperature of exhaust gas is impractical, documents are to be submitted demonstrating safety to based on the risk assessment.

702. Internal combustion engines of piston type

1. Internal combustion engines are to be type-approved by the Society and the followings, but not limited to, are to be demonstrated;

(1) Measures to prevent accumulation of LPG gas in the space below the piston and extract LPG gas in the space.
(2) Safety precaution for unburned LPG gas in exhaust systems
(3) Measures to extract unburned gas in the event of ignition failure

703. Gas turbines

1. In applying **Ch 10, 501. 1** of the Rules, gas leakage in the enclosed space and the consequence are be evaluated based on the risk assessment.

2. In applying **Ch 10, 501. 3** of the Rules, gas detection system in the space containing the gas turbine is to activate an audible/visual alarm and stop the gas supply at 10% of LEL.

<Newly added>

Section 8 Fire Safety

801. Fire protection

1. In applying **Ch 11, 301. 3** of the Rules, the fuel preparation room is to be separated from a machinery space of category A and rooms with high fire risks. The separation is to be done by a cofferdam of at least 900 mm with insulation of A-60 class.

802. Fire extinction

1. In applying **Ch 11, Sec. 4** of the Rules, the fuel preparation room are to be provided with a fixed fire-extinguishing system complying with the provisions of the FSS Code and taking into account the necessary concentrations/application rate required for extinguishing gas fires.

Section 9 Explosion Prevention

901. Functional requirements

1. In applying **Ch 12, Sec. 4** of the Rules, classification of hazardous area are to be subject to special consideration from the aspect that LPG gas is heavier than air. IEC 60079-10-1 may be referred if necessary.

Section 10 Ventilation

1001. General requirements

1. In applying **Ch 13** of the Rules, Ventilation ducts serving hazardous areas are not to be led through accommodation, service space, machinery space, control stations and ro-ro space, except as allowed in **Ch 13, Sec 8** of the Rules.

2. In applying **Ch 13, Sec. 3** of the Rules, the ventilation outlets of hazardous spaces are to be located at the lowest part of the space and close to the bottom as far as ventilation is not interfered considering LPG gas is heavier than air. In addition, the ducts, and this emergency intake is to have a damper which is capable of being opened or closed from the weather deck and in the spaces.

3. In applying **Ch 13, Sec. 3** of the Rules, The number and location of the ventilation outlets in each space are to be considered taking into account the size, layout of the space. Where bottom arrangements are complicated, it is to be demonstrated based on ventilation analysis that capacity and duct arrangements of ventilation are adequate for the space.

4. In applying **Ch 13, 305.** of the Rules, air outlets and air inlets for hazardous enclosed spaces are to be arranged to prevent exhausted gas from re-entering to the space through air inlets. Satisfaction of this arrangement is to be demonstrated based on the risk assessment if necessary.

5. In applying **Ch 13, 305.** of the Rules, ventilation exhaust ducts from gas-dangerous spaces are to discharge upwards.

6. In applying **Ch 13, 308.** of the Rules, effectiveness of ventilation is to be verified in accordance with IEC 60092-10-1. Ventilation capacity is to be defined in such way that degree of dilution for LPG gas leakage is to provide equivalent level of degree of dilution for LNG gas leakage with special consideration of density and LEL of LPG gas.

1002. Fuel preparation room

1. In applying **Ch 13, 601.** of the Rules, approved automatic fail-safe fire dampers are to be fitted in the ventilation trunk for the fuel preparation room.

<Newly added>

1003. Ducts and double pipes

1. In applying **Ch 13, 801. 1** of the Rules, ventilation inlets and outlets of double wall piping and ducts are to be located so that negative pressures is maintained in the whole space between inner pipes and outer ducts/pipes.

2. In applying **Ch 13, 801. 3** of the Rules, the ventilation inlets for the double wall piping and ducts are always to be located in a non-hazardous open area away from ignition sources.

3. For ships subject to **Pt 7**, **Ch 5, Sec. 16** of **Rules for the classification of steel ships**, the ventilation inlet for the double wall piping and ducts are to be complied with **Par 2** nevertheless **Pt 7**, **Ch 5, 1604. 3** (2) of **Rules for the classification of steel ships**.

Section 11 Electrical Installations

1101. General requirements

1. In applying **Ch 13** of the Rules, equipment for hazardous areas is to be of a certified safe type appropriate for compositions of LPG in accordance with IEC 60079-20. IEC 60079-20 classifies the temperature class and equipment groups for propane and butane as the followings;

	Temperature class	Equipment group
Propane	T2	IIA
Butane	T2	IIA

Section 12 Control, Monitoring and Safety Systems

1201. Gas detection

1. In addition to location required in **Ch 15, 801.1** of the Rules, permanently installed gas detectors are to be fitted in:

(1) ventilation inlet of ro-ro space if required based on the risk assessment
(2) bunkering station

2. In applying **Ch 15, 801.1** of the Rules, in the detection of leakage of gas in the bunkering station, an alarm is to be given when the gas concentration reaches 30% of LEL and an ESD system of bunkering is to be activated when the gas concentration reaches 60% of LEL.

Section 13 Special Consideration for Passenger Ships

1301. General requirements

1. Gas detection systems are to be fitted at openings of passenger spaces facing gas dangerous area.

2. Risks of gas facilities and gas leakage on board that may affect safety of passengers are to be identified based on the risk assessment.

<Newly added>

Annex 4 Risk assessment *(2019)*

Section 1 General

101. General

To help eliminate or mitigate risks a risk assessment is required by this Rules. In this regard it requires that the risk assessment is undertaken using acceptable and recognised techniques, and the risks and their mitigation are documented to the satisfaction of the Society.
It is recognised that there are many acceptable and recognised techniques and means to document a risk assessment. As such, it is not the intent of this document to limit a risk assessment to a particular technique or means of documentation. This document does, however, describe recommended practice and examples to help satisfy this Rules.

102. Objective

The objective or goal of the risk assessment, as noted in this Rules, is to help “eliminate or mitigate any adverse effect to the persons on board, the environment or the ship”. That is, to eliminate or mitigate unwanted events related to the use of low-flashpoint fuels that could harm individuals, the environment or the ship.

103. Scope

1. This Rules requires the risk assessment to cover the use of low-flashpoint fuel. The following items may be considered in the risk assessment.

(1) Equipment installed on board to receive, store, condition as necessary and transfer fuel to one or more engines, boilers or other fuel consumers;
Such equipment includes manifolds, valves, pipes/lines, tanks, pumps/compressors, heat exchangers and process instrumentation from the bunker manifold(s) to delivery of fuel to the consumers.

(2) Equipment to control the operation;
For example, pressure and temperature regulators and monitors, flow controllers, signal processors and control panels.

(3) Equipment to detect, alarm and initiate safety actions;
For example, detectors to identify fuel releases and subsequent fires, and to initiate shutdown of the fuel supply to consumers.

(4) Equipment to vent, contain or handle operations outside of that intended (i.e. outside of process norms);
For example, vent lines, masts and valves, overflow tanks, secondary containment, and ventilation arrangements.

(5) Fire-fighting appliances and arrangements to protect surfaces from fire, fuel contact and escalation of fire;
For example, water sprays, water curtains and fire dampers.

(6) Equipment to purge and inert fuel lines;
For example, equipment to store and supply nitrogen for the purposes of purging/inerting bunker lines, and equipment used for the safe transfer/disposal of fuel.

(7) Structures and constructions to house equipment;
For example, fuel storage hold spaces, tank connection spaces and fuel preparation rooms.

2. The scope can exclude items that have been previously subjected to a risk assessment, provided there are no changes to ‘context of use’ and mitigation measures taken as a result of previous risk assessment are to be included. This can help reduce assessment time and effort.

The term ‘context of use’ (used above) refers to differences, such as differences in design or arrangement, installed location, mode of operation, use of surrounding spaces, and the number and type of persons exposed. For example, if an item is located on a cargo ship on-deck, it is a change to the ‘context of use’ if the same item is then installed below deck on a passenger ship. In addressing ‘context of use’ it is important to recognise that these ‘differences’ can significantly decrease or increase risk resulting in the need for fewer, more, changed or alternative means to eliminate or mitigate the risks.

<Newly added>

3. With regards to liquefied natural gas (LNG), the this Rules states that risk assessment “need only be conducted where explicitly required by **Ch 5, Sec. 10 1001**. **5**, **Ch 5 Sec. 12 1201. 3**, **Ch 6 Sec.4 401. 1**, **Ch 6 Sec.4 415. 4** (7) (B), **Ch 8 Sec. 3 301. 1**, **Ch 13 Sec. 4, 401. 1**, **Ch 13 Sec.7 701.** and **Ch 15 Sec.8 801. 1** (10) as well as by paragraphs 4.4 and 6.8 of the annex”. Hence, the this Rules allows the scope of the risk assessment to be limited to these paragraphs. It is important to note that there are differences of opinion on the scope of risk assessment required by these paragraphs. Therefore, the views of stakeholders and approval by the Society should be sought when finalising the scope of the risk assessment.

4. The risk assessment includes consideration of bunkering equipment installed on board but does not cover the bunkering operation of: ship arrival, approach and mooring, preparation, testing and connection, fuel transfer, and completion and disconnection. Bunkering of fuel is the subject of separate assessment as per ISO/TC18683 and reference should be made to appropriate and specific guidance.

5. This Rules requires that consideration is given to physical layout, operation and maintenance. Typically, the risks associated with maintenance are controlled by job specific risk assessments before the activity is undertaken. Therefore, consideration of maintenance is taken to mean high-level consideration of design and arrangements to facilitate a safe and appropriate working environment. This requires consideration of, for example, equipment isolation, ventilation of spaces, emergency evacuation, heating and lighting, and access to equipment. The purpose of this is to minimise the likelihood of unwanted events resulting in harm during maintenance. In addition, the purpose is to minimise the likelihood of unwanted events after maintenance, as a result of deficient work where a contributory cause was ‘a poor working environment’.

6. The assessment should also appreciate potential systems integration issues such as equipment control and connection compatibility. This is particularly important where a number of stakeholders are involved in separate elements of design, supply, construction and installation.

7. Occupational risks can be excluded from the risk assessment. They are an important safety consideration and are expected to be covered by the safety management system of the ship. The scope should obviously cover the design and arrangement as installed on board. Therefore, where the risk assessment is undertaken prior to finalising the design, it may require revision to ensure that the risks remain ‘mitigated as necessary’.

8. This Rules makes no reference to periodic update of the risk assessment. This should be undertaken where changes to the design/arrangement and/or its operation have been made, and in response to changes in performance of equipment and controls. This helps ensure the risks are ‘mitigated as necessary’ through-out the life of the fuel system. The final scope of the risk assessment should be agreed with appropriate Society and guided by applicable **Rules for the Classification of Steel Ships** and the this Rules.

104. Approach

IMO has published guidance on formal safety assessment (FSA) and this provides useful information on risk assessment approaches and criteria5. The purpose of the guidance is to help evaluate new regulations on maritime safety and protection of the environment. In this regard, assessment is focused on risk quantification and cost benefit analysis to inform decision-making. As such, it is a useful reference to IMO’s views on risk assessment and criteria. However, the this Rules does not require a quantitative measure of risk to people, the environment or assets from the use of fuel. The risk assessment is simply required to provide information to help determine if further measures are needed to ‘eliminate’ risks or to ensure they are ‘mitigated as necessary’. Therefore, a qualitative or semi-quantitative approach to the risk assessment is appropriate (i.e. Qualitative Risk Assessment, QualRA. That is not to say that a fully quantitative approach is inappropriate or that circumstances might not favour its use (i.e. Quantitative Risk Assessment, QRA). What is important is that the risk assessment is of sufficient depth to help demonstrate that risks have been ‘eliminated’ or ‘mitigated as necessary’.

As a minimum, the risk assessment should detail:

- how the low-flashpoint fuel could potentially cause harm − Hazard identification;
  That is, systematic identification of unwanted events that could result in, for example, major injuries or fatality, damage to the environment, and/or loss of structural strength or integrity of the ship.
- the potential severity of harm − Consequence analysis;
  That is, the potential severity of harm (i.e. consequences) expressed in terms of, for example, major injuries, single and multiple fatalities, adverse environmental impact, and structural/ship damage sufficient to compromise safe operations.

<Newly added>

- the likelihood of harm − Likelihood analysis;
  That is, the probability or frequency with which harm might occur.
- a measure of risk − Risk analysis;
  That is, a combination of consequence (2) and likelihood (3).
- judgements on risk acceptance − Risk assessment.
  The measure of risk (4) should be compared against criteria to judge if the risk has been 'mitigated as necessary'. Acceptable and recognised techniques to address the requirements noted above (i.e. A-D) are described in, for example, ISO 310107, ISO 177768, ISO 169019, NORSOK Z-01310, CPR 12E11, and publications by CCPS12 and HSE13, etc.
  The following **1**, outlines an approach to meeting the above requirements.

1. An approach to satisfying the this Rules requirements - Qualitative Risk Assessment (QualRA)

(1) Hazard identification

(A) Divide the fuel system into discrete parts with respects to equipment function and location.
This promotes systematic consideration of each part of the system and helps identify specific causes of unwanted events related to a particular item, activity or section. A typical division of the system might be, for example:

(a) the bunker station and fuel lines to the storage tank;
(b) the fuel storage hold space;
(c) the tank connection space;
(d) the fuel preparation room; and
(e) the fuel lines and valves 'regulating' fuel delivery to the engine.

(B) Develop a set of guidewords/phrases and example causes that could result in unwanted events (e.g. a release of fuel or fuel system failure resulting in loss of power).

(C) By reference to design and arrangement information, location plans, process flow diagrams, mitigation measures and planned emergency actions use the prompts to identify potential causes of unwanted events (e.g. fuel releases and loss of power).
The prompts are used to stimulate discussion and ideas within a workshop led by a facilitator and attended by subject matter experts (SMEs).

(D) Record the potential causes of unwanted events and mitigation measures

(2) Consequence analysis

(A) For each identified cause, estimate the potential consequences in terms of, for example, major injuries, single and multiple fatalities, adverse environmental impact and damage sufficient to compromise safe operations. The potential consequences can be estimated by the SMEs using judgement and reference to:

(a) the fuel's properties/hazards: The properties and hazards of liquefied natural gas (LNG) noted in (a) are summarised in **Sec.2**.
(b) the release location;
(c) dispersion/leak pathways;
(d) location and 'strength' of ignition sources;
(e) proximity of vulnerable receptors;
(f) generic or (if commissioned) specific fire and explosion modelling; and (f) expected effectiveness of existing/planned mitigation measures.

(B) Categorise the consequence estimates.
The consequences can be categorised by the SMEs to provide an indication of severity. For example, categories for harm to persons can distinguish between major injury, single fatality and multiple fatalities.

(3) Likelihood analysis

(A) Estimate the annual likelihood of occurrence of 'cause and consequence'.
Likelihood can be estimated by the SMEs (or a suitably qualified individual) for each 'cause-consequence' pair or a grouping of causes with the same consequence. The estimation can be informed by reference to accident and near-miss reports, accident and equipment release data, analogy to accidents in similar or other industries and consideration of the reliability and effectiveness of mitigation measures. It is not always apparent if the likelihood of a 'cause-consequence' combination is credible (i.e. reasonably foreseeable). An unwanted event may be considered credible if:

(a) it has happened before and it could happen again;
(b) it has not happened but is considered possible with an annual likelihood of 1 in a million or more; and
(c) it is planned for, that is, emergency actions cover such a situation or maintenance is undertaken to prevent it.

<Newly added>

(B) Categorise the likelihood estimates.

Likelihood can be categorised by the SMEs (or a suitably qualified individual) to provide an indication of accident/incident occurrence or other unwanted event occurrence.

(4) Risk analysis

(A) Estimate the risk.

Risk can be estimated by the SMEs (or a suitably qualified individual) by combining the consequence and likelihood categories to provide a risk rating.

(5) Risk assessment

(A) Judge if the risk has been 'mitigated as necessary'.

The estimated risk can be compared against risk criteria embedded within a risk matrix. The matrix shows the risk rating (with respects to consequence and likelihood) and the criteria illustrate whether the risk has been 'mitigated as necessary'.

Practically, the risk rating is an indication that additional or alternative mitigation measures:

- Unacceptable rating: must be provided; or
- Manageable rating: must be considered and implemented if practical and cost effective; or
- Negligible rating: need not be considered further, beyond accepted good practice of reducing risk where practicable.

2. Mitigated as necessary

(1) Essentially, a risk is considered ALARP if all reasonably practicable mitigation measures have been implemented. This means that additional or alternative measures have been identified and implemented unless they are demonstrated as impractical or the cost of implementation is disproportionate to the reduction in risk. This concept of ALARP is established practice in many industries and recognised as best practice by IMO.

(2) Best practice:

(A) Measures to prevent an unwanted event;

That is, to ensure the unwanted event cannot occur or its likelihood of occurrence is greatly reduced;

(B) Measures to protect against harm given an unwanted event.

That is, to reduce the consequences after the unwanted event has occurred.

(3) In addition, when considering mitigation measures it is good practice to consider engineering solutions in preference to procedural controls. This helps promote an inherently safer design. Furthermore, it is good practice to consider passive measures in preference to active measures. Examples of mitigation measures are listed in **Sec.3**.

(4) To help judge if mitigation measures are effective it can be useful to illustrate or map the pathway from 'cause' to 'consequence' and review the effectiveness of the mitigation measures.

(5) Whether a single mitigation measure or a collection of mitigation measures is practical and cost-effective is in some respects relative to the resources and skills available. If the SMEs cannot decide then the use of cost benefit analysis can be helpful. In any case, a documented justification for not implementing a mitigation measure should be made where SMEs judge the measure to be practical and cost-effective.

105. Team

The team conducting the risk assessment should comprise of subject matter experts (SMEs) who are, collectively, suitably qualified and experienced. For the QualRA noted above, this means the workshop team includes individuals who are degree qualified and/or chartered/professional engineers, have operational ship experience and are experienced in risk assessment. Such qualifications and experience should be in relevant disciplines to cover engineering design and safe use of the fuel.

It is unlikely that one SME can satisfy the above team requirements. In any case, to ensure investigative discussion, generation of ideas, for example, mechanical, process, electrical and operational aspects, a typical number of SMEs might be four to eight.

In addition to the SMEs, the team should be led by a facilitator (also referred to as the chair or chairman). The facilitator should be impartial with no vested interests in the fuel system, and experienced in leading such risk assessments. The facilitator may be supported by a scribe (also referred to as a secretary) to aid reporting.

The time expended by the team depends upon the agreed scope and the designs' 'complexity'. For example, a QualRA workshop for a new design might require two or three working days, whereas, a minor variation to a previously assessed and approved design might require only half a day.

