BUREAU VERITAS MARINE & OFFSHORE

RULE NOTE

GAS-FUELLED SHIPS

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These rules are provided within the scope of the Bureau Veritas Marine & Offshore General Conditions, enclosed at the end of Part A of NR467, Rules for the Classification of Steel Ships. The latest version of these General Conditions is available on the Bureau Veritas Marine & Offshore website.

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Rule Note
NR529

GAS-FUELLED SHIPS

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January 2026

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CHAPTER 1
GENERAL

Section 1	Application
Section 2	Risk Assessment
Section 3	Functional requirements
Appendix 1	Correspondence between Current Edition of this Rule Note, IMO IGF Code and Former Revision of NR529

Section 1 Application

1 General

1.1 Scope

1.1.1 This Rule Note applies to ships, other than liquefied gas carriers, using:

- liquefied natural gas (LNG), or
- compressed natural gas (CNG), or
- gas other than methane, liquefied petroleum gas (LPG), ammonia or hydrogen, or
- other low-flashpoint fuel other than methyl/ethyl alcohol,

as fuel either as single fuel or together with oil fuel.

In accordance with NR467, Pt A, Ch 1, Sec 2, [6.17], such ships are to be assigned the additional class notations **LNGfuel**, **CNGfuel** or **LFPfuel** as defined in [1.2.1] or [1.2.2].

Note 1: Ships using LPG, ammonia, hydrogen or methyl/ethyl alcohol as fuel are covered by other specific Rule Notes published by the Society.

1.1.2 This Rule Note also applies to ships prepared to use LNG as fuel.

In accordance with NR467, Pt A, Ch 1, Sec 2, [6.17], such ships may be assigned the additional class notation **LNGFUEL-PREPARED,** as defined in [1.2.5].

1.1.3 This Rule Note provides requirements for the arrangement, installation, control and monitoring of machinery, equipment and systems using low-flashpoint fuel to minimize the risk to the ship, its crew and the environment, having regard to the nature of the fuel involved.

1.1.4 This Rule Note covers the gas-fuel related installations of the ship. It covers the bunkering system only as far as it is part of the ship.

1.1.5 This Rule Note does not apply to ships having the service notation **liquefied gas carrier**.

1.2 Classification

1.2.1 LNG or CNG-fuelled ships

In accordance with [1.1.1], ships, other than liquefied gas carriers, using liquefied or compressed natural gas as fuel either as single fuel or together with oil fuel, that are designed and built in accordance with the requirements of this Rule Note, are to be assigned the additional class notations **LNGfuel** or **CNGfuel**. These additional class notations are completed, as applicable, by the notations defined in [1.2.3].

For ship fitted with fuel cells the additional requirements of [1.2.4] are to be considered.

1.2.2 Ships using other gases or low-flashpoint fuel

In accordance with [1.1.1], ships, other than liquefied gas carriers, using:

- gases as fuel, other than methane, LPG, hydrogen or ammonia, or
- other low-flashpoint fuel other than methyl alcohol or ethyl alcohol,

and which have been specially considered by the Society for compliance with Chapter 1, taking into account the provisions of NR467, Pt A, Ch 1, Sec 1, [2.2] for equivalence, and designed and built in accordance with the relevant requirements of this Rule Note, are to be assigned the additional class notation **LFPfuel**. This additional class notation is completed, as applicable, by the notations defined in [1.2.3].

For ship fitted with fuel cells the additional requirements of [1.2.4] are to be considered.

1.2.3 The additional class notations defined in [1.2.1] or [1.2.2] are to be completed by one of the following notations:

singlefuel for ships fitted with engines, fuel cells or gas turbines using only the fuel considered

dualfuel for ships fitted with engines or gas turbines using both the fuel considered and fuel oil.

The notations **singlefuel** and **dualfuel** may be completed by:

-aux, when the ship uses the fuel considered only for the generating set

-prop, when the ship uses the fuel considered only for the propulsion system.

Examples:

CNGfuel singlefuel -prop

LNGfuel dualfuel

LFPfuel dualfuel -aux

1.2.4 Ships fitted with fuel cells

In addition to the requirements of [1.2.1] to [1.2.3], gas-fuelled ships fitted with fuel cells using natural gas, other gas or low-flashpoint liquid as fuel are to comply with the requirements of NR547 “Ships using fuel cells” and are to be assigned the additional class notation **fuelcell** to complete the additional class notation **LNGfuel**, **CNGfuel**, or **LFPfuel**.

1.2.5 LNG fuel prepared ships

New ships that are designed to accommodate the future installation of an LNG fuel system at a later stage and complying with the requirements of Chapter 10 may be assigned the additional class notation **LNGFUEL-PREPARED** completed, as applicable, by notations **S**, **A**, **P**, **ME-DF**, **AE**, **B**, as defined in Ch 10, Sec 1, [1.1.1] and Ch 10, Sec 1, [1.1.2].

When the ship is effectively converted to operate on LNG fuel, the additional class notation **LNGFUEL-PREPARED** will be replaced by the additional class notation **LNGfuel dualfuel**, provided that the requirements of Ch 10, Sec 1, [1.1.3] are fulfilled.