<Newly added>

106. Reporting

1. Main report

A written report documenting the risk assessment should be produced. This needs to be sufficiently detailed to support results, conclusions, recommendations and any actions taken. This is because the assessment will inform important design and operational decisions. Furthermore, the report is a record in helping to demonstrate 'mitigated as necessary'. A report only consisting of a completed worksheet is insufficient.

The specific contents of the report and its structure are dependent upon design and assessment specifics, and reporting preferences. However, for a QualRA, the report should provide:

(1) An overview of the design and arrangement;
This is a simple explanation of the design and arrangement with respects to its intended operation and process conditions. Technical appendices should include process flow diagrams, general arrangement plans and all information used during the assessment. Where this is too cumbersome to include in the report in full, reference to this material is sufficient provided it remains accessible.

(2) An explanation of the risk assessment process;
This is a description of the risk assessment method and includes how the design was divided into parts for assessment, how hazard identification was undertaken, and the selection of consequence and likelihood categories and risk criteria.

(3) Information on the relevant qualifications and expertise of the team;
This can be a table listing the names, job titles, relevant qualifications, expertise and experience of all team members (including the facilitator and scribe).

(4) Risk results and conclusions;
This is a listing or discussion of the results and a judgement on whether or not the risk has been 'mitigated as necessary'.

(5) Recommendations and actions.
This can include requests for modelling and analysis (e.g. gas dispersion or thermal radiation extent, etc.) and will most likely include additional and alternative mitigation measures to be investigated and/or implemented, who is responsible for these and, if known, an expected completion date.

<Newly added>

Section 2 Properties & Hazards of Liquefied Natural Gas

201. LNG Properties

Liquefied natural gas (LNG) is a cryogenic liquid. It consists of methane with small amounts of ethane, propane and inert nitrogen. When used as a fuel, typically 94% or more is methane. Stored at ambient or near ambient pressure, its temperature approximates minus 162 deg.C and its specific gravity is about 0.42. Hence, if released onto the sea LNG floats (and can rapidly 'boil' − refer to 3.2.7). When stored at pressures of up to 10 bar the temperature typically remains below minus 130 deg.C with a specific gravity of approximately 0.4.

Released into atmospheric conditions, LNG rapidly boils forming a colourless, odourless and non-toxic gas. Although colourless, due to its very low temperature, water vapour in the air condenses forming a visible mist or cloud. The cold gas is initially heavier than air and it remains negatively buoyant until its temperature rises to about minus 100 deg.C. At this stage the gas becomes lighter than air, and in an open environment it is thought that this coincides with a gas concentration of less than 5%. At this temperature and concentration the gas is still within the visible cloud. As the gas continues to warm to ambient conditions its volume is approximately 600 times that of the liquid with a relative vapour density of about 0.55, and so the gas is much lighter than air (air = 1).

As the gas disperses, its concentration reduces. At a concentration in air of between 5% and 15% the mix is flammable and can ignite in the presence of ignition sources or in contact with hot sources at or above a temperature of approximately 595 deg.C (referred to as the auto-ignition temperature). Once below a concentration of 5% the mix is no longer flammable and cannot be ignited (and this is the case if the concentration remains above 15%). The 15% and 5% concentrations of LNG in air are commonly known as the upper and lower flammability limits, respectively. More recently, the limits are referred to as the upper and lower explosion limits, although ignition may not necessarily result in explosion.

202. LNG Hazards

1. Cryogenic burns

Owing to its very low liquid temperature, in contact with the skin LNG causes burns. In addition, breathing the cold gas as it 'boils' can damage the lungs. The severity of burns and lung damage is directly related to the surface area contacted by the liquid/gas and duration of exposure.

2. Low temperature embrittlement

In contact with low temperature LNG, many materials lose ductility and become brittle. This includes carbon and low alloy steels typically used in ship structures and decking. Such low temperature embrittlement can result in material fracture, such that existing stresses in the contacted material cause cracking and failure even without additional impact, pressure or use. For LNG duty, materials resistant to low temperature embrittlement are used. These materials include stainless steel, aluminium, and alloy steels with a high-nickel content.

3. Asphyxiation

LNG is non-toxic and is not a known carcinogen. However, as it boils to gas it can cause asphyxiation as it displaces and then mixes with the surrounding air. The likelihood of asphyxiation is related to the concentration of gas in air and duration of exposure.

4. Expansion and pressure

Released into the atmosphere LNG will rapidly boil with the volume of gas produced being hundreds of times that of the liquid (approximately 600 times at ambient conditions). Hence, if confined and unrelieved, the pressure will increase and this can damage surrounding structures and equipment.

5. Fire

(1) Pool fire

A 'small' release of LNG will rapidly boil and 'flash' to gas (i.e. evaporate). However, given a 'large' and sudden release, a cold pool of LNG will form with gas boiling from the pool and mixing and dispersing with the surrounding air. If this mix is within the flammable range (i.e. 5% to 15% with air) and contacts an ignition source or a heated surface above the auto-ignition temperature (595 deg.C) it will ignite and the resultant flame will 'travel back' to the pool resulting in a pool fire.

<Newly added>

(2) Jet fire

If stored under pressure then a release of LNG may discharge as a jet of liquid, entraining, vapourising and mixing with air. If the mix disperses and reaches an ignition source or a heated surface (above the auto-ignition temperature) whilst in the flammable range it will ignite. The resultant flame will 'travel back' and may result in a pressurised jet fire from the release source. Similarly, where contained LNG has been heated to form gas, a pressurised release of this gas could ignite and result in a jet fire.

(3) Flash fire

Release of LNG to atmosphere and ignition within a few tens of seconds is likely to result in a pool fire or jet fire (as noted above) with no damaging overpressure. This is because the flammable part of the cloud is likely to be relatively small and close to the release point upon ignition. However, if ignition is delayed, the gas cloud will be larger and may have travelled further from the release point. Ignition will then result in a flash fire as the flammable part of the cloud is rapidly consumed within a few seconds. This ignition is likely to be violent and audible, and is often mistaken for an explosion, although there is little appreciable overpressure.

(4) Thermal radiation from a pool fire, jet fire and flash fire

Harm to people and damage to structures and equipment from fire is dependent upon the size of the fire, distance from the fire, and exposure duration. Within a metre of the fire, thermal radiation may approximate 170 kW/m^2 but this rapidly falls with distance from the fire.

As a rough guide:

- 6 kW/m^2 or more and escape routes are impaired and persons only have a few minutes or less to avoid injury or fatality16;
- 35 kW/m^2 results in immediate fatality16;
- 37.5 kW/m^2 has long been considered as the onset of damage to industrial equipment and structures exposed to a steady state fire17;
- industrial equipment and structures within a flash fire are unlikely to be significantly damaged; and
- persons within a pool, jet or flash fire are likely to be fatally injured.

An LNG fire on a ship could result in fatalities and damage to equipment and structures (including the hull).

6. Explosion

Release of LNG to atmosphere and delayed ignition of the resultant flammable cloud beyond a few tens of seconds can result in an explosion. This is because the cloud may have dispersed in and around equipment and structures causing a degree of confinement and increased surface area over which to increase flame speed as it travels (i.e. burns) through the flammable mixture. The resultant overpressure may be sufficient to harm individuals, and damage structures and equipment. Such an explosion is most likely to be a deflagration (rather than a detonation), categorised by high-speed subsonic combustion (i.e. the rate at which the flame travels through the flammable cloud).

(1) Overpressure from an explosion

Harm to people and damage to structures and equipment from an explosion is dependent upon the magnitude of overpressure generated and the rate at which the overpressure is delivered (known as impulse). In addition, harm is often a result of falling or being thrown against hard surfaces or being struck by objects and debris as a result of the blast.

(2) As a rough guide:

- the probability of fatality from exposure to an explosion of 0.25 bar and 1 bar is about 1% and 50%, respectively18;
- less than 0.25 bar could throw an individual against a hard surface resulting in injury or fatality18; and
- 0.3 bar is typically the limit of damage to structures and industrial equipment.

An explosion of vapourised LNG on a ship could result in fatalities and damage to equipment and structures (including the hull).

7. Rapid phase transition

Upon release, LNG rapidly boils due to heat from the surrounds, be this from the air, water/sea, steel or ground. However, this rapid and sometimes violent boiling is not rapid phase transition (RPT); RPT is an explosive vaporisation of the liquid, that is, a near instantaneous transition from liquid to gas. This is a more violent event than rapid boiling and it can result in liquid ejection and damaging overpressure19. The phenomenon is well known in the steel industry, where accidental contact between molten metal and water can result in RPT.

8. Rollover

Slowly, stored refrigerated LNG evaporates (i.e. 'boils-off') as heat from the surrounds gradually 'leaks' into the tank. Essentially, liquid in contact with the wall of the tank warms, becomes less dense and rises to the top. This top-layer then begins to evaporate (i.e. boil-off) increasing the liquid layer's density. Liquid further away from the walls also warms but at a slower rate and because of this a less dense layer below the top layer forms. Owing to the hydrostatic head, the saturation condition of this layer changes and although it heats-up, it does not evaporate but remains in the liquid state and becomes 'superheated'. As the heating continues, the trapped layer's density reduces; this is an unstable state and when the density of this layer is similar to the top layer the two layers rapidly mix and the superheated lower layer vaporises. This rapid mixing and vaporisation is known as roll-over and can cause damaging over-pressure and release of gas if not appropriately controlled.

The heating mechanism described above can result in a number of differing layers and is referred to as stratification. It is a phenomenon that is well known and is safely managed through venting, mixing and temperature control.

The above phenomenon is hastened by, or can directly occur when differing densities of LNG are bunkered.

<Newly added>

Table 1 Comparison of the Hazards of LNG and Fuel Oil

Hazard	LNG	Fuel Oil
1. Cryogenic Burns Liquid contact with skin will cause burns and can result in fatality. Inhalation of gas can cause burns to the lungs and lead to fatal injury.	○	×
2. Low Temperature Embrittlement Equipment/structures can fail on contact with liquid.	○	×
3. Rapid Phase Transition (RPT) Released onto the sea a near instantaneous ‘explosive’ transition from liquid to gas can occur. This can result in structural damage to the hull.	○	×
4. Gas Expansion A liquid pool rapidly boils, and as the gas warms and expands it requires a volume 600 times that of the liquid. This can result in equipment damage.	○	×
5. Asphyxiation In a confined space, displacement and mixing of the gas in the air will reduce oxygen content and can cause asphyxiation.	○	○
6. Pool Fire Gas/vapour above the pool can ignite resulting in a pool fire. The intensity of the radiation can cause fatal injury and fail structure and critical equipment.	○	○
7. Flash Fire Gas/vapour can disperse away from the pool and ignite resulting in a flash fire. The short-duration and intense radiation can instigate secondary fires, and cause fatal injuries to those within the fire and to critical equipment. Most probably the fire will burn back to the pool and result in a pool fire.	○	× (If a fuel oil is ‘sprayed’ as an aerosol resulting in fine air-borne droplets, ignition can result in flash fire or explosion.)
8. Explosion Gas/vapour can disperse and collect in confined areas and ignite resulting in an explosion. The explosion can cause fatal injuries, instigate secondary fires, and fail structure and critical equipment. Most probably the explosion will burn back to the pool/gas source and result in a pool fire or jet fire.	○	× (If a fuel oil is ‘sprayed’ as an aerosol resulting in fine air-borne droplets, ignition can result in flash fire or explosion.)
9. Rollover Stored liquid can stratify, that is different layers can have different densities and temperatures. This can cause the layers to ‘rollover’ resulting in significant gas/vapour generation that must be contained. If released, this can result in flash fire or explosion.	○	×
10. Boil-off Gas (BoG) LNG continually boils and must be re-liquefied or burnt-off. A release of BoG can ignite and result in a jet fire (given sufficient release pressure), flash fire or explosion.	○	×
(Note) 1. Fuel oil means heavy fuel oil(HFO)(ISO 8217)		

<Newly added>

Section 3 Example mitigation measures

301. General

Within this Rules, measures to reduce likelihood and measures to reduce consequences are both understood to be mitigation measures (i.e. they mitigate the risk). To align with this Rules, this understanding is maintained within this document. It is recognised that in many other industries it is common to use the terms ‘prevention measures’ and ‘mitigation measures’, where the former reduces likelihood and the latter reduces consequences. Prevention and mitigation measures are often referred to as ‘safeguards’ or ‘barriers’.

302. Engineering Mitigation Measures

1. Protection from mechanical impact damage
2. Protection from vibration / vibration monitoring
3. Protection from wind, waves and weather
4. Pressure relief, venting
5. Increased separation or increased physical protection from collision / grounding
6. Secondary containment (e.g. double-walled pipework)
7. Welded connections in preference to flanged connections
8. Alarmed and self-closing doors
9. Bulkhead separation / cofferdam
10. Drip tray capacity, liquid detection
11. Spray shield coverage
12. Protection of structure from cryogenic temperatures and pressure from evolved vapour / gas
13. Independent bilge
14. Fire and gas detection, monitoring, audible / visual alarm and shutdown
15. Pressure and temperature detection, audible / visual monitoring, alarm and shutdown
16. Level detection
17. Forced / natural ventilation - airlock
18. Minimisation of ignition sources - Ex proof electrical equipment
19. Fire-fighting fire and cooling appliances - foam, water spray
20. Fire dampers
21. Separation of spaces
22. Access arrangements
23. Physical shielding
24. Mooring tension monitoring / alarm
25. Strain monitoring of supports
26. Buffer/overflow tank - Fuel recycling
27. Independent safety critical controls to IEC 61508
28. Radar monitoring
29. Service fluid - level / gas detection, alarm and shutdown
30. Flame arrestor

<Newly added>

303. Procedural Mitigation Measures

1. Increased frequency of inspection (and maintenance)

2. Reduced parts replacement frequency

3. Specific training for low-flashpoint fuels

4. Restricted access

5. Monitoring

<Newly added>

Amendments for Guidance Relating to Rules for Classification of Ships Using Low-flashpoint Fules

(Hull Part)

Hull Rule Development Team

<Newly added>

- Main Amendments -

(1) Effective Date : 1 July 2019

- ◉ Establishment of requirement in IGF Code Annex(Standard for the use of limit state methodologies in the design of fuel containment systems of novel configuration)
- ◉ Reflection of requirements in MSC.1/Circ.1591(Unified Interpretation of the IGF Code).
- ◉ Reflection of request for establish/revision of classification technical rules(MET4200-438-2018, preparation for basis of Type Approval of thermal insulation material of fuel containment system).
- ◉ Reflection of requirements in PT 7, Ch 5 of Rules for Classification of Steel Ships.
- ◉ Correction of documentational error and Terminology

<Newly added>

Present	Amendment
CHAPTER 5 SHIP DESIGN AND ARRANGEMENT	**CHAPTER 5 SHIP DESIGN AND ARRANGEMENT**
Section 4 <u>Arrangement of Machinery Space</u>	**Section 4 <u>Machinery Space Concepts</u>**
401. Machinery space concepts	**401. Machinery space concepts**
1. <omitted>	**1.** <same as the present>
Section 7 <u>Arrangement of Other Systems and Spaces</u>	**Section 7 <u>Location and Protection of Fuel Piping</u>**
701. Location and protection of fuel piping	**701. Location and protection of fuel piping**
1. <omitted>	**1.** <omitted>
Section 8 <omitted>	**Section 8 <omitted>**

<Newly added>

<table>
<tr><th>Present</th><th>Amendment</th></tr>
<tr><td>

CHAPTER 6 FUEL CONTAINMENT SYSTEM

Section 3 <omitted>

Section 4 Liquefied gas fuel containment

404. <newly added>

</td><td>

CHAPTER 6 FUEL CONTAINMENT SYSTEM

Section 3 <same as the present>

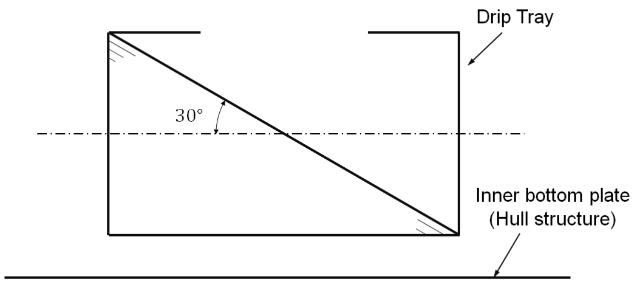
Section 4 Liquefied gas fuel containment

404. Design of secondary barriers

1. In applying 404. of the Rules, the secondary barriers of nonmetal material are to conform to the following requirements :
(1) Compatibility with the fuel is to have been verified, and to have necessary mechanical properties at the fuel temperature under the atmospheric pressure.
(2) A model test may be required to prove that the secondary barrier has effective performance when the Society deems it necessary.
(3) For joints, joining procedure tests and production test are to be conducted. The test plans for the above are to have been approved by the Society beforehand.
2. In applying 404. 1 of the Rules, no special analysis of the complete secondary barrier for verifying that "it is capable of containing any envisaged leakage of liquid fuel for a period of 15 days" may be carried out except for cases where the Society deems it specially necessary.
3. In applying 404. 4 of the Rules, the test procedure where visual inspection of the secondary barrier is not possible is to be in accordance with the following requirements :
(1) The inspection method of the secondary barrier and its criteria relating to the performance to act as the secondary barrier are to be verified for their effectiveness through model test.
(2) The secondary barrier is to be verified by model test for the required performance. This model test is to be capable of verifying that the secondary barrier can maintain the necessary performance throughout the life of the ship.
(3) When sufficient data to prove the effectiveness and reliability relative to the preceding (1) and (2) are submitted to the satisfaction of the Society, this model test may be omitted.

</td></tr>
</table>

<Newly added>

Present	Amendment
405. <newly added>	**405. Partial secondary barriers and primary barrier small leak protection system** **1. Partial secondary barrier** (1) The protection of the inner bottom plating at the lower part of fuel tanks is to conform to the following requirements : (A) In case where a drip tray is provided as a secondary barrier for example as shown in **Fig 6.1** with consideration so as not to allow the leaked liquid fuel to overflow from the secondary barrier, no protection may be required. However, where no such consideration is taken, the inner bottom plating is to be protected by insulation materials.  **Fig. 6.1 Drip Tray to protect the inner bottom plate** (2) The spray shield specified in **405. 1** of the Rules is to have been verified by test that it has satisfactory performance to act as the shield.
406. <newly added>	**405. Supporting Arrangement** 1. In spaces between the refrigerated tanks and supports, suitable insulation materials are to be provided so that hull structure might not be cooled excessively through the supporting structures according to requirement of **413. 1** of the Rules.

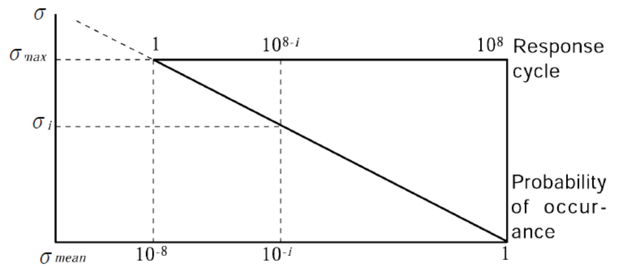
<Newly added>

Present	Amendment
408. Thermal insulation **<omitted>** **409. <newly added>**	**408. Thermal insulation** **<same as the present>** **409. Design Loads** **1. Thermally induced loads** (1) In applying **409. 3** (3) (C) (a) of the Rules, arrangements for cooling down are to be provided so as not to cause excessive stress on the tank structures. (2) The arrangements shown in the preceding (1) are to be such that safety in cooling down using the arrangements has been proved by records of fuel tanks of similar design or cooling down operation is performed at a rate not exceeding the safe temperature reduction curve which has been proved by thermal stress analysis. (3) The installations shown in the preceding (1) are to be also capable of performing cooling down at time when excessive thermal loads may be anticipated due to splashing of the residual fuel liquid in ballast passage of the ship under heavy weather as well as at time of fuel loading. (4) In applying **409. 3** (3) (C) (b) of the Rules, the structural strength is to be verified through thermal stress analysis by taking into account the vertical temperature distribution at time of cooling down and partial fuel loading, and when necessary, the temperature distribution in the direction of the plate thickness of plating of full loaded tanks. (5) For tanks other than those specified in the preceding (4), the Society may request thermal stress analysis of the fuel tank by taking into account the constraining condition of the fuel tank by tank supporting structure in case where the tank supporting system is special, and thermal analysis in consideration of the effect of materials with different coefficients of thermal expansion in case where such materials are used. (6) In the cases referred to in the preceding (4) and (5) where the type of tank supporting system is special, the Society may request thermal analysis on the tank supporting structure itself.

<Newly added>

Present	Amendment
<newly added>	**2. Vibration** (1) In applying **409. 3** (3) (D) of the Rules, the liquefied gas fuel tank plates and stiffeners are to have such scantlings as not to be caused harmful effects by resonance with the vibrations of exciting sources such as propeller and main engine. The natural frequencies of the liquefied gas fuel tanks and stiffeners used in the above assessment are to be minimum values in a state in contact with fuel liquid. **3. Static heel loads** (1) In applying **419. 3** (3) (H)of the Rules, the added mass due to hull damage or flooding may not be considered. **4. Loads due to ship motion** (1) The "Ships for the restricted service" referred to in **409. 4** (1) (A) of the Rules means those ships with notations "Coasting Service" or "Smooth Water Service" affixed. In this case, the dynamic load may be determined by the results of calculation of ship motions carried out on the basis of the data on sea and weather conditions at the navigating area which are considered appropriately by the Society. **5. Sloshing Loads** (1) In applying **409. 4** (1) (D) of the Rules, sloshing loads are to be determined in such a way that assessments are made by model experiment for each type of fuel tanks. Data concerning the resonant period of the hull and natural period of the liquids are to be available on board the ship for avoiding the danger of resonance. (2) Notwithstanding the requirements in the preceding (1), in the type C independent tank in ships with L_f not exceeding 90 m, consideration for structural strength of cargo tanks due to sloshing loads may not be necessary. However, sufficient consideration is to be taken for the installation of equipment in cargo tanks such as cargo piping and cargo pump, against impact loads due to sloshing.

<Newly added>

Present	Amendment
412. <newly added>	**412. Design Conditions** **1. Ultimate design condition** (1) In applying **412. 1** (1) (C) of the Rules, the values of R_e and R_m when the strength of welds is less than that of the parent metal as in the case of 9 % nickel steel are to be of the required values of mechanical properties of the weld metal. For welded joints of aluminium alloys 5083-O and 5083/5183 and 9 % nickel steel, the values of R_e and R_m may be modified in consideration of the increase in the yield stress and tensile stress at low temperature after taking into account the welding procedure employed. **2. Fatigue design condition** (1) In applying **412. 2** of the Rules, the stress due to fatigue load may be generally determined by using the cumulative probability curve as shown in **Fig 6.2.**  **Fig 6.2 Cumulative probability curve** (2) When the fatigue strength analysis specified in the requirements in **415. 2** (B) of the Rules is carried out using the frequency distribution of cyclic stress shown in the preceding (1), the number of representative stress(σ_i) is to be eight, and σ_i and its number of repetition n_i may be obtained from the following equations : $\sigma_i = \frac{17-2 \cdot i}{16}\sigma_{\max}$ $n_i = 0.9 \times 10^i$

Present	Amendment
<newly added>	where : i = 1, 2, ..., 8 σ_{max} : stress induced by the predicted maximum dynamic load (3) For the purpose of **412. 2** (6) of the Rules, the fatigue load used in the calculation of propagation speed of fatigue cracks is, as a rule, to be the predicted maximum load value that can occur at the most severe period in the trade area specified. In case where analysis is made by using the load frequency distribution given in **Fig 6.3** of the Rules, the number of representative stress(σ_i) is to be set at five and its number of repetition n_i may be obtained from the following equations : $\sigma_i = \frac{5.5 - i}{5.3}\sigma_{max}$ $n_i = 1.8 \times 10^i$ where : i = 1, 2, . . ., 5 σ_{max} : stress created by the predicted maximum load (4) The "ships engaged in particular voyages." referred to in **412. 2** (7) of the Rules means “the ships for restricted service“ of **409. 4** (1).

<Newly added>

Present	Amendment
413. Materials ~~and construction~~ **<newly added>**	**413. Materials** **1. Calculation the temperature of hull structures** In applying **419. 1** (1) of the Rules, the calculation conditions in computing the temperature of hull structures are to be in accordance with the following requirements : (1) The loading condition of the ship for the calculation is to be full loaded condition. (2) At the upright fuel leakage is to be considered for the calculation in accordance with the following requirements. However, no leakage may be considered for type C independent tanks. (A) It is to be assumed that the failure of all fuel tanks located between transverse watertight bulkheads are caused. However, in case where the cross section of the ship is divided into more than one compartments by longitudinal bulkheads of the ship, it is to be assumed that the failure of all fuel tanks within each such compartment is caused. (B) It is to be assumed that the locations of the failure of the fuel tank cover all conceivable ones. (C) It is to be assumed that only the liquid fuel leaks out where the fuel tank, supports and hull remain intact without involving any deflections or fracture. (D) For fuel tanks where the complete secondary barrier is required, it is to be assumed that the leakage of liquid fuel occurs instantaneously and the levels of residual liquid fuel in damaged fuel tank and the leaked liquid level in the hold space reach the same level instantaneously. (3) The boundary conditions of the calculation mode1 are to be in accordance with the following requirements : (A) The temperature of the compartment adjacent to fuel storage hold spaces is to be determined by heat transmission calculation. The atmosphere of the compartment which is adjacent to the compartment contiguous to fuel storage hold space may be taken as a still air at 0°C. In the case of machinery space, it may be assumed as a still air at 5°C. (B) It is to be assumed that there is no radiation of sun beam. (C) The structures in fuel storage hold space such as insulation materials and supports are to be assumed that they do not absorb liquid fuel. (D) It is to be assumed that the gas and liquid within the same compartment are at the same temperature.

<Newly added>

Present	Amendment
<newly added>	(E) At time of damage to the fuel tank, the gaseous phase in the fuel tank and that in fuel storage hold spaces are to be assumed to have a pressure equals to the atmospheric pressure. (F) It is to be assumed that there is no transfer of gases within the insulation materials. (G) It is to be assumed that there is no influence of moisture. (H) The ship is to be assumed to stay upright. (I) It is to be assumed that there is no influence of paints. (4) The calculation conditions in heat transmission calculation are to be in accordance with the following requirements : (A) Temperature distribution and heat transmission are to be dealt with as the phenomena in a steady state. No transient condition may be considered. (B) Sea water is to be assumed to have a density of 1,025 kg/m^3 and a coagulation point of -2.5°C with physical properties compatible with those of fresh water for other items. (C) The liquid fuel is to be assumed to have uniform temperature distribution. (D) The heat transfer coefficients at various boundaries can be computed by using the numeral values given in **Table 6.1**, but calculation may be carried out by using empirical equations given in the heat transfer engineering data which has been made public. In this case, heat transfer due to radiation is also to be taken into account.

Table 6.1 The Heat Transfer Coefficient at Various Boundaries

Boundaries	Heat transfer coefficients ($W/m^2 \cdot °C$)
Still gas ← → Hull or liquid	5.8
Still sea water ← → Hull	116.3
fuel vapour ← → Hull contacted to air	11.6

Present	Amendment
<newly added>	(E) The substance for which temperature distribution is investigated is to be assumed to be of homogeneous one without directivity. (F) Frames may be dealt with as fins. (G) The cooling effect by the latent heat of evaporation of the liquid fuel may not be taken into account. (H) The temperature of structural members is to be represented by the temperature at their half thickness, and for individual members, the following requirements are to be complied with : (a) The temperature of those frames fitted to plates is to be assumed to be the same as the temperature of the plates, but when the temperature distribution of the frame in the direction of depth is known, the area mean of the temperature distribution may be taken. (b) The temperature of web frames supporting frames or plates is to be the temperature at their half depth for webs, and the temperature of face plates for these. (c) The temperature of members connecting the inner shell and outer shell, e.g., brackets and girders is to be of the mean of the temperature of the inner shell and that of the outer shell. (d) The temperature of brackets is to be the temperature at their centroid. **2. Hull material not forming secondary barrier** (1) When the design temperature of a material falls under the higher temperature range than the specified one for the material in **Table 7.3** and **Table 7.4** of the Rules in accordance with **413. 2** (2) of the Rules, the impact test temperature given in **Table 7.1** to **Table 7.4** of the Rules correspondingly to the design temperature may be used instead of the impact test temperature depending on the material. For example, in the case of 2.25 % nickel steel pipes used at the design temperature of -45°C, the impact test temperature may be -50°C, while in the case of 3.5 % nickel steel plates used at the design temperature of -61°C, the impact test temperature may be -70°C.

<Newly added>

Present	Amendment
<newly added>	**3. Insulation materials** (1) In applying **413. 3** (1) of the Rules, insulation materials of independent tanks are to be free from generating harmful defects that degrade the insulation performance even under such conditions of service that can actually take place in insulation structure including forced deflection and thermal expansion and contraction. (2) The performance referred to in the preceding (1) is to be verified in the insulation procedure test specified in **6** below as necessary. **4. Protection of insulation** In applying **413. 3** (4) of the Rules, insulation materials are to be protected in accordance with the following requirements : (1) For insulation materials installed in hold spaces and tank covers, no fire protections and protections for mechanical damage may be provided except for cases where such are specially necessary. However, these insulation materials are to be applied with coating or subjected to surface treatment with aluminium foil, etc. (2) Insulation materials provided at exposed areas are to be protected by galvanized iron sheets or to be of the non-combustible insulation materials specified in the requirements in **Pt 8, Ch 3, 201.** of **Rules for the Classification of Steel Ships** applied with moisture-resistant coating. In case where the Society deems necessary, provision of steel covering may be requested as a protection against mechanical damage. (3) The coating materials to be applied on the surface of insulation materials are to comply with the requirements in **Pt 8, Ch 4, Sec 1** of **Rules for the Classification of Steel Ships** or equivalent. **5. Properties of insulation materials**
2. In applying **413. 3** (2) of this Rules, properties of insulation materials are, in general, to be verified by the tests given in **Table 6.1** of this Guidance.	(1) In applying **413. 3** (2) of the Rules, the properties of insulation materials are, in general, to be verified by the tests given in **Table 6.2**.
3. In addition to complying with the requirements in the preceding **2,** property verification test may be requested by the Society depending on the insulation system.	(2) In addition to complying with the requirements in the preceding (1), property verification test may be requested by the Society depending on the insulation system.

<Newly added>

Table 6.1 Properties of Insulation Material for Fuel Tank Types

No.	Ensuring items		~~Integral tank~~	Membrane~~/ semi-membrane tank[3)]~~	Type A/B independent tank	Type C independent tank	Note
1	Compatibility with the fuel			○[1)]	○[1)]		
2	Solubility in the fuel			○[1)]	○[1)]		
3	Absorption of the fuel		~~□~~	○[1)]	○[1)]		
4	Shrinkage			○[1)]	○[1)]	~~○~~	
5	Aging		~~□~~	○	○[1)]	□	
6	Closed cell content		~~△~~	△	△	△	applied only to closed cell material
7	Density		~~○~~	○	○	○	
8	Mechanical properties	Bending strength	~~○~~	○	○	○	
		Compress. strength		○			
		Tensile strength	~~○~~	○	○	○	
		Shearing strength	~~○~~	○	~~○[2)]~~	~~○[2)]~~	
9	Thermal expansion		~~□~~	○			
10	Abrasion			○	~~△[1)]~~		
11	Cohesion		~~□~~	△		□	applied to cohered material
12	Thermal conductibility		~~○~~	○	○	○	
13	Resistance to vibration		~~△~~	△	△[1)]		refer to **413. 3 (7)** of this Rules
14	Resistance to fire and flame spread		~~○~~	○	○	○	

Remarks

○ : Items to be verified through verification test for properties.

△ : Items to be verified through verification test where deemed necessary depending on the insulation material.

□ : Items for which preparation of data on the properties is desirable.

Notes :

1) Necessary when the insulation material acts as spray shield specified in the requirements in **405. 1** of this Rules. In other cases, data on the properties is to be prepared.

2) Not generally required for cargo tanks where the design temperature exceeds -10°C.

~~3) It is necessary to verify the fatigue strength characteristics.~~

<Newly added>

Table 6.2 Properties of Insulation Material for Fuel Tank Types

No.	Ensuring items		Membrane	Type A/B independent tank	Type C independent tank	Note
1	Compatibility with the fuel		○ 1)	○ 1)		
2	Solubility in the fuel		○ 1)	○ 1)		
3	Absorption of the fuel		○ 1)	○ 1)		
4	Shrinkage		○ 1)	○ 1)		
5	Aging		○	○ 1)	□	
6	Closed cell content		△	△	△	applied only to closed cell material
7	Density		○	○	○	
8	Mechanical properties	Bending strength	○	○	○	
		Compress. strength	○			
		Tensile strength	○	○	○	
		Shearing strength	○			
		Thermal expansion	○	○ 2)	○ 2)	
9	Abrasion		○			
10	Cohesion		△	△ 1)	□	applied to cohered material
11	Thermal conductibility		○	○	○	
12	Resistance to vibration		△	△ 1)		refer to **413. 3 (7)** of the Rules
13	Resistance to fire and flame spread		○	○	○	
14	Resistance to fatigue failure and crack propagation		△			

Remarks

○ : Items to be verified through verification test for properties.

△ : Items to be verified through verification test where deemed necessary depending on the insulation material.

□ : Items for which preparation of data on the properties is desirable.

Notes :

1) Necessary when the insulation material acts as spray shield specified in the requirements in **405. 1** of the Rules. In other cases, data on the properties is to be prepared.
2) Not generally required for fuel tanks where the design temperature exceeds -10°C.

<Newly added>

Present	Amendment
4. If the material, satisfies the performance requirements and such performance is considered to serve the purpose, the tests referred to in the preceding **2** may be omitted.	(3) If the material, which has been approved according to the Guidance given by the Society, satisfies the performance requirements and such performance is considered to serve the purpose, the tests referred to in the preceding (1) may be omitted.
5. For insulation materials to which the requirements in the preceding **2** to **4** do not apply, the following requirements are to be complied with: (1) For insulation materials used for supports of independent tanks, the requirements given in the column of membrane tank in **Table 6.1**. (2) For insulation materials provided in fuel tanks to which no provision of insulation, data on the necessary properties of those specified in **413. 3 (2)** depending on the insulation system is to be submitted to the Society.	(4) For insulation materials to which the requirements in the preceding (1) to (3) do not apply, the following requirements are to be complied with : (A) For insulation materials used for supports of independent tanks, the requirements given in the column of membrane tank in **Table 6.2** apply. (B) For insulation materials provided in fuel tanks to which no provision of insulation is required according to the requirements in **408.** of the Rules, data on the necessary properties of those specified in **413. 3** (2) of the Rules depending on the insulation system is to be submitted to the Society.
<newly added>	(5) The test method for the properties specified in **413. 3** (2) of the Rules is to be **Table 6.3** or to the satisfaction of the Society.
<newly added>	**6. Quality control of insulation materials** In applying **413. 3** (2) of the Rules, control of manufacture, storage, handling, assembly, quality control and effect from exposure of the sun is as shown in the following requirements: (1) The insulation materials are to be approved in accordance with the Guidance. In the above, tests and inspection are to be conducted according to the procedures on the manufacture, storage, handling and product quality control established by the manufacturer.
1. In applying **413. 3** (2) of this Rules, tests and inspection for insulation work is to include the following items of tests and inspections (1) to (3): (1) Insulation procedure test For insulation system and insulation procedure without previous records, tests are to be conducted in accordance with the test plan approved by the Society. The test may be conducted at the manufacturer of insulation materials or shipyard as necessary.	(2) The inspection for insulation work is to include the following tests and inspections : (A) Insulation procedure test For insulation system and insulation procedure without previous records, tests are to be conducted in accordance with the test plan approved by the Society. The test may be conducted at the manufacturer of insulation materials or shipyard as necessary.

<Newly added>

Table 6.3 Test Items for Insulation Materials

Test items	Test methods
1. Compatibility with the fuel	Tensile, compress., shearing, bending test after dipping in the fuel (DIN 53428)
2. Solubility in the fuel	Changes in the size and weight of test specimen before and after dipping in the fuel (DIN 53428)
3. Absorption of the fuel	Comparison of weight of test specimen or test of water absorbing properties before and after dipping in the fuel (DIN 53428)
4. Shrinkage	ISO 2796, ASTM D 2126
5. Aging	-
6. Closed cell content	ISO 4590, ASTM D2856
7. Density	ISO 845, ASTM D1622
8. Mechanical properties	Bending (ISO 1209, ASTM C203, D790) Compress.(ASTM D695, D1621) Tensile (ISO1926, EN 1607, ASTM D638, D1623) Shearing (ISO 1922, ASTM C273) Thermal expansion (ASTM D696, E831)
9. Abrasion	-
10. Cohesion	ASTM D1623
11. Thermal conductibility	ISO 8302, KS L9016, ASTM C177, C518
12. Resistance to vibration	ISO 10055
13. Resistance to fire and flame spread	DIN 4102
14.	-

Present	Amendment
(2) Insulation production test In accordance with the test plan approved by the Society in advance, tests are to be conducted to verify the work control, working environment control and product quality control during insulation procedure.	(B) Insulation production test In accordance with the test plan approved by the Society in advance, tests are to be conducted to verify the work control, working environment control and product quality control during insulation procedure.
(3) Completion inspection After the insulation work is completed, inspection is to be conducted for dimensions, shape, appearance, etc. in accordance with the procedures already approved by the Society, and in addition, the insulation performance is also to be verified in the test specified in **Ch 16 501. 6** of this Rules.	(C) Completion inspection After the insulation work is completed, inspection is to be conducted for dimensions, shape, appearance, etc. in accordance with the procedures already approved by the Society, and in addition, the insulation performance is also to be verified in the test specified in **Ch 16, 501. 6** of the Rules.
414. <newly added>	**414. Construction processes** **1. Weld joint design** (1) The "dome-to-shell connections" referred to in the requirements in **414. 1** (1) of the Rules are applicable to tanks with MARVS is 0.07 Mpa or below, and the connections mean ordinary fuel pipes or other penetrations of equivalent size sufficiently small when compared with the size of dome. (2) In welding of the penetrations referred to in the preceding (1) full penetration type welding may not be required, but are to have proper grooves. In this case, all the weld lines for penetrations of pipes with outside diameter exceeding 100 mm, and the partial weld lines for those with outside diameter of 100 mm or below, are to be subjected to non-destructive test as appropriate. (3) The "very small process pressure vessels" referred to in the requirements in **414. 1** (2) (A) of the Rules means pressure which are so small that it is difficult to remove their backing strip.

<Newly added>

Present	Amendment
415. <newly added>	**415. Tank types** **1.Type A independent tanks** 【See Rules】 (1) Design basis "Recognized standards" of the requirements in **415. 1** (1) (A) of the Rules means normally the requirements in **Pt 3, Ch 15** of **Rules for the Classification of Steel Ships**. (2) Structural analysis (A) In applying **415. 1** (2) (A) of the Rules, the corrosion allowance may be reduced or may not be required in accordance with the requirements in **401. 7** of the Rules. In structures where the membrane or axial force due to internal pressure can not be neglected, the calculation equation specified in **Pt 3, Ch 15** of **Rules for the Classification of Steel Ships** may be used after suitable modification. (B) In case where no corrosion allowance specified in **401. 7** of the Rules is required in accordance with the preceding (1), stiffeners may have section modulus more than 1/1.2 of one required in **Pt 3, Ch 15, Sec 2** of **Rules for the Classification of Steel Ships**. (C) In applying **415. 1** (2) (B) of the Rules, the following requirements are to be considered for loads and ship deflections. (a) Ship deflections due to longitudinal bending moment in waves and longitudinal still water bending moment. (b) Ship deflections due to horizontal bending moment in waves and twisting moment, when necessary due to type of supporting structures. (c) Internal pressure specified in **409 3** (3) (A) of the Rules. **3. Allowable stresses** (1) The "classical analysis procedures" referred to in the requirements in **415. 1** (3) (A) of the Rules means the beam theory where the type of stress to be assessed is the combined stress of bending stress and axial stress. (2) In applying **415. 1** (3) (A) of the Rules, the allowable stress for the equivalent stress σ_c when detailed stress calculations are made on primary members is to be as given in **Table 6.4**.

Present	Amendment
<newly added>	**Table 6.4 Allowable Stresses for the Primary Equivalent Stress**

Ferrite steels	Austenitic steels	Aluminium alloys
0.79 R_e	0.84 R_e	0.79 R_e
0.53 R_m	0.42 R_m	0.42 R_m

(Note)
For each member, the smaller of the above values is to be used with R_e and R_m as specified in **412. 1** (1) (C)of the Rules

2. Type B independent tanks

(1) Structural analysis
In applying **415. 2** (2) of the Rules, the following requirements are to be complied with :
(A) The fuel tank structure is to be analyzed by three dimensional frame structural analysis method or finite element method. The model for the analysis is to include concerned hull structures and support construction considering ship deflections and local deflections of hull due to vertical, horizontal and twisting moments.
(B) The strength members of fuel tanks are to be computed in details by the finite element method. In case where compatible results can be obtained, however, the frame structural analysis method may be used in replacement therewith.
(C) In the preceding (A) and (B), dynamic loads necessary for the calculation of interactions between the hull and fuel tanks specified in **415. 2** (2) (B) of the Rules are, as a rule, to be determined by long-term distribution in accordance with the requirements in **409. 4** (1) (A) and **415. 2** (2) (C) of the Rules where the most probable largest load in terms of the probability of occurrence as deemed appropriate by the Society is to be used. The dynamic stress(σ_{dyn}) due to such loads are to be evaluated for their phase difference according to the requirements in **411. 2** (3) of the Rules, and the total stress including dynamic stress is to be the sum of such dynamic stress and static stress(σ_{st}). However, the load within fuel tanks may be considered as the internal pressure specified in the requirements in **409. 3** (3) (A) (e) of the Rules by using the value of long-term distribution of acceleration computed by direct calculation according to the requirements in **409. 4** (1) (A)and **415. 2** (2) (C) of the Rules.

Present	Amendment
<newly added>	(D) The scantlings of fuel tank plates and stiffeners fitted to tank plates are to the satisfaction of the Society in consideration of the stress distribution and the mode of stress. (E) In case where bulkheads are provided in fuel tanks, the scantlings of bulkhead plates and stiffeners fitted to the bulkhead plates are to the satisfaction of the Society. (F) The strength members in fuel tanks are to be subjected to fatigue strength analysis for both the base metal and welded joints of high stress regions and stress concentration regions. S-N curves are to be plotted by experiment by the taking into account the following requirements : (a) Shape and size of test specimen (b) Stress concentration and notch sensitivity (c) Mode of stress (d) Mean stress (e) Welding conditions (f) Ambient temperature (G) Relative to the design standards for the secondary barrier, the crack propagation analysis specified in the requirements in **415. 2** (2) (A) of the Rules is to be carried out to verify that the assumed initial cracks would not reach the critical crack length in a period. The rate of fuel leakage is to be computed on the basis of the crack length obtained by this analysis. (H) It is to be verified that the fuel tank plates and associated structural members have sufficient strength against compressive buckling, torsional buckling of stiffeners, shearing buckling, and bending buckling of tripping brackets. (I) The accuracy in stress analysis is to be verified by model tank test or pressure measurements taken at time of pressure tests on a real ship in accordance with the requirements in **CH 16, 501. 5** of the Rules.

<Newly added>

Present	Amendment
<newly added>	**3. Type C independent tanks** (1) Structural analysis (A) In applying **415. 3** (1) of the Rules, for the scantlings, shapes and reinforcements of openings of fuel tanks against internal pressure in fuel tanks, the requirements for Class 1 pressure vessels in **Pt 5, Ch 5** of the Rules apply. (B) In applying **415. 3** (2) (C) of the Rules, P_4 among design external pressure P_0 is to be the value computed by applying the requirements in **Pt 3, Ch 10, Sec 2**, in **Pt 3, Ch 16, Sec 2** and in **Pt 3, Ch 17, Sec 2** of **Rules for the Classification of Steel Ships** corresponding to the location of the tanks. (2) Allowable stresses In applying **415. 3** (3) (A) of the Rules, the circumferential stresses at supports shall be calculated by a procedure acceptable to the Classification Society for a sufficient number of load cases. (A) Permissible stresses in stiffening rings: For horizontal cylindrical tanks made of C-Mn steel supported in saddles, the equivalent stress in the stiffening rings shall not exceed the following values if calculated using finite element method: $\sigma_e \le \sigma_{all}$ where: $\sigma_{all} = \min(0.57R_m; 0.85R_e)$ R_m and R_e : as defined in **412. 1** (1) (C) of the Rules $\sigma_e = \sqrt{(\sigma_n + \sigma_b)^2 + 3\tau^2}$ σ_e : equivalent stress(N/mm^2) σ_n : nominal stress in the circumferential direction of the stiffening ring (N/mm^2) σ_b : bending stress in the circumferential direction of the stiffening ring (N/mm^2) τ : shear stress in the stiffening ring (N/mm^2) Equivalent stress values σ_e is to be calculated over the full extent of the stiffening ring by a procedure acceptable to this Society, for a sufficient number of load cases as defined in **409. 3** (3) (H), **4** (1) (B) and **5** of the Rules.

<Newly added>

Present	Amendment
<newly added>	(B) The following assumptions are to be made for the stiffening rings: (a) The stiffening ring is to be considered as a circumferential beam formed by web, face plate, if any, and associated shell plating. The effective width of the associated plating should be taken as: (i) For cylindrical shells: an effective width (mm) not greater than $0.78\sqrt{rt}$ on each side of the web. A double plate, if any, may be included within that distance. where: r = mean radius of the cylindrical shell (mm) t = shell thickness (mm) (ii) For longitudinal bulkheads (in the case of lobe tanks): the effective width (mm) is to be determined according to established standards. A value of 20 t_b on each side of the web may be taken as a guidance value. where: t_b = bulkhead thickness (mm) (b) The stiffening ring is to be loaded with circumferential forces, on each side of the ring, due to the shear stress, determined by the bi-dimensional shear flow theory from the shear force of the tank. (C) For calculation of reaction forces at the supports, the following factors are to be taken into account: (a) Elasticity of support material (intermediate layer of wood or similar material) (b) Change in contact surface between tank and support, and of the relevant reactions, due to: (i) thermal shrinkage of tank (ii) elastic deformations of tank and support material The final distribution of the reaction forces at the supports is not to show any tensile forces. (D) The buckling strength of the stiffening rings is to be examined.

<Newly added>

Present	Amendment
<newly added>	**4. Membrane tanks** (1) Design basis In case where the design vapour pressure is made higher than 0.025 MPa in accordance with the provision to the requirements in **415. 4** (1) (D) of the Rules, this vapour pressure is to be taken into account when model test specified in **Ch 16, 505. 1** (1) of the Rules is conducted. In this case, special consideration is to be given to stress concentration for the welding and construction details of the adjacent hull structure. (2) Design considerations (A) In applying **415. 4** (2) (A) of the Rules, in the assessments of plastic deformations and fatigue of the membrane and thermal insulation materials, all static and dynamic stresses and thermal stress specified in **409.** of the Rules (B) In the assessments referred to in the preceding (A), verification is to be made through fatigue tests on a model combining the elements of the tank, second barrier, insulation structure and tank supporting structure considering the dimensional effects on real tank and the effects of dispersions in materials and fabrication accuracy as an integral part of the test specified in **Ch 16, 505. 1** (1) of the Rules. (3) Loads and load combinations The assessments of collapse of the membrane referred to in the requirements of **415. 4** (3) of the Rules are to be made in accordance with the following requirements : (A) For overpressure and negative pressure in the interbarrier space, collapse test is to be conducted on a prototype model of the membrane to verify its ultimate strength. (B) For sloshing loads, impact load experiment is to be carried out on a prototype model of the membrane to verify its strength when the Society considers necessary.

<Newly added>

Present	Amendment
<newly added>	(4) Structural analyses In applying **415. 4** (4) (B) of the Rules, the hull structure adjacent to membrane tanks is to comply with the requirements in **Pt 3, Ch 15** of **Rules for the Classification of Steel Ships** and, in addition, the stress in the hull structure is to be restricted in consideration of the structural strength of membrane tanks, if necessary. The allowable stresses of the membrane, membrane supporting structures and insulation materials are to be determined in each case according to the mechanical properties of materials, records of construction, product specifications and levels of product quality control practice.
Section 7 Pressure Relief System	**Section 7 Pressure Relief System**
702. Pressure relief systems for liquefied gas fuel tanks	**702. Pressure relief systems for liquefied gas fuel tanks**
1. In applying **702. 3** of this Rules, sizing of pressure relief device is to be in accordance with the following (1) to (4): (1) ~ (2) <omitted> (3) The relieving capacity of pressure relief devices of interbarrier spaces of membrane ~~and semi-membrane~~ tanks is to be evaluated on the basis of specific membrane ~~or semi-membrane~~ tank design. ~~(4) The relieving capacity of pressure relief devices of interbarrier spaces adjacent to integral type cargo tanks may, if applicable, be determined as for type A independent cargo tanks.~~	**1.** In applying **702. 3** of the Rules, sizing of pressure relief device is to be in accordance with the following requirements : (1) ~ (2) <same as the present> (3) The relieving capacity of pressure relief devices of interbarrier spaces of membrane tanks is to be evaluated on the basis of specific membrane tank design.
703. <omitted>	**703. <same as the present>**

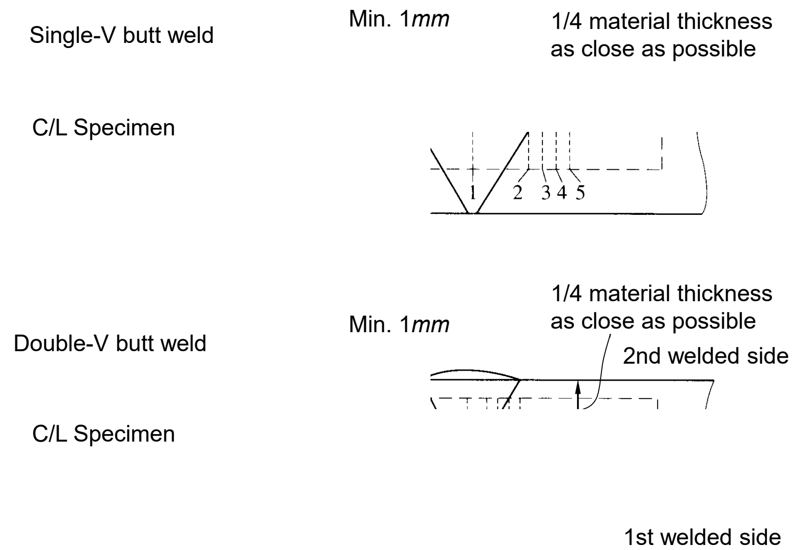
<Newly added>

Present	Amendment
Section 8 <newly added>	**Section 8 Loading Limit for Liquefied Gas Fuel Tanks**
801. <newly added>	**801. Loading Limits** **1.** In applying **801. 2** of the Rules, storage tank loading limits higher than calculated using reference temperature is understood to be an alternative to **801. 1** of the Rules and should only be applicable when the calculated loading limit using the formulae in **801. 1** of the Rules gives a lower value than 95%.
Section 9 Maintaining of fuel storage condition	**Section 9 Maintaining of fuel storage condition**
901. Control of tank pressure and temperature **1.** In applying **901. 1** of this Rules, liquefied gas fuel tanks' pressure and temperature should be controlled and maintained within the design range at all times including after activation of the safety system required in **Ch 15. 201. 2.** for a period of minimum 15 days. The activation of the safety system alone is not deemed as an emergency situation. .	**901. Control of tank pressure and temperature** **1.** In applying **901. 1** of the Rules, liquefied gas fuel tanks' pressure and temperature should be controlled and maintained within the design range at all times including after activation of the safety system required in **Ch 15, 301. 2.** for a period of minimum 15 days. The activation of the safety system alone is not deemed as an emergency situation.

<Newly added>

Present	Amendment
CHAPTER 16 MANUFACTURE, WORKMANSHIP AND TESTING	**CHAPTER 16 MANUFACTURE, WORKMANSHIP AND TESTING**
Section 1 <omitted>l	**Section 1 <same as the present>l**
Section 2 General test regulations and specifications	**Section 2 General test regulations and specifications**
201. Tensile test	**201. Tensile test**
1. The required values of tensile strength, yield stress and elongation of a material are to be in accordance with the requirement in **Pt 2** of **Rules for the classification of steel ships**.	**1.** In applying **201. 1** of the Rules, the required values of tensile strength, yield stress and elongation of a material are to be in accordance with the requirement in **Pt 2** of **Rules for the Classification of Steel Ships**.
202. Toughness test	**202. Toughness test**
1. <omitted>	**1.** <same as the present>
<newly added>	**2.** For the purpose of the requirements in **202. 2** of the Rules, in the case where the material thickness is 40mm or below, the Charpy V-notch impact test specimens are to be cut with their edge within 2 mm from the "as rolled" surface with their longitudinal axes either parallel or transverse to the final direction of rolling of the material as shown in **Figure 16.1**. Max. 2mm (for material thickness of 40mm or below) C/L Specimen 1/4 material thickness as close as possible (for material thickness of more than 40mm) **Fig 16.1 Sampling position of Charpy V-notch impact test spevimens(Base metal)**

<Newly added>

Present	Amendment
<newly added>	**3.** In application to **202. 3** of the Rules, the position of the specimens is to be in accordance with **Figure 16.2**.  **Fig 16.2 Sampling position of Charpy V-notch impact test specimens (Weld)** **4.** In application to **202. 4** of the Rules, the re-testing of Charpy V-notch impact test specimens is to be in accordance with **Pt 2, Ch 1, 109.** of **Rules for the classification of steel ships**.

Present	Amendment
Section 3 Welding of metallic materials and non-destructive testing for the fuel containment system	**Section 3 Welding of metallic materials and non-destructive testing for the fuel containment system**
301. General	**301. General**
1. The requirements in this section apply to independent tanks, semi-membrane tanks, process pressure vessels, integral tanks and piping. The requirements on membrane tanks, are to the satisfaction of the Society depending on the structural type of the tank.	**1.** The requirements in **Sec 3** of the Rules apply to independent tanks, process pressure vessels and piping. The requirements on membrane tanks, are to the satisfaction of the Society depending on the structural type of the tank.
2. For the purpose of the requirements in this section, the following requirements (1) and (2) are to be complied with.	**2.** In applying **303.** of the Rules, the following requirements are to be complied with.
(1) The impact test may generally be omitted for austenitic stainless steels of types given in **Table 7.3** and **Table 7.4** of the Rules.	(1) The impact test may generally be omitted for austenitic stainless steels of types given in **Table 7.3** and **Table 7.4** of the Rules.
(2) The impact test may generally be omitted for aluminum alloys of 5083 and welding material of 5183.	(2) The impact test may generally be omitted for aluminum alloys of 5083 and welding material of 5183.
<newly added>	(3) Welding procedure tests for secondary barriers are to be in accordance with **Pt 2, Ch 2, Sec 4** of **Rules for the Classification of Steel Ships.**
303. Welding procedure tests for fuel tanks and process pressure vessels	**303. Welding procedure tests for fuel tanks and process pressure vessels**
6. In application to **303. 5** of the Rules, radiographic or ultrasonic testing may be performed at the option of the Society.	**1.** In application to **303. 3** of the Rules, radiographic or ultrasonic testing may be performed at the option of the Society.
1. For the purpose of the requirements in **303. 4** of the Rules the following requirements are to be complied with :	**2.** For the purpose of the requirements in **303. 4** of the Rules the following requirements are to be complied with :

<Newly added>

Present	Amendment
(1) Longitudinal bend tests which are required in lieu of transverse bend tests in the case where the base material and weld metal have different strength level are to be in accordance with the requirements in **Pt 2, Ch 2, 402.** of **Rules for the classification of steel ships**.	(1) Longitudinal bend tests which are required in lieu of transverse bend tests in the case where the base material and weld metal have different strength level specified in **303. 4** (3) of the Rules are to be in accordance with the requirements in **Pt 2, Ch 2, 404.** of **Rules for the Classification of Steel Ships**
(2) For type C independent tanks and process pressure vessels, macroscopic and microscopic examinations and hardness tests are to be carried out according to the requirements of **Pt 7, Ch 5, 605.** of **Rules for the classification of steel ships**. For other independent tanks, ~~integral tank and semi-membrane tanks,~~ macroscopic examinations are to be carried out according to the requirements in **Pt 2, Ch 2, Sec 4** of **Rules for the classification of steel ships**.	(2) For type C independent tanks and process pressure vessels, macroscopic and microscopic examinations and hardness tests are to be carried out according to the requirements of **303. 4** (5) of the Rules. For other independent tanks, macroscopic examinations are to be carried out according to the requirements in **Pt 2, Ch 2, Sec 4** of **Rules for the Classification of Steel Ships**.
2. For the purpose of the requirements in **605. 3** (5) of the Rules, the welding procedure qualification test are also to comply with the relevant requirements in **Pt 2, Ch 2, Sec 4.** and **Pt 5, Ch 5, Sec 4** of **Rules for the classification of steel ships**.	**3.** In applying **605. 3** (5) of the Rules, the welding procedure qualification test are also to comply with the relevant requirements in **Pt 2, Ch 2, Sec 4.** and **Pt 5, Ch 5, Sec 4** of **Rules for the Classification of Steel Ships**.
3. For the purpose of the requirements in **303. 5** (1) of this Rules, the transverse tensile strength of weld metal which has lower tensile strength than that of the parent metal, e.g. in the case of 9 % nickel steel, is to comply with the requirements in **Pt 2, Ch 2, 404. 5** of **Rules for the classification of steel ships**.	**4.** In applying **303. 5** (1) of the Rules, the transverse tensile strength of weld metal which has lower tensile strength than that of the parent metal, e.g. in the case of 9 % nickel steel, is to comply with the requirements in **Pt 2, Ch 2, 404. 5** of **Rules for the Classification of Steel Ships**.
4. For the purpose of the requirements in **303. 5** (2) of this Rules, bend tests are also to comply with the requirements in **Pt 2, Ch 2, 404. 6** of **Rules for the classification of steel ships**. In case where the base metal is of RLP9 specified in **Pt 2, Ch 1** of **Rules for the classification of steel ships**, bend tests may be omitted.	**5.** In applying **303. 5** (2) of the Rules, bend tests are also to comply with the requirements in **Pt 2, Ch 2, 404. 6** of **Rules for the Classification of Steel Ships**. In case where the base metal is of RLP9 specified in **Pt 2, Ch 1** of **Rules for the Classification of Steel Ships**, bend tests may be omitted.

<Newly added>

Present	Amendment
5. For the purpose of the requirements in **303. 5** (3) of the Rules, the test temperature of impact tests may be determined in accordance with the requirements in **Pt 7, Ch 5, 603. 2** of the Guidance relating to **Rules for the classification of steel ships**.	**6.** In applying **303. 5** (3) of the Rules, the test temperature of impact tests may be determined in accordance with the requirements in **Ch 6, 413. 2 (1)**.
304. Welding procedure tests for piping	**304. Welding procedure tests for piping**
1. Welding procedure qualification tests for pipes are also to be in accordance with the relevant requirements in **Pt 2, Ch 2** of **Rules for the classification of steel ships**.	**1.** Welding procedure qualification tests for pipes are also to be in accordance with the relevant requirements in **Pt 2, Ch 2** of **Rules for the Classification of Steel Ships.**
305. Production weld tests	**305. Production weld tests**
1. <omitted>	**1. <same as the present>**
2. For the purpose of the requirements in **305. 1** of the Rules, the number of test specimens for production weld tests of secondary barriers may be reduced to the extent as deemed appropriate by the Society considering the experience of same welding procedures in past, workmanship and quality control. In general, intervals of production weld tests for secondary barriers may be approximately 200 m of butt weld joints and the tests are to be representative of each welding position. Test requirements are to be in accordance with **Pt 7, Ch 5, 605. 3** (5). of **Rules for the classification of steel ships**.	**2.** For the purpose of the requirements in **305. 1** of the Rules, the number of test specimens for production weld tests of secondary barriers may be reduced to the extent as deemed appropriate by the Society considering the experience of same welding procedures in past, workmanship and quality control. In general, intervals of production weld tests for secondary barriers may be approximately 200 m of butt weld joints and the tests are to be representative of each welding position. Test requirements are to be in accordance with **303. 5** of the Rules.
3. <omitted>	**3. <same as the present>**

<Newly added>

Present	Amendment
306. Non-destructive testing **1.** In applying **306.** of this Rules, The following requirements (1) through (4) are to apply as the testing procedures. (1) ~ (4) <omitted> **2.** <omitted> **3.** In applying **306. 2** of this Rules, for the non-destructive tests for the remaining welds of tank plates of type A and B independent tanks and semi-membrane tanks other than butt welds, fillet welds of highly stressed parts of main structural members of cargo tanks are to be examined magnetic particle or dye penetrant tests given in **1**. Butt welds of highly stressed parts of main structural members such as face plates of girders are to be subjected to radiographic test given in **1**. **4.** <omintted>	**306. Non-destructive testing** **1.** In applying **306. 1** of the Rules, The following requirements are to apply as the testing procedures. (1) ~ (4) <omitted> **2.** <omitted> **3.** In applying **306. 2** of the Rules, for the non-destructive tests for the remaining welds of tank plates of type A and B independent tanks other than butt welds, fillet welds of highly stressed parts of main structural members of fuel tanks are to be examined magnetic particle or dye penetrant tests given in **1**. Butt welds of highly stressed parts of main structural members such as face plates of girders are to be subjected to radiographic test given in **1**. **4.** <omintted>

<Newly added>

Present	Amendment
Section 4 <newly added>	**Section 4 Other Regulations for Construction in Metallic Materials** **404. Membrane Tanks** **1.** In applying **404.** of the Rules, quality assurance procedure, welding control, design details, quality control of materials, construction method, inspection and standards of production testing of components for membrane tanks are to be developed during the prototype scaled model test specified in **Ch 16, 505. 1** (1) of the Rules or another prototype test separately conducted for development of production procedure, and their effectiveness is to be verified. The relevant data is to be noted in the construction procedure manual for fuel tanks including the insulation construction of membrane tanks. **2.** The construction procedure manual referred to in the preceding **1** is to be approved by the Society after being verified through prototype scaled model test. **Section 5 Testing** **501. Testing and Inspections during Construction** **1. Structural Test and Tightness test for fuel tanks** In case where leakage of fuel tanks can not be inspected in the hydraulic test or hydrostatic-hydropneumatic test according to the requirements in **501. 2** of the Rules, the tightness test of fuel tanks is to be conducted separately. This test is to be of the airtightness test conducted at a pressure of MARVS or more of the fuel tank. **2. Stress measurements instrumentation of type B independent tanks** In applying **501. 5** of the Rules, in case where stress measurements of the fuel tank previously built which can be regarded as the tank of the same design manufactured at the same shipyard had resulted in good agreement with design stress levels, provision of instrumentation of independent tanks stress levels for tanks subsequently built may be omitted.

<Newly added>

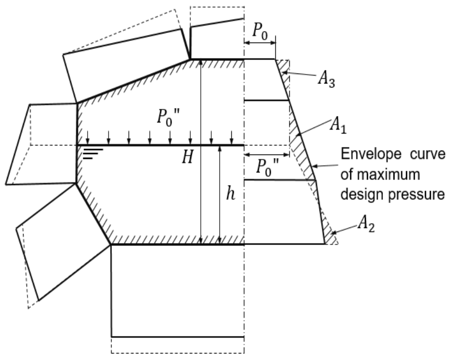
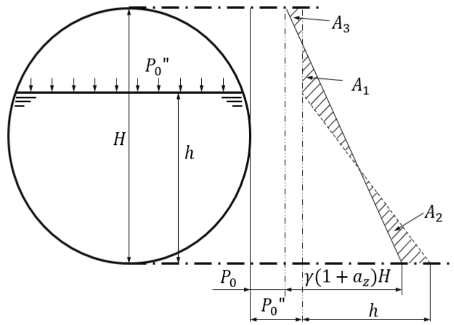
Present	Amendment
<newly added>	**3. Gas-trial and fuel full loading test** (1) In accordance with the requirements in **501. 6** and **702. 5** of the Rules, the following tests are to be conducted in the attendance of the Surveyor to verify the performance of the fuel containment installations and fuel handling equipment : (A) Gas-trial On items given in **Table 16.1**, tests are to be conducted to verify the performance of the fuel containment system fuel handling equipment and instrumentation using a suitable quantity of the fuel after the completion of all the construction work. However, for fuel tanks which do not require either cool-down operations or the fuel pressure/temperature controls specified in **Ch 6, 901. 1** of the Rules, omission of this test may be accepted if substitution is made by the operating test with the substituting medium to verify the performance of equipments specified in item 5 and 6 of **Table 16.1**, except for the case where the tank is of the first fuel tank manufactured by the manufacturer of fuel tanks. (B) Fuel full loading test Where deemed necessary by the Society, tests are to be conducted after completion of all the construction work to verify that the fuel containment installations, fuel handling equipment and instrumentation satisfy the design conditions under the fully loaded condition of fuel. (2) The kinds of real liquid fuel and gas used in the gas-trial and fuel full loading test specified in the preceding (1) are to be such that reproduction of the most severe conditions of those design conditions of the fuel containment system, the transfer installations, the reliquefaction system, etc. In addition, the verification relative to design temperatures is to be made by reproducing the condition that the fuel on the basis of which design temperature has been determined is cooled down as close to the design temperature as practicable. (3) The quantities of the real fuel and vapour used in the gas-trial and fuel full loading test referred to in the preceding (1) are to be sufficient to conducting the tests specified in (1). (4) The fuel full loading test to capacity specified in the preceding (1) (B) may be conducted simultaneously with the gas-trial indicated in the preceding (1) (A).

<Newly added>

Table 16.1 Test Items at the Gas Trial

Test item	◎ : Attendance of the Surveyor ○ : Submission of the record	Inspection equipment	Survey item
1. Drying test	○	· Inert gas generator(IGS)	· Dew point · Change of dryness in fuel tanks and hold spaces
2. Inerting test	○	· Inert gas generator	· Operation of the inert gas generator · Measuring of atmosphere in fuel tanks
3. Inert gas purge test using fuel vapour	○	· Fuel vapourizer · Compressor	· Change of O_2/temperature of fuel vapour in fuel tanks · Quantity of fuel vapour (or liquid) supply · Capacity of the vapourizer · Capacity of the compressor
4. Cool-down test	◎/○	· Spray pump · Compressor · Fuel piping · Temperature indicators for fuel tank · Spray piping	· Temperature curve of fuel tanks · Inspection of hold spaces/condition of insulation of tanks[1)] (after cool-down) · Cooling condition of spray piping·Cooling condition of fuel piping · Capacity of spray pump · Fuel consumption · Capacity of compressor (property of return gas) · Temperature/pressure in fuel tank · Shrinkage of fuel tank[2)]
5. Loading test of fuel liquid	◎/○	· Compressor · Fuel piping related for loading · Level gauge/temperature indicator	· Temperature/pressure level in fuel tanks · Temperature/pressure in hold spaces · Temperature/pressure of fuel liquid/gas at manifolds · Service condition of fuel piping
6. Operation test of fuel pump	◎/○	· All fuel pumps	· Discharge pressure/current of fuel pumps · Liquid level/pressure in fuel tanks · Stripping
7. Operation test of pressure/temperature control system	◎/○	· Depend on the type of controls	· Depend on the type of controls
Notes : 1) The Society may approve omission in consideration of the quality control status and manufacturing records of insulation materials. 2) To be verified only in case of independent tanks.			

<Newly added>

Present	Amendment
<newly added>	**4. Cold spot inspection** (1) The cold spot inspection of fuel tanks specified in **501. 7** of the Rules is to be carried out during the fuel full loading test to capacity specified in **3** (1) for the membrane tank, internal insulation tank, and when necessary, independent tank.
502. <newly added>	**502. Independent Tank Type A** **1. Hydrostatic or hydropneumatic test for independent tank** (1) In applying **502.** of the Rules, the hydrostatic or hydropneumatic test of fuel tanks is to be conducted by simulating the actual load conditions (static load + dynamic load) in accordance with the following requirements : (A) Test of fuel tanks Hydrostatic-hydropneumatic test is to simulate the static pressure of fuel, acceleration by ship motions and internal pressure including the vapour pressure by water head and pneumatic pressure. (See **Fig 16.3**, **Fig 16.4** and **Fig 16.5**) (B) Load test of supporting structures Hydraulic test is to simulate the fuel weight and the load created by the acceleration due to ship motions solely by the weight of water. (See **Fig 16.6**)  **Fig 16.3 Simulating the Internal Pressure Distribution of Rectangular Tank**  **Fig 16.4 Simulating the Internal Pressure Distribution of Spherical Tank**

Present	Amendment
<newly added>	(see below)

Amendment:

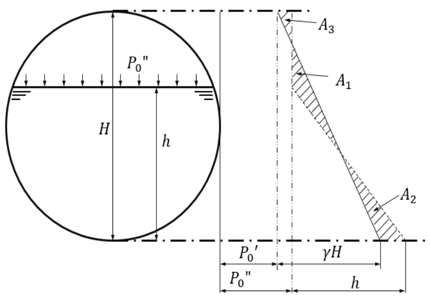


Fig 16.5 Simulating the Internal Pressure Distribution at Pressure Discharge

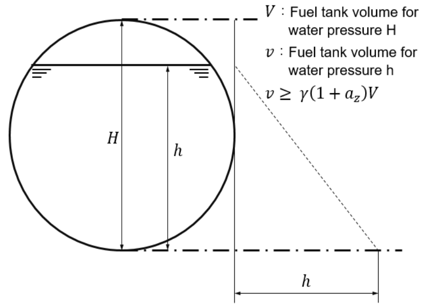


Fig 16.6 Simulating the Loading Condition of Support Structure

* Explanatory notes on symbols in **Fig 16.3** to **Fig 16.6.**

------ : maximum loading condition which is predicted to actually encounter

⋯ : pressure testing condition simulating as far as practicable (P_0'' and h are to be chosen so that $P_0'' > P_0$ or $P_0'' > P_0'$ and $A_2 + A_3 > A_1$ as far as practicable)

H : depth of tank

h : water head

γ : specific gravity of fuel

a_z : maximum vertical acceleration (non-dimensional)

P_0 : design vapour pressure at ordinary passage

P_0' : design vapour pressure during pressurized unloading in port

P_0'' : air pressure

(2) All tests specified in the preceding (1) (A) and (B) may be conducted individually.

(3) In the case of the fuel tank of supports which can be regarded as those of the same type manufactured at the same manufacturing plant, implementation of the second and subsequent tests of fuel tanks and supports specified in the preceding (1) (B) may be omitted when deemed acceptable by the Society.

<Newly added>

Present	Amendment
<newly added> **503. <newly added>** **504. <newly added>**	**503. Independent Tank Type B** **1. Structural Test and Tightness test for fuel tanks** (1) Refer to the requirements in **501. 1** and **502. 1.** **504. Independent Tank Type C** **1. Hydrostatic or hydropneumatic test for independent tank** (1) The "pressure vessels other than simple cylindrical and spherical pressure vessels" referred to in the requirements in **504. 1** of the Rules means those cylindrical or spherical pressure vessels with supporting structures of well proved records. In tanks of special shape having supporting structures likely to cause excessive bending stress or bicylindrical shape tanks, the stress levels are to be verified by strain measurement through prototype test. (2) "Where necessary" referred to in the requirements in **504. 4** of the Rules means a case in which the shipbuilding berth or hull structure can not withstand the hydrostatic load when fuel tanks are filled with water to the tank top level and another case in which a large load exceeding the design load is imposed on the structural members of the tank or adjacent structures by conducting the hydrostatic test. (3) In applying **504. 6** of the Rules, the leakage test is to be of the airtightness test conducted at a pressure of MARVS or more of the pressure vessel.

<Newly added>

Present	Amendment
505. <newly added>	**505. Membrane Tank** **1. Design development testing** (1) Tests specified in the requirements in **505. 1** (1) of the Rules, are to be conducted on a model in combination of the primary barrier, insulation structure and secondary barrier. Test object and testing procedure are to be determined for each type of tank in each case. **2. Hull structure adjacent to membrane tanks** (1) The "hydrostatically tested" referred to in the requirements in **505. 2** (1) of the Rules means the hydraulic test according to the requirements in **Pt 3, Ch 1, 209.** of **Rules for the Classification of Steel Ships.** of the Rules. In this case, hydraulic pressure may be applied from hull structures such as ballast tanks and cofferdams. (2) The leakage test for the "all hold structure supporting the membrane" referred to in the requirements in **505. 2** (2) of the Rules is to be in accordance with the testing procedure applicable to general hull structures as specified in **Pt 3, Ch 1, 209.** of **Rules for the Classification of Steel Ships.**
Section 7 <omitted>	**Section 7 <same as the present>**

Present	Amendment
<newly added>	**Annex 3 Standard for the use of limit state methodologies in the design of fuel containment systems of novel configuration** **101. General** 1. The purpose of this standard is to provide procedures and relevant design parameters of limit state design of fuel containment systems of a novel configuration in accordance with **Ch 6, 416.** of the Rule. 2. Limit state design is a systematic approach where each structural element is evaluated with respect to possible failure modes related to the design conditions identified in **Ch 6, 401. 6** of the Rule. A limit state can be defined as a condition beyond which the structure, or part of a structure, no longer satisfies the regulations. 3. The limit states are divided into the three following categories: (1) Ultimate Limit States (ULS), which correspond to the maximum load carrying capacity or, in some cases, to the maximum applicable strain, deformation or instability in structure resulting from buckling and plastic collapse; under intact (undamaged) conditions; (2) Fatigue Limit States (FLS), which correspond to degradation due to the effect of cyclic loading; and (3) Accident Limit States (ALS), which concern the ability of the structure to resist accident situations. 4. **Ch 6, 401.** through to **Ch 6, 414.** of the Rule are to be complied with as applicable depending on the fuel containment system concept. **102. Design format** 1. The design format in this standard is based on a Load and Resistance Factor Design format. The fundamental principle of the Load and Resistance Factor Design format is to verify that design load effects, L_d, do not exceed design resistances, R_d, for any of the considered failure modes in any scenario: $L_d \leq R_d$

<Newly added>

Present	Amendment
<newly added>	(1) A design load F_{dk} is obtained by multiplying the characteristic load by a load factor relevant for the given load category: $F_{dk} = \gamma_f \cdot F_k$ where: γ_f = load factor; and F_k = the characteristic load as specified in **Ch 6, 409.** through to **412.** of the Rule A design load effect L_d (e.g. stresses, strains, displacements and vibrations) is the most unfavorable combined load effect derived from the design loads, and may be expressed by: $L_d = q(F_{d1}, F_{d2}, \cdots, F_{dN})$ where q = the functional relationship between load and load effect determined by structural analysis. (2) The design resistance R_d is determined as follows: $R_d = \frac{R_k}{\gamma_R \cdot \gamma_C}$ where: R_k = the characteristic resistance. In case of materials covered by **Ch 7** of the Rule, it may be, but not limited to, specified minimum yield stress, specified minimum tensile strength, plastic resistance of cross sections, and ultimate buckling strength; γ_R = the resistance factor, which is determined as follows $\gamma_R = \gamma_m \cdot \gamma_s$; where γ_m = the partial resistance factor to take account of the probabilistic distribution of the material properties(material factor)

Present	Amendment
<newly added>	γ_s = the partial resistance factor to take account of the uncertainties on the capacity of the structure, such as the quality of the construction, method considered for determination of the capacity including accuracy of analysis; and γ_C is the consequence class factor, which accounts for the potential results of failure with regard to release of fuel and possible human injury. 2. Fuel containment design is to take into account potential failure consequences. Consequence classes are defined in **Table 1.1**, to specify the consequences of failure when the mode of failure is related to the Ultimate Limit State, the Fatigue Limit State, or the Accident Limit State. **Table 1.1 – Consequence classes**

Consequence class	Definition
Low	Failure implies minor release of the fuel.
Medium	Failure implies release of fuel and potential for human injury.
High	Failure implies significant release of the fuel and high potential for human injury/ fatality

103. Required analyses

1. Three-dimensional finite element analyses are to be carried out as an integrated model of the tank and the ship hull, including supports and keying system as applicable. All the failure modes are to be identified to avoid unexpected failures. Hydrodynamic analyses are to be carried out to determine the particular ship accelerations and motions in irregular waves, and the response of the ship and its fuel containment systems to these forces and motions.

2. Buckling strength analyses of fuel tanks subject to external pressure and other loads causing compressive stresses are to be carried out in accordance with recognized standards. The method is to adequately account for the difference in theoretical and actual buckling stress as a result of plate out of flatness, plate edge misalignment, straightness, ovality and deviation from true circular form over a specified arc or chord length, as relevant.

Present	Amendment
<newly added>	3. Fatigue and crack propagation analysis is to be carried out in accordance with **105. 1**. **104. Ultimate limit states** 1. Structural resistance may be established by testing or by complete analysis taking account of both elastic and plastic material properties. Safety margins for ultimate strength are to be introduced by partial factors of safety taking account of the contribution of stochastic nature of loads and resistance (dynamic loads, pressure loads, gravity loads, material strength, and buckling capacities). 2. Appropriate combinations of permanent loads, functional loads and environmental loads including sloshing loads are to be considered in the analysis. At least two load combinations with partial load factors as given in **Table 1.2** are to be used for the assessment of the ultimate limit states. **Table 1.2 Partial load factors** Load combination / Permanent loads / Functional loads / Environmental loads 'a' / 1.1 / 1.1 / 0.7 'b' / 1.0 / 1.0 / 1.3 The load factors for permanent and functional loads in load combination 'a' are relevant for the normally well-controlled and/or specified loads applicable to fuel containment systems such as vapour pressure, fuel weight, system self-weight, etc. Higher load factors may be relevant for permanent and functional loads where the inherent variability and/or uncertainties in the prediction models are higher. 3. For sloshing loads, depending on the reliability of the estimation method, a larger load factor may be required by the Society.

Table 1.2 Partial load factors

Load combination	Permanent loads	Functional loads	Environmental loads
'a'	1.1	1.1	0.7
'b'	1.0	1.0	1.3

<Newly added>

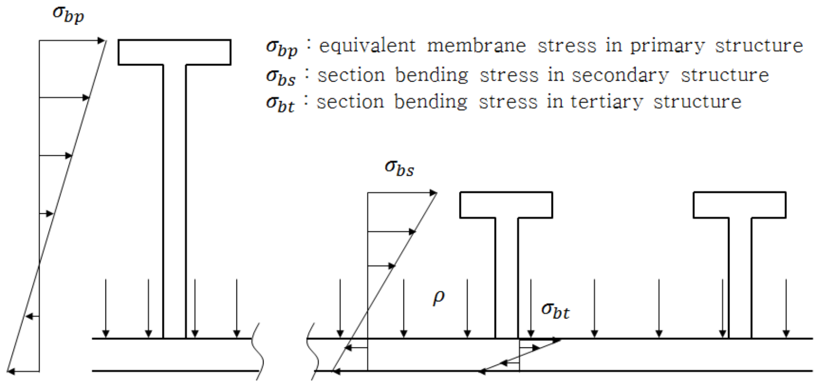
Present	Amendment
<newly added>	4. In cases where structural failure of the fuel containment system are considered to imply high potential for human injury and significant release of fuel, the consequence class factor is to be taken as γ_C = 1.2. This value may be reduced if it is justified through risk analysis and subject to the approval by the Society. The risk analysis is to take account of factors including, but not limited to, provision of complete or partial secondary barrier to protect hull structure from the leakage and less hazards associated with intended fuel. Conversely, higher values may be fixed by the Society, for example, for ships carrying more hazardous or higher pressure fuel. The consequence class factor is to in any case not be less than 1.0. 5. The load factors and the resistance factors used are to be such that the level of safety is equivalent to that of the fuel containment systems as described in sections **Ch 6, 402. 1** to **5** of the Rule. This may be carried out by calibrating the factors against known successful designs. 6. The material factor γ_m is to in general reflect the statistical distribution of the mechanical properties of the material, and needs to be interpreted in combination with the specified characteristic mechanical properties. For the materials defined in **Ch 7** of the Rule, the material factor γ_m may be taken as: 1.1 when the characteristic mechanical properties specified by the Society typically represents the lower 2.5% quantile in the statistical distribution of the mechanical properties; or 1.0 when the characteristic mechanical properties specified by the Society represents a sufficiently small quantile such that the probability of lower mechanical properties than specified is extremely low and can be neglected. 7. The partial resistance factors γ_{si} are to in general be established based on the uncertainties in the capacity of the structure considering construction tolerances, quality of construction, the accuracy of the analysis method applied, etc.

Present	Amendment
<newly added>	(1) For design against excessive plastic deformation using the limit state criteria given in **8**, the partial resistance factors γ_{si} are to be taken as follows: $\gamma_{s1} = 0.76 \cdot \frac{B}{\kappa 1}$ $\gamma_{s2} = 0.76 \cdot \frac{D}{\kappa 2}$ $\kappa_1 = Min\left(\frac{R_m}{R_e} \cdot \frac{B}{A}; 1.0\right)$ $\kappa_2 = Min\left(\frac{R_m}{R_e} \cdot \frac{D}{C}; 1.0\right)$ where A, B, C and D = defined in **Ch 6, 415. 2** (3) (A) of the Rule. R_m and R_e = defined in **Ch 6, 412. 1** (1) (C) of the Rule. The partial resistance factors given above are the results of calibration to conventional type B independent tanks. 8. Design against excessive plastic deformation (1) Stress acceptance criteria given below refer to elastic stress analyses. (2) Parts of fuel containment systems where loads are primarily carried by membrane response in the structure are to satisfy the following limit state criteria: $\sigma_m \le f$ $\sigma_L \le 1.5f$ $\sigma_b \le 1.5F$ $\sigma_L + \sigma_b \le 1.5F$ $\sigma_m + \sigma_b \le 1.5F$ $\sigma_m + \sigma_b + \sigma_g \le 3.0F$ $\sigma_L + \sigma_b + \sigma_g \le 3.0F$

Present	Amendment
<newly added>	where: σ_m = equivalent primary general membrane stress σ_L = equivalent primary local membrane stress σ_b = equivalent primary bending stress σ_g = equivalent secondary stress $f = \frac{R_e}{\gamma_{s1} \cdot \gamma_m \cdot \gamma_c}$ $F = \frac{R_e}{\gamma_{s2} \cdot \gamma_m \cdot \gamma_c}$ The stress summation described above is to be carried out by summing up each stress component (σ_x, σ_y, τ_{xy}), and subsequently the equivalent stress is to be calculated based on the resulting stress components as shown in the example below. $\sigma_L + \sigma_b = \sqrt{(\sigma_{Lx} + \sigma_{bx})^2 - (\sigma_{Lx} + \sigma_{bx})(\sigma_{Ly} + \sigma_{by}) + (\sigma_{Ly} + \sigma_{by})^2 + 3(\tau_{Lxy} + \tau_{bxy})^2}$ (3) Parts of fuel containment systems where loads are primarily carried by bending of girders, stiffeners and plates, are to satisfy the following limit state criteria: $\sigma_{ms} + \sigma_{bp} \leq 1.25F$ (See notes 1,2) $\sigma_{ms} + \sigma_{bp} + \sigma_{bs} \leq 1.25F$ (See note 2) $\sigma_{ms} + \sigma_{bp} + \sigma_{bs} + \sigma_{bt} + \sigma_g \leq 3.0F$ where: σ_{ms} = equivalent section membrane stress in primary structure σ_{bp} = equivalent membrane stress in primary structure and stress in secondary and tertiary structure caused by bending of primary structure σ_{bs} = section bending stress in secondary structure and stress in tertiary structure caused by bending of secondary structure σ_{bt} = section bending stress in tertiary structure σ_g = equivalent secondary stress

<Newly added>

Present	Amendment
<newly added>	$F = \dfrac{R_e}{\gamma_{s2} \cdot \gamma_m \cdot \gamma_c}$ σ_{ms}, σ_{bp}, σ_{bs} and σ_{bt} = defined in (4). Note 1: The sum of equivalent section membrane stress and equivalent membrane stress in primary structure ($\sigma_{ms}+\sigma_{bp}$) will normally be directly available from three-dimensional finite element analyses. Note 2: The coefficient, 1.25, may be modified by the Society considering the design concept, configuration of the structure, and the methodology used for calculation of stresses. Skin plates are to be designed in accordance with the requirements of the Society. When membrane stress is significant, the effect of the membrane stress on the plate bending capacity shall be appropriately considered in addition. (4) Section stress categories (A) Normal stress is the component of stress normal to the plane of reference. (B) Equivalent section membrane stress is the component of the normal stress that is uniformly distributed and equal to the average value of the stress across the cross section of the structure under consideration. If this is a simple shell section, the section membrane stress is identical to the membrane stress defined in (2). (C)Section bending stress is the component of the norm al stress that is linearly distributed over a structural section exposed to bending action, as illustrated in **Fig 1.1**.

Present	Amendment
<newly added>	 **Fig 1.1: Definition of the three categories of section stress (Stresses σ_{bp} and σ_{bs} are normal to the cross section shown.)** 9. The same factors γ_C, γ_m, γ_{si} shall be used for design against buckling unless otherwise stated in the applied recognized buckling standard. In any case the overall level of safety shall not be less than given by these factors. **105. Fatigue limit states** 1. Fatigue design condition as described in **Ch 6, 412. 2** of the Rule shall be complied with as applicable depending on the fuel containment system concept. Fatigue analysis is required for the fuel containment system designed under **Ch 6 416.** and this standard. 2. The load factors for fatigue limit states shall be taken as 1.0 for all load categories. 3. Consequence class factor γ_C and resistance factor γ_R shall be taken as 1.0. 4. Fatigue damage shall be calculated as described in **Ch 6, 412. 2** (2) to (5) of the Rule. The calculated cumulative fatigue damage ratio for the fuel containment systems shall be less than or equal to the values given in **Table 1.3**.

Present	Amendment
<newly added>	**Table 1.3 – Maximum allowable cumulative fatigue damage ratio** | | Consecutive class | | | Consequence class: Low / Medium / High C_W: 1.0 / 0.5 / 0.5* * Lower value shall be used in accordance with **Ch 6, 412. 2** (7) to (9) of the Rule, depending on the detectability of defect or crack, etc. 5. Lower values may be fixed by the Society. 6. Crack propagation analyses are required in accordance with **Ch 6, 412. 2** (6) to (9) of the Rule. The analysis is to be carried out in accordance with methods laid down in Guidelines on Assessment of fatigue and crack propagation for High Manganese Steel developed by the Society. **106. Accident Limit States** 1. Accident design condition as described in **Ch 6, 412. 3** of the Rule is to be complied with as applicable, depending on the fuel containment system concept. 2. Load and resistance factors may be relaxed compared to the ultimate limit state considering that damages and deformations can be accepted as long as this does not escalate the accident scenario. 3. The load factors for accident limit states are to be taken as 1.0 for permanent loads, functional loads and environmental loads. 4. Loads mentioned in **Ch 6, 409. 3** (3) (H) and **5** of th Rule need not be combined with each other or with environmental loads, as defined in **Ch 6, 409. 4** of the Rule. 5. Resistance factor γ_R is to in general be taken as 1.0. 6. Consequence class factors γ_C are to in general be taken as defined in **104. 4** of this standard, but may be relaxed considering the nature of the accident scenario. 7. The characteristic resistance R_k is to in general be taken as for the ultimate limit state, but may be relaxed considering the nature of the accident scenario. 8. Additional relevant accident scenarios are to be determined based on a risk analysis.

<Newly added>

Present	Amendment
<newly added>	**107. Testing** Fuel containment systems designed according to this standard are to be tested to the same extent as described in **Ch 16, Section 2.**, as applicable depending on the fuel containment system concept. <END>.

Amendments for Rules for Classification of Ships Using Low-flashpoint Fuels

(Chapter 5 & 6)

KOREAN REGISTER

Hull Rule Development Team

- Main Amendments -

(1) Effective Date : 1 July 2019 (Date of which contracts for construction are signed)

◉ Chapter 5 & Chapter 6 : correction of documentational error, correction of hierarchy

Present	Amendment
CHAPTER 1 ~ 4 <omitted>	**CHAPTER 1 ~ 4 <omitted>**
CHAPTER 5 SHIP DESIGN AND ARRANGEMENT	**CHAPTER 5 SHIP DESIGN AND ARRANGEMENT**
Section 1 ~ 2 <omitted>	**Section 1 ~ 2 <same as the present>**
Section 3 Arrangement of Fuel Tanks	**Section 3 Arrangement of Fuel Tanks**
301. <omitted>	**301. <same as the present>**
302. Location of fuel tanks	**302. Location of fuel tanks**
1. <omitted>	**1. <same as the present>**
2. <omitted>	**2. <same as the present>**
(1) <omitted>	(1) <same as the present>
(2) <omitted>	(2) <omitted>
f_l is calculated by use of the formulations for factor p contained in **SOLAS II-1/7-1.1.1.1**. <omitted>	f_l = the calculated value by use of the formulations for factor p contained in **SOLAS II-1/7-1.1.1.1**. <omitted>
f_t is calculated by use of the formulations for factor r contained in **SOLAS II-1/7-1.1.2**, and reflects the probability that the damage penetrates beyond the outer boundary of the fuel tank. The formulation is: <omitted>	f_t = the calculated value by use of the formulations for factor r contained in **SOLAS II-1/7-1.1.2**, and reflects the probability that the damage penetrates beyond the outer boundary of the fuel tank. The formulation is: <omitted>
f_v is calculated by use of the formulations for factor v contained in **SOLAS II-1/7-2.6.1.1** and reflects the probability that the damage is not extending vertically above the lowermost boundary of the fuel tank. The formulations to be used are: <omitted>	f_v = the calculated value by use of the formulations for factor v contained in **SOLAS II-1/7-2.6.1.1** and reflects the probability that the damage is not extending vertically above the lowermost boundary of the fuel tank. The formulations to be used are: <omitted>

Present	Amendment
where:	where:
H is the distance from baseline, in metres, to the lowermost boundary of the fuel tank; and	H = the distance from baseline, in metres, to the lowermost boundary of the fuel tank; and
d is the deepest draught (summer load line draught).	d = the deepest draught (summer load line draught).
(3) ~ (8) <omitted>	(3) ~ (8) <same as the present>
3. <omitted>	**3. <same as the present>**
Section 4 Arrangement of Machinery Space	**Section 4 Machinery Space Concepts**
401. Machinery space concepts	**401. Machinery space concepts**
<omitted>	**<same as the present>**
Section 5 <omitted>	**Section 5 <same as the present>**
Section 6 ESD-Protected Machinery Spaces	**Section 6 ESD-Protected Machinery Spaces**
601. ~~Regulations for~~ ESD-protected machinery spaces	**601. ESD-protected machinery spaces**
1. ~ 7. <omitted>	**1. ~ 7. <same as the present>**
Section 7 Arrangement of Other Systems and Spaces	**Section 7 Location and protection of fuel piping**
701. <omitted>	**701. <same as the present>**
Section 8 ~ Section 12 <omitted>	**Section 8 ~ Section 12 <same as the present>**

Present	Amendment
CHAPTER 6 FUEL CONTAINMENT SYSTEM **Section 1 ~ Section 3 <omitted>** **Section 4 Liquefied gas fuel containment** **401. ~ 412. <omitted>** **413. Materials~~ and construction~~** **~~1. Materials~~** (1) Materials forming ship structure (A) <omitted> (a) <omitted> (b) In addition to (a) above, <omitted> (c) <omitted> (d) <omitted> (e) <omitted> (f) <omitted> (g) Credit for hull heating may be taken in accordance with (C), provided the heating arrangements are in compliance with (D). (h) No credit is to be given for any means of heating, except as described in (C). (i) <omitted> (B) <omitted> (C) Means of heating structural materials may be used to ensure that the material temperature does not fall below the minimum allowed for the grade of material specified in **Table 7.5**. In the calculations required in (A), credit for such heating may be taken in accordance with the following principles: (a) <omitted> (b) for longitudinal hull structure referred to in (B) where colder ambient temperatures are specified, provided the material remains suitable for the ambient temperature conditions of plus 5 °C for air and 0 °C for seawater with no credit taken in the calculations for heating; and	**CHAPTER 6 FUEL CONTAINMENT SYSTEM** **Section 1 ~ Section 3 <omitted>** **Section 4 Liquefied gas fuel containment** **401. ~ 412. <omitted>** **413. Materials** **1. Materials forming ship structure** (1) <same as the present> (A) <same as the present> (B) In addition to (A) above, <same as the present> (C) <same as the present> (D) <same as the present> (E) <same as the present> (F) <same as the present> (G) Credit for hull heating may be taken in accordance with (3), provided the heating arrangements are in compliance with (4). (H) No credit is to be given for any means of heating, except as described in (3). (I) <same as the present> (2) <same as the present> (3) Means of heating structural materials may be used to ensure that the material temperature does not fall below the minimum allowed for the grade of material specified in **Table 7.5**. In the calculations required in (1), credit for such heating may be taken in accordance with the following principles: (A) <same as the present> (B) for longitudinal hull structure referred to in (2) where colder ambient temperatures are specified, provided the material remains suitable for the ambient temperature conditions of plus 5 °C for air and 0 °C for seawater with no credit taken in the calculations for heating; and

Present	Amendment
(c) as an alternative to (b) for longitudinal bulkhead between liquefied gas fuel tanks, credit may be taken for heating provided the material remain suitable for a minimum design temperature of minus 30 °C, or a temperature 30 °C lower than that determined by (a) with the heating considered, whichever is less. In this case, the ship's longitudinal strength is to comply with ~~**Pt 3, Ch 3** of~~ **Rules for the classification of steel ships** for both when those bulkhead(s) are considered effective and not.	(C) as an alternative to (2) for longitudinal bulkhead between liquefied gas fuel tanks, credit may be taken for heating provided the material remain suitable for a minimum design temperature of minus 30 °C, or a temperature 30 °C lower than that determined by (1) with the heating considered, whichever is less. In this case, the ship's longitudinal strength is to comply with **Rules for the classification of steel ships** for both when those bulkhead(s) are considered effective and not.
(D) The means of heating referred to in (C) are to comply with the following: (a) <omitted>; (b) the heating system is to be considered as an essential auxiliary. All electrical components of at least one of the systems provided in accordance with (C) (a) are to be supplied from the emergency source of electrical power; and (c) <omitted>	(4) The means of heating referred to in (3) are to comply with the following: (A) <same as the present>; (B) the heating system is to be considered as an essential auxiliary. All electrical components of at least one of the systems provided in accordance with (3) (A) are to be supplied from the emergency source of electrical power; and (C) <same as the present>
2. ~ 3. <omitted>	**2. ~ 3. <same as the present>**
414. <omitted>	**414. <same as the present>**

Present	Amendment
415. Tank types	**415. Tank types**
1. <omitted>	**1. <same as the present>**
2. Type B independent tanks	**2. Type B independent tanks**
(1) ~ (2) <omitted>	(1) ~ (2) <same as the present>
(3) Ultimate design condition	(3) Ultimate design condition
(A) Plastic deformation	(A) Plastic deformation
<omitted>	<omitted>
with R_m and R_e as defined in **412. 1** (1) (C). With regard to the stresses σ_m, σ_L, σ_g and σ_b see also the definition of stress categories in **2** (3) (F).	R_m and R_e = as defined in **412. 1** (1) (C). σ_m, σ_L, σ_g and σ_b = as defined in (7).
The values A, B, C and D are to have at least the following minimum values:	The values A, B, C and D are to have at least the following minimum values:
<omitted>	<omitted>
(B) <omitted>	(B) <same as the present>
(C) Fatigue design condition	(4) Fatigue design condition
(a) Fatigue and crack propagation assessment <omitted>	(A) Fatigue and crack propagation assessment <omitted>
(b) Fatigue analysis is to consider construction tolerances.	(B) Fatigue analysis is to consider construction tolerances.
(c) Where deemed necessary by the Society, <omitted>	(C) Where deemed necessary by the Society, <omitted>
(D) Accidental design condition	(5) Accidental design condition
(a) The tanks and the tank supports <omitted>	(A) The tanks and the tank supports <omitted>
(b) When subjected to the accidental loads <omitted>	(B) When subjected to the accidental loads <omitted>
(E) Marking	(6) Marking
Any marking of the pressure vessel <omitted>	Any marking of the pressure vessel <omitted>
(F) Stress categories	(7) Stress categories
<omitted>	<omitted>
(a) Normal stress <omitted>	(A) Normal stress <omitted>
(b) Membrane stress <omitted>	(B) Membrane stress <omitted>
(c) Bending stress <omitted>	(C) Bending stress <omitted>
(d) Shear stress <omitted>	(D) Shear stress <omitted>
(e) Primary stress <omitted>	(E) Primary stress <omitted>
(f) Primary general membrane stress <omitted>	(F) Primary general membrane stress <omitted>
(g) Primary local membrane stress <omitted>	(G) Primary local membrane stress <omitted>
(h) Secondary stress <omitted>	(H) Secondary stress <omitted>

<table>
<tr><th>Present</th><th>Amendment</th></tr>
<tr><td>

3. Type C independent tanks
(1) Design basis
(A) <omitted>
(B) <omitted>
ρ_r = the relative density of the cargo (ρ_r = 1 for fresh water) at the design temperature.
(2) Shell thickness
(A) ~ (C) <omitted>
(D) <omitted>
Openings in pressure-containing parts of pressure vessels are to be reinforced in accordance with ~~Pt 4, Ch 2 of~~ **Rules for the classification of steel ships**.
(E) <omitted>
(3) Ultimate design condition
(A) Plastic deformation
<omitted>
with R_m and R_e as defined in **412. 1** (1) (C). With regard to the stresses σ_m, σ_L, σ_g and σ_b see also the definition of stress categories in **415. 3** (6).
<omitted>
(B) Buckling ~~criteria is to be as follows:~~
<omitted>
(4) Fatigue design condition
(A) For type C independent tanks where the liquefied gas fuel at atmospheric pressure is below minus 55 °C, the Society may require additional verification to check their compliance with **415. 3** (1), regarding static and dynamic stress depending on the tank size, the configuration of the tank and arrangement of its supports and attachments.
(B) <omitted>
(5) Accidental design condition
(A) <omitted>
(B) When subjected to the accidental loads specified in **409. 5**, the stress is to comply with the acceptance criteria specified in **415. 3** (3) (A), modified as appropriate taking into account their lower probability of occurrence.
(6) <omitted>

</td><td>

3. Type C independent tanks
(1) Design basis
(A) <same as the present>
(B) <omitted>
ρ_r = the relative density of the fuel (ρ_r = 1 for fresh water) at the design temperature.
(2) Shell thickness
(A) ~ (C) <same as the present>
(D) <omitted>
Openings in pressure-containing parts of pressure vessels are to be reinforced in accordance with **Rules for the classification of steel ships**.
(E) <same as the present>
(3) Ultimate design condition
(A) Plastic deformation
<omitted>
R_m and R_e = as defined in **412. 1** (1) (C).
σ_m, σ_L, σ_g and σ_b = as defined in **2** (7).
<omitted>
(B) Buckling
<same as the present>
(4) Fatigue design condition
(A) For type C independent tanks where the liquefied gas fuel at atmospheric pressure is below minus 55 °C, the Society may require additional verification to check their compliance with (1), regarding static and dynamic stress depending on the tank size, the configuration of the tank and arrangement of its supports and attachments.
(B) <same as the present>
(5) Accidental design condition
(A) <same as the present>
(B) When subjected to the accidental loads specified in **409. 5**, the stress is to comply with the acceptance criteria specified in (3) (A), modified as appropriate taking into account their lower probability of occurrence.
(6) <same as the present>

</td></tr>
</table>

Present	Amendment
4. Membrane tanks (1) Design basis (A) ~ (F) <omitted> (G) The circulation of inert gas throughout the primary and the secondary insulation spaces, in accordance with **411. 1** is to be sufficient to allow for effective means of gas detection. (2) Design considerations (A) Potential incidents that could lead to loss of fluid tightness over the life of the membranes are to be evaluated. These include, but are not limited to: (a) ~ (b) <omitted> (c) Accident design events : Designs where a single internal event could cause simultaneous or cascading failure of both membranes are unacceptable. - accidental mechanical damage (such as dropped objects inside the tank while in service); - accidental over pressurization of thermal insulation spaces; - accidental vacuum in the tank; and - water ingress through the inner hull structure. (B) <omitted> (3) ~ (7) <omitted>	**4. Membrane tanks** (1) Design basis (A) ~ (F) <same as the present> (G) The circulation of inert gas throughout the primary and the secondary insulation spaces, in accordance with **1101. 1** is to be sufficient to allow for effective means of gas detection. (2) Design considerations (A) Potential incidents that could lead to loss of fluid tightness over the life of the membranes are to be evaluated. These include, but are not limited to: (a) ~ (b) <same as the present> (c) Accident design events - accidental mechanical damage (such as dropped objects inside the tank while in service); - accidental over pressurization of thermal insulation spaces; - accidental vacuum in the tank; and - water ingress through the inner hull structure. Designs where a single internal event could cause simultaneous or cascading failure of both membranes are unacceptable. (B) <same as the present> (3) ~ (7) <same as the present>
416. <omitted>	**416. <same as the present>**
Section 5 Portable Liquefied Gas Fuel Tanks	**Section 5 Portable Liquefied Gas Fuel Tanks**
501. Portable liquefied gas fuel tanks **1. ~ 9. <omitted>** **10.** After connection to the ship's fuel piping system, (1) with the exception of the pressure relief system in **6** each portable tank is to be capable of being isolated at any time; (2) ~ (3) <omitted>	**501. Portable liquefied gas fuel tanks** **1. ~ 9. <same as the present>** **10.** After connection to the ship's fuel piping system, (1) with the exception of the pressure relief system in **7** each portable tank is to be capable of being isolated at any time; (2) ~ (3) <same as the present>

Present	Amendment
Section 6 <omitted>	**Section 6 <same as the present>**
Section 7 Pressure Relief System	**Section 7 Pressure Relief System**
701. <omitted>	**701. <same as the present>**
702. Pressure relief systems ~~for liquefied gas fuel tanks~~	**702. Pressure relief systems**
1. ~ 2. <omitted>	**1. ~ 2. <same as the present>**
3. Interbarrier spaces are to be provided with pressure relief devices ~~referring to **Pt 7, Ch 5, 802. 1** of **Rules for the classification of steel ships**~~. For membrane systems, the designer is to demonstrate adequate sizing of inter-barrier space PRVs.	**3.** Interbarrier spaces are to be provided with pressure relief devices. For membrane systems, the designer is to demonstrate adequate sizing of inter-barrier space PRVs.
4. ~ 13. <omitted>	**4. ~ 13. <same as the present>**
703. Sizing of pressure relieving system	**703. Sizing of pressure relieving system**
1. <omitted>	**1. <same as the present>**
2. Sizing of vent pipe system (1) <omitted> (2) Upstream pressure losses (A) the pressure drop in the vent line from the tank to the PRV inlet is not to exceed 3 % of the valve set pressure at the calculated flow rate, in accordance with **1** ~~(3)~~ ; (B) ~ (C) <omitted> (3) ~ (4) <omitted>	**2. Sizing of vent pipe system** (1) <same as the present> (2) Upstream pressure losses (A) the pressure drop in the vent line from the tank to the PRV inlet is not to exceed 3 % of the valve set pressure at the calculated flow rate, in accordance with **1** ; (B) ~ (C) <same as the present> (3) ~ (4) <same as the present>
Section 8 ~ Section 9 <omitted>	**Section 8 ~ Section 9 <same as the present>**
Section 10 Atmospheric Control within the Fuel Containment System	**Section 10 Atmosphere Control within the Fuel Containment System**
1001. Atmospheric control within the fuel containment system	**1001. Atmosphere control within the fuel containment system**
1. ~ 4. <same as the present>	**1. ~ 4. <same as the present>**

Amendments for Rules for Classification of Ships Using Low-flashpoint Fuels

KOREAN REGISTER

Machinery Rule Development Team

- Main Amendments -

(1) Effective Date : 1 January 2019 (Date of which contracts for construction are signed)

- ◉ has been newly added application of LPG fuel

(2) Effective Date : 1 January 2019 (Date of the application for Classification Survey is submitted)

- ◉ has been reflected IACS UR Z25 (Rev.1 Sep 2017)

(3) Effective Date : 1 July 2019 (Date of which contracts for construction are signed)

- ◉ has bee reorganized to equal as IGF Code (Ch. 3, Ch 11, Ch 12)

Present	Amendment
CHAPTER 1 GENERAL	**CHAPTER 1 GENERAL**
Section 1 General	**Section 1 General**
101. Application	**101. Application**
1. This Rules applies to ships using low-flashpoint fuels. However, does not apply to the ships specified in the following. (1) Ships carrying liquefied gases in bulk using their cargoes as fuel and complying with the requirements of **Pt 7**, **Ch 5** of **Rules for the classification of steel ships** (2) Ships carrying liquefied gases in bulk using other low-flashpoint gaseous fuels provided that the fuel storage and distribution systems design and arrangements for such gaseous fuels comply with the requirements of **Pt 7**, **Ch 5** of **Rules for the classification of steel ships**	**1.** This Rules applies to ships using low-flashpoint fuels. However, does not apply to the ships specified in the following. (1) Ships carrying liquefied gases in bulk using their cargoes as fuel and complying with the requirements of **Pt 7**, **Ch 5** of **Rules for the classification of steel ships** (2) Ships carrying liquefied gases in bulk using other low-flashpoint gaseous fuels provided that the fuel storage and distribution systems design and arrangements for such gaseous fuels comply with the requirements of **Pt 7**, **Ch 5** of **Rules for the classification of steel ships**
	2. Notwithstanding the requirement specified in **1**, for ships carrying liquefied gases in bulk using LPG cargoes as fuel, **101. 1** of **Annex 2** is to be complied.
2. Notwithstanding the requirement specified in **1**, for the ships specified in the following (1) or (2), some requirements of this Rules may be modified, as appropriate. (1) ships to which **SOLAS II-1** does not apply; or (2) ships which are subjected to Korean Ship Safety Act and Notification having a restricted to domestic service.	**3.** Notwithstanding the requirement specified in **1**, for the ships specified in the following (1) or (2), some requirements of this Rules may be modified, as appropriate. (1) ships to which **SOLAS II-1** does not apply; or (2) ships which are subjected to Korean Ship Safety Act and Notification having a restricted to domestic service.
3. **Ch 5** to **Ch 15** of this Rules applies to ships using natural gas as fuel, either in its liquefied or gaseous state.	**4.** **Ch 5** to **Ch 15** of this Rules applies to ships using natural gas as fuel, either in its liquefied or gaseous state and the requirement of **Annex 2** applies to ships using liquefied or gaseous petroleum gas as fuel.
4. In addition to the requirements in this Rules, they meet other related requirements in **Rules for the classification of steel ships.**	**5.** In addition to the requirements in this Rules, they meet other related requirements in **Rules for the classification of steel ships.**

Present	Amendment
CHAPTER 1 ~ 2 <omitted>	**CHAPTER 1 ~ 2 <same as the present>**
CHAPTER 3 GENERAL REQUIREMENTS	**CHAPTER 3 GENERAL REQUIREMENTS**
Section 1 <omitted>	**Section 1 <same as the present>**
Section 2 Risk Assessment	**Section 2 Risk Assessment**
201. Risk assessment	**201. Risk assessment**
1. ~ 2. <omitted>	**1. ~ 2.** <same as the present>
3. The risks are to be analysed using acceptable and recognized risk analysis techniques, and loss of function, component damage, fire, explosion and electric shock are to as a minimum be considered. The analysis is to ensure that risks are eliminated wherever possible. Risks which cannot be eliminated are to be mitigated as necessary.	**3.** The risks are to be analysed using acceptable and recognized risk analysis techniques, and loss of function, component damage, fire, explosion and electric shock are to as a minimum be considered. The analysis is to ensure that risks are eliminated wherever possible. Risks which cannot be eliminated are to be mitigated as necessary. <u>See **Annex 4** for detailed requirements.</u>
4. <omitted>	**4.** <same as the present>
<u>**202. Limitation of explosion consequences [See Guidance]**</u>	<u>**Section 3 Limitation of explosion consequences**</u> <u>**301. Limitation of explosion consequences [See Guidance]**</u>
<omitted>	<same as the present>

Present	Amendment
CHAPTER 4 CLASSIFICATION AND SURVEYS	**CHAPTER 4 CLASSIFICATION AND SURVEYS**
Section 1 ~ 2 <omitted>	**Section 1 ~ 2 <same as the present>**
Section 3 Periodical Surveys	**Section 3 Periodical Surveys**
301. ~ 302. <omitted>	**301. ~ 302. <same as the present>**
303. Special Survey	**303. Special Survey**
1. ~ 3. <omitted>	**1. ~ 3. <same as the present>**
4. Pressure Relief Valves	**4. Pressure Relief Valves**
(1) <omitted> (2) Fuel Supply and Bunkering Piping Pressure Relief Valves A random selection of pressure relief valves for the fuel supply and bunkering piping are to be opened for examination, adjusted, and function tested. <hereafter, omitted>	(1) <omitted> (2) Fuel Supply and Bunkering Piping Pressure Relief Valves ~~A random selection of~~ Pressure relief valves for the fuel supply and bunkering piping are to be opened for examination, adjusted, and function tested. <hereafter, same as the present>

Amendments for Rules for Classification of Ships Using Low-flashpoint Fuels

(Except Chapter 5 & 6)

KOREAN REGISTER

Machinery Rule Development Team

- Main Amendments -

(1) Effective Date : 1 January 2019 (Date of which contracts for construction are signed)

◉ has been newly added application of LPG fuel

(2) Effective Date : 1 January 2019 (Date of the application for Classification Survey is submitted)

◉ has been reflected IACS UR Z25 (Rev.1 Sep 2017)

(3) Effective Date : 1 July 2019 (Date of which contracts for construction are signed)

◉ has bee reorganized to equal as IGF Code (Ch. 3, Ch 11, Ch 12)

Present	Amendment
CHAPTER 1 GENERAL	**CHAPTER 1 GENERAL**
Section 1 General	**Section 1 General**
101. Application	**101. Application**
1. This Rules applies to ships using low-flashpoint fuels. However, does not apply to the ships specified in the following. (1) Ships carrying liquefied gases in bulk using their cargoes as fuel and complying with the requirements of **Pt 7**, **Ch 5** of **Rules for the classification of steel ships** (2) Ships carrying liquefied gases in bulk using other low-flash-point gaseous fuels provided that the fuel storage and distribution systems design and arrangements for such gaseous fuels comply with the requirements of **Pt 7**, **Ch 5** of **Rules for the classification of steel ships**	**1.** This Rules applies to ships using low-flashpoint fuels. However, does not apply to the ships specified in the following. (1) Ships carrying liquefied gases in bulk using their cargoes as fuel and complying with the requirements of **Pt 7**, **Ch 5** of **Rules for the classification of steel ships** (2) Ships carrying liquefied gases in bulk using other low-flash-point gaseous fuels provided that the fuel storage and distribution systems design and arrangements for such gaseous fuels comply with the requirements of **Pt 7**, **Ch 5** of **Rules for the classification of steel ships**
	2. Notwithstanding the requirement specified in **1**, for ships carrying liquefied gases in bulk using LPG cargoes as fuel, **101. 1** of **Annex 2** is to be complied.
2. Notwithstanding the requirement specified in **1**, for the ships specified in the following (1) or (2), some requirements of this Rules may be modified, as appropriate. (1) ships to which **SOLAS II-1** does not apply; or (2) ships which are subjected to Korean Ship Safety Act and Notification having a restricted to domestic service.	**3.** Notwithstanding the requirement specified in **1**, for the ships specified in the following (1) or (2), some requirements of this Rules may be modified, as appropriate. (1) ships to which **SOLAS II-1** does not apply; or (2) ships which are subjected to Korean Ship Safety Act and Notification having a restricted to domestic service.
3. **Ch 5** to **Ch 15** of this Rules applies to ships using natural gas as fuel, either in its liquefied or gaseous state.	**4.** **Ch 5** to **Ch 15** of this Rules applies to ships using natural gas as fuel, either in its liquefied or gaseous state and the requirement of **Annex 2** applies to ships using liquefied or gaseous petroleum gas as fuel.
4. In addition to the requirements in this Rules, they meet other related requirements in **Rules for the classification of steel ships.**	**5.** In addition to the requirements in this Rules, they meet other related requirements in **Rules for the classification of steel ships.**

Present	Amendment
CHAPTER 3 GENERAL REQUIREMENTS	**CHAPTER 3 GENERAL REQUIREMENTS**
Section 1 <omitted>	**Section 1 <same as the present>**
Section 2 Risk Assessment	**Section 2 Risk Assessment**
201. Risk assessment	**201. Risk assessment**
1. ~ 2. <omitted>	**1. ~ 2.** <same as the present>
3. The risks are to be analysed using acceptable and recognized risk analysis techniques, and loss of function, component damage, fire, explosion and electric shock are to as a minimum be considered. The analysis is to ensure that risks are eliminated wherever possible. Risks which cannot be eliminated are to be mitigated as necessary.	**3.** The risks are to be analysed using acceptable and recognized risk analysis techniques, and loss of function, component damage, fire, explosion and electric shock are to as a minimum be considered. The analysis is to ensure that risks are eliminated wherever possible. Risks which cannot be eliminated are to be mitigated as necessary. See **Annex 4** for detailed requirements.
4. <omitted>	**4.** <same as the present>
	Section 3 Limitation of explosion consequences
202. Limitation of explosion consequences 【See Guidance】	**301. Limitation of explosion consequences** 【See Guidance】
<omitted>	<same as the present>

Present	Amendment
CHAPTER 4 CLASSIFICATION AND SURVEYS	**CHAPTER 4 CLASSIFICATION AND SURVEYS**
Section 1 ~ 2 <omitted>	**Section 1 ~ 2 <same as the present>**
Section 3 Periodical Surveys	**Section 3 Periodical Surveys**
301. ~ 302. <omitted>	**301. ~ 302. <same as the present>**
303. Special Survey	**303. Special Survey**
1. ~ 3. <omitted>	**1. ~ 3. <same as the present>**
4. Pressure Relief Valves	**4. Pressure Relief Valves**
(1) <omitted> (2) Fuel Supply and Bunkering Piping Pressure Relief Valves A random selection of pressure relief valves for the fuel supply and bunkering piping are to be opened for examination, adjusted, and function tested. <hereafter, omitted>	(1) <omitted> (2) Fuel Supply and Bunkering Piping Pressure Relief Valves ~~A random selection of~~ Pressure relief valves for the fuel supply and bunkering piping are to be opened for examination, adjusted, and function tested. <hereafter, same as the present>

Amendments for Rules for Classification of Ships Using Low-flashpoint Fuels

(Chapter 5 & 6)

KOREAN REGISTER

Hull Rule Development Team

- Main Amendments -

(1) Effective Date : 1 July 2019 (Date of which contracts for construction are signed)

◉ Chapter 5 & Chapter 6 : correction of documentational error, correction of hierarchy

Present	Amendment
CHAPTER 1 ~ 4 <omitted>	**CHAPTER 1 ~ 4 <omitted>**
CHAPTER 5 SHIP DESIGN AND ARRANGEMENT	**CHAPTER 5 SHIP DESIGN AND ARRANGEMENT**
Section 1 ~ 2 <omitted>	**Section 1 ~ 2 <same as the present>**
Section 3 Arrangement of Fuel Tanks	**Section 3 Arrangement of Fuel Tanks**
301. <omitted>	**301. <same as the present>**
302. Location of fuel tanks	**302. Location of fuel tanks**
1. <omitted>	**1. <same as the present>**
2. <omitted>	**2. <same as the present>**
(1) <omitted>	(1) <same as the present>
(2) <omitted>	(2) <omitted>
f_l is calculated by use of the formulations for factor p contained in **SOLAS II-1/7-1.1.1.1**. <omitted>	f_l = the calculated value by use of the formulations for factor p contained in **SOLAS II-1/7-1.1.1.1**. <omitted>
f_t is calculated by use of the formulations for factor r contained in **SOLAS II-1/7-1.1.2**, and reflects the probability that the damage penetrates beyond the outer boundary of the fuel tank. The formulation is: <omitted>	f_t = the calculated value by use of the formulations for factor r contained in **SOLAS II-1/7-1.1.2**, and reflects the probability that the damage penetrates beyond the outer boundary of the fuel tank. The formulation is: <omitted>
f_v is calculated by use of the formulations for factor v contained in **SOLAS II-1/7-2.6.1.1** and reflects the probability that the damage is not extending vertically above the lowermost boundary of the fuel tank. The formulations to be used are: <omitted>	f_v = the calculated value by use of the formulations for factor v contained in **SOLAS II-1/7-2.6.1.1** and reflects the probability that the damage is not extending vertically above the lowermost boundary of the fuel tank. The formulations to be used are: <omitted>

Present	Amendment
where: H is the distance from baseline, in metres, to the lowermost boundary of the fuel tank; and d is the deepest draught (summer load line draught).	where: H = the distance from baseline, in metres, to the lowermost boundary of the fuel tank; and d = the deepest draught (summer load line draught).
(3) ~ (8) <omitted>	(3) ~ (8) <same as the present>
3. <omitted>	**3. <same as the present>**
Section 4 Arrangement of Machinery Space	**Section 4 Machinery Space Concepts**
401. Machinery space concepts	**401. Machinery space concepts**
<omitted>	**<same as the present>**
Section 5 <omitted>	**Section 5 <same as the present>**
Section 6 ESD-Protected Machinery Spaces	**Section 6 ESD-Protected Machinery Spaces**
601. ~~Regulations for~~ ESD-protected machinery spaces	**601. ESD-protected machinery spaces**
1. ~ 7. <omitted>	**1. ~ 7. <same as the present>**
Section 7 Arrangement of Other Systems and Spaces	**Section 7 Location and protection of fuel piping**
701. <omitted>	**701. <same as the present>**
Section 8 ~ Section 12 <omitted>	**Section 8 ~ Section 12 <same as the present>**

Present	Amendment
CHAPTER 6 FUEL CONTAINMENT SYSTEM	**CHAPTER 6 FUEL CONTAINMENT SYSTEM**
Section 1 ~ Section 3 <omitted>	**Section 1 ~ Section 3 <omitted>**
Section 4 Liquefied gas fuel containment	**Section 4 Liquefied gas fuel containment**
401. ~ 412. <omitted>	**401. ~ 412. <omitted>**
413. Materials ~~and construction~~	**413. Materials**
~~1. Materials~~ (1) Materials forming ship structure (A) <omitted> (a) <omitted> (b) In addition to (a) above, <omitted> (c) <omitted> (d) <omitted> (e) <omitted> (f) <omitted> (g) Credit for hull heating may be taken in accordance with (C), provided the heating arrangements are in compliance with (D). (h) No credit is to be given for any means of heating, except as described in (C). (i) <omitted> (B) <omitted> (C) Means of heating structural materials may be used to ensure that the material temperature does not fall below the minimum allowed for the grade of material specified in **Table 7.5**. In the calculations required in (A), credit for such heating may be taken in accordance with the following principles: (a) <omitted> (b) for longitudinal hull structure referred to in (B) where colder ambient temperatures are specified, provided the material remains suitable for the ambient temperature conditions of plus 5 °C for air and 0 °C for seawater with no credit taken in the calculations for heating; and	**1. Materials forming ship structure** (1) <same as the present> (A) <same as the present> (B) In addition to (A) above, <same as the present> (C) <same as the present> (D) <same as the present> (E) <same as the present> (F) <same as the present> (G) Credit for hull heating may be taken in accordance with (3), provided the heating arrangements are in compliance with (4). (H) No credit is to be given for any means of heating, except as described in (3). (I) <same as the present> (2) <same as the present> (3) Means of heating structural materials may be used to ensure that the material temperature does not fall below the minimum allowed for the grade of material specified in **Table 7.5**. In the calculations required in (1), credit for such heating may be taken in accordance with the following principles: (A) <same as the present> (B) for longitudinal hull structure referred to in (2) where colder ambient temperatures are specified, provided the material remains suitable for the ambient temperature conditions of plus 5 °C for air and 0 °C for seawater with no credit taken in the calculations for heating; and

Present	Amendment
(c) as an alternative to (b) for longitudinal bulkhead between liquefied gas fuel tanks, credit may be taken for heating provided the material remain suitable for a minimum design temperature of minus 30 °C, or a temperature 30 °C lower than that determined by (a) with the heating considered, whichever is less. In this case, the ship's longitudinal strength is to comply with ~~**Pt 3, Ch 3** of~~ **Rules for the classification of steel ships** for both when those bulkhead(s) are considered effective and not.	(C) as an alternative to (2) for longitudinal bulkhead between liquefied gas fuel tanks, credit may be taken for heating provided the material remain suitable for a minimum design temperature of minus 30 °C, or a temperature 30 °C lower than that determined by (1) with the heating considered, whichever is less. In this case, the ship's longitudinal strength is to comply with **Rules for the classification of steel ships** for both when those bulkhead(s) are considered effective and not.
(D) The means of heating referred to in (C) are to comply with the following:	(4) The means of heating referred to in (3) are to comply with the following:
(a) <omitted>;	(A) <same as the present>;
(b) the heating system is to be considered as an essential auxiliary. All electrical components of at least one of the systems provided in accordance with (C) (a) are to be supplied from the emergency source of electrical power; and	(B) the heating system is to be considered as an essential auxiliary. All electrical components of at least one of the systems provided in accordance with (3) (A) are to be supplied from the emergency source of electrical power; and
(c) <omitted>	(C) <same as the present>
2. ~ 3. <omitted>	**2. ~ 3. <same as the present>**
414. <omitted>	**414. <same as the present>**

Present	Amendment
415. Tank types	**415. Tank types**
1. <omitted>	**1. <same as the present>**
2. Type B independent tanks	**2. Type B independent tanks**
(1) ~ (2) <omitted>	(1) ~ (2) <same as the present>
(3) Ultimate design condition	(3) Ultimate design condition
(A) Plastic deformation	(A) Plastic deformation
<omitted>	<omitted>
with R_m and R_e as defined in **412. 1** (1) (C). With regard to the stresses σ_m, σ_L, σ_g and σ_b see also the definition of stress categories in **2** (3) (F).	R_m and R_e = as defined in **412. 1** (1) (C). σ_m, σ_L, σ_g and σ_b = as defined in (7).
The values A, B, C and D are to have at least the following minimum values: <omitted>	The values A, B, C and D are to have at least the following minimum values: <omitted>
(B) <omitted>	(B) <same as the present>
(C) Fatigue design condition	(4) Fatigue design condition
(a) Fatigue and crack propagation assessment <omitted>	(A) Fatigue and crack propagation assessment <omitted>
(b) Fatigue analysis is to consider construction tolerances.	(B) Fatigue analysis is to consider construction tolerances.
(c) Where deemed necessary by the Society, <omitted>	(C) Where deemed necessary by the Society, <omitted>
(D) Accidental design condition	(5) Accidental design condition
(a) The tanks and the tank supports <omitted>	(A) The tanks and the tank supports <omitted>
(b) When subjected to the accidental loads <omitted>	(B) When subjected to the accidental loads <omitted>
(E) Marking	(6) Marking
Any marking of the pressure vessel <omitted>	Any marking of the pressure vessel <omitted>
(F) Stress categories	(7) Stress categories
<omitted>	<omitted>
(a) Normal stress <omitted>	(A) Normal stress <omitted>
(b) Membrane stress <omitted>	(B) Membrane stress <omitted>
(c) Bending stress <omitted>	(C) Bending stress <omitted>
(d) Shear stress <omitted>	(D) Shear stress <omitted>
(e) Primary stress <omitted>	(E) Primary stress <omitted>
(f) Primary general membrane stress <omitted>	(F) Primary general membrane stress <omitted>
(g) Primary local membrane stress <omitted>	(G) Primary local membrane stress <omitted>
(h) Secondary stress <omitted>	(H) Secondary stress <omitted>

Present	Amendment
3. Type C independent tanks	**3. Type C independent tanks**
(1) Design basis (A) <omitted> (B) <omitted> ρ_r = the relative density of the cargo (ρ_r = 1 for fresh water) at the design temperature.	(1) Design basis (A) <same as the present> (B) <omitted> ρ_r = the relative density of the fuel (ρ_r = 1 for fresh water) at the design temperature.
(2) Shell thickness (A) ~ (C) <omitted> (D) <omitted> Openings in pressure-containing parts of pressure vessels are to be reinforced in accordance with ~~**Pt 4, Ch 2** of~~ **Rules for the classification of steel ships**. (E) <omitted>	(2) Shell thickness (A) ~ (C) <same as the present> (D) <omitted> Openings in pressure-containing parts of pressure vessels are to be reinforced in accordance with **Rules for the classification of steel ships**. (E) <same as the present>
(3) Ultimate design condition (A) Plastic deformation <omitted> with R_m and R_e as defined in **412. 1** (1) (C). With regard to the stresses σ_m, σ_L, σ_g and σ_b see also the definition of stress categories in **415. 3** (6). <omitted> (B) Buckling ~~criteria is to be as follows:~~ <omitted>	(3) Ultimate design condition (A) Plastic deformation <omitted> R_m and R_e = as defined in **412. 1** (1) (C). σ_m, σ_L, σ_g and σ_b = as defined in **2** (7). <omitted> (B) Buckling <same as the present>
(4) Fatigue design condition (A) For type C independent tanks where the liquefied gas fuel at atmospheric pressure is below minus 55 °C, the Society may require additional verification to check their compliance with **415. 3** (1), regarding static and dynamic stress depending on the tank size, the configuration of the tank and arrangement of its supports and attachments. (B) <omitted>	(4) Fatigue design condition (A) For type C independent tanks where the liquefied gas fuel at atmospheric pressure is below minus 55 °C, the Society may require additional verification to check their compliance with (1), regarding static and dynamic stress depending on the tank size, the configuration of the tank and arrangement of its supports and attachments. (B) <same as the present>
(5) Accidental design condition (A) <omitted> (B) When subjected to the accidental loads specified in **409. 5**, the stress is to comply with the acceptance criteria specified in **415. 3** (3) (A), modified as appropriate taking into account their lower probability of occurrence. (6) <omitted>	(5) Accidental design condition (A) <same as the present> (B) When subjected to the accidental loads specified in **409. 5**, the stress is to comply with the acceptance criteria specified in (3) (A), modified as appropriate taking into account their lower probability of occurrence. (6) <same as the present>

Present	Amendment
4. Membrane tanks	**4. Membrane tanks**
(1) Design basis	(1) Design basis
(A) ~ (F) <omitted>	(A) ~ (F) <same as the present>
(G) The circulation of inert gas throughout the primary and the secondary insulation spaces, in accordance with **411. 1** is to be sufficient to allow for effective means of gas detection.	(G) The circulation of inert gas throughout the primary and the secondary insulation spaces, in accordance with **1101. 1** is to be sufficient to allow for effective means of gas detection.
(2) Design considerations	(2) Design considerations
(A) Potential incidents that could lead to loss of fluid tightness over the life of the membranes are to be evaluated. These include, but are not limited to:	(A) Potential incidents that could lead to loss of fluid tightness over the life of the membranes are to be evaluated. These include, but are not limited to:
(a) ~ (b) <omitted>	(a) ~ (b) <same as the present>
(c) Accident design events : Designs where a single internal event could cause simultaneous or cascading failure of both membranes are unacceptable.	(c) Accident design events
- accidental mechanical damage (such as dropped objects inside the tank while in service);	- accidental mechanical damage (such as dropped objects inside the tank while in service);
- accidental over pressurization of thermal insulation spaces;	- accidental over pressurization of thermal insulation spaces;
- accidental vacuum in the tank; and	- accidental vacuum in the tank; and
- water ingress through the inner hull structure.	- water ingress through the inner hull structure.
	Designs where a single internal event could cause simultaneous or cascading failure of both membranes are unacceptable.
(B) <omitted>	(B) <same as the present>
(3) ~ (7) <omitted>	(3) ~ (7) <same as the present>
416. <omitted>	**416. <same as the present>**
Section 5 Portable Liquefied Gas Fuel Tanks	**Section 5 Portable Liquefied Gas Fuel Tanks**
501. Portable liquefied gas fuel tanks	**501. Portable liquefied gas fuel tanks**
1. ~ 9. <omitted>	**1. ~ 9. <same as the present>**
10. After connection to the ship's fuel piping system,	**10.** After connection to the ship's fuel piping system,
(1) with the exception of the pressure relief system in **6** each portable tank is to be capable of being isolated at any time;	(1) with the exception of the pressure relief system in **7** each portable tank is to be capable of being isolated at any time;
(2) ~ (3) <omitted>	(2) ~ (3) <same as the present>

Present	Amendment
Section 6 <omitted>	**Section 6 <same as the present>**
Section 7 Pressure Relief System	**Section 7 Pressure Relief System**
701. <omitted>	**701. <same as the present>**
702. Pressure relief systems ~~for liquefied gas fuel tanks~~	**702. Pressure relief systems**
1. ~ 2. <omitted>	**1. ~ 2. <same as the present>**
3. Interbarrier spaces are to be provided with pressure relief devices ~~referring to **Pt 7, Ch 5, 802. 1** of **Rules for the classification of steel ships**~~. For membrane systems, the designer is to demonstrate adequate sizing of inter-barrier space PRVs.	**3.** Interbarrier spaces are to be provided with pressure relief devices. For membrane systems, the designer is to demonstrate adequate sizing of inter-barrier space PRVs.
4. ~ 13. <omitted>	**4. ~ 13. <same as the present>**
703. Sizing of pressure relieving system	**703. Sizing of pressure relieving system**
1. <omitted>	**1. <same as the present>**
2. Sizing of vent pipe system	**2. Sizing of vent pipe system**
(1) <omitted> (2) Upstream pressure losses (A) the pressure drop in the vent line from the tank to the PRV inlet is not to exceed 3 % of the valve set pressure at the calculated flow rate, in accordance with **1** ~~(3)~~ ; (B) ~ (C) <omitted> (3) ~ (4) <omitted>	(1) <same as the present> (2) Upstream pressure losses (A) the pressure drop in the vent line from the tank to the PRV inlet is not to exceed 3 % of the valve set pressure at the calculated flow rate, in accordance with **1** ; (B) ~ (C) <same as the present> (3) ~ (4) <same as the present>
Section 8 ~ Section 9 <omitted>	**Section 8 ~ Section 9 <same as the present>**
Section 10 Atmospheric Control within the Fuel Containment System	**Section 10 Atmosphere Control within the Fuel Containment System**
1001. Atmospheric control within the fuel containment system	**1001. Atmosphere control within the fuel containment system**
1. ~ 4. <same as the present>	**1. ~ 4. <same as the present>**