2 Reference documents

2.1 References to International Maritime Organisation (IMO) IGF Code

2.1.1 IMO IGF Code

IMO IGF Code means the International Code of Safety for Ship Using Gases or Other Low-flashpoint Fuels, as adopted by IMO Resolution MSC.391(95) as amended by:

- IMO Resolution MSC.422(98)
- IMO Resolution MSC.458(101)
- IMO Resolution MSC.475(102)
- IMO Resolution MSC.551(108).

2.1.2 IMO IGF Code requirements and the Society’s Rules

The requirements of the present Rule Note include:

- provisions of IMO IGF Code applicable for the purpose of Classification, printed in italic type.
- functional requirements from IMO IGF Code, printed in italic type. These functional requirements are reproduced for ease of reference.
- additional Society's requirements.

In reproducing such IMO IGF Code text in this Rule Note, the word “Administration”, wherever mentioned, has been replaced by the word “Society”.

The correspondence between the references of IMO IGF Code, the previous version of the NR529 and the present Rule Note is provided in App 1.

2.1.3 IMO IGF Code requirements not within the scope of classification

The following requirements of the IMO IGF Code are not within the scope of classification:

- Part C-1, 17 - Drills and emergency exercises
- Part C-1, 18 - Operation
- Part D, 19 - Training

2.2 References to Society’s Rules for Classification and Rule Notes

2.2.1 The following references to BV Rules and Rule Notes are used in this Rule Note:

- NR467 Rules for the classification of steel ships
- NR216 Rules on materials and welding for the classification of marine units
- NR320 Certification scheme of materials and equipment for the classification of marine units
- NR480 Approval of the manufacturing process of metallic materials
- NR598 Safe Return to port and orderly evacuation
- NR620 Bunkering ships
- NR669 Requirements for non-destructive testing suppliers.

3 Equivalence

3.1 General

3.1.1 Appliances and arrangements of low-flashpoint fuel systems may deviate from those set out in this Rule Note, provided that these meet the intent of the goal and functional requirements concerned, taking into account the provisions of NR467, Pt A, Ch 1, Sec 1, [2.2] for equivalence.

4 Documents to be submitted

4.1 General

4.1.1 The documents listed in Tab 1 are to be submitted for ships to be assigned the additional class notations **LNGfuel**, **CNGfuel** or **LFPfuel**.

Table 1 : Documents to be submitted

No.	A/I **(1)**	Document	Particulars
1	A	Fuel installation general arrangement	General arrangements showing the location of the bunkering stations, gas tanks, TCS, fuel preparation rooms, vent masts, etc
2	A	General arrangement of the machinery spaces	Containing the gas consumers (engines, gas turbines, boilers and gas combustion units)
3	A	Hazardous area plan	
4	A	Airlocks between safe and hazardous area spaces	
5	I	Risk assessment and follow-up report of the recommendations	See Sec 2
6	A	Leakage scenario and TCS leakage containment analysis	As required by Ch 3, Sec 1, [2.1.5]
7	A	Details of hull structure in way of liquefied gas fuel containment system and relative stress analysis	Including support arrangement for tanks, saddles, anti-floating and anti-lifting devices, deck sealing arrangements, etc.
8	A	Calculation of the hull temperature and associated distribution of quality and steel grades	
9	A	Scantlings, material and arrangement of the fuel containment system	Including the secondary barrier, if any
10	A	Hull ship motion analysis	Where a direct analysis is preferred to the methods indicated in Chapter 3
11	A	Sloshing calculation where relevant	
12	A	Stress analysis of the fuel containment	Including fatigue analysis and crack propagation analysis for type “B” tanks
13	A	Details of ladders, fittings, swash bulkheads and towers in tanks and relative stress analysis, if any	
14	A	Details of tank domes and deck sealings	
15	A	Fuel containment system testing and inspection procedures	
16	A	Inspection/survey plan for the liquefied gas fuel containment system	As requested in Ch 3, Sec 2, [1.1.8]
17	A	Vent mast detailed drawing	
18	A	Calculation of the thermal insulation suitability	Including boil-off rate and refrigeration plant capability, if any, cooling down and temperature gradients during loading and unloading operations
19	A	Gas fuel tank pressure control philosophy	
20	A	Details of insulation	
21	A	Plans and calculations of safety relief valves	
22	A	Diagram of the liquefied and gaseous fuel gas piping system	Including venting system
23	A	Arrangement of the double piping or duct system	
24	A	Specification of the control, monitoring and safety systems for the gas installation	Cause and effect matrix

(1) A: To be submitted for approval; I: To be submitted for information

No.	A/I **(1)**	Document	Particulars
25	A	Stress analysis of the piping system	When their design temperature is –110°C or lower
26	A	Material, thickness and joints of the gas pipes	
27	A	Diagram of the inert gas piping system	
28	A	Ventilation systems in hazardous area spaces and spaces containing gas piping	Including ventilation duct arrangement in adjacent zones
29	A	Diagram of the gas detection system	
30	A	Diagram of heating media system	
31	A	Details of gas fuel pumps and compressors	
32	I	Documents and information related to the operation of gas fuel pumps and compressors under static and dynamic conditions and shipboard accelerations	See Ch 5, Sec 2, [5.1.3]
33	A	Details of process pressure vessels and relative valving arrangement	
34	A	Bilge system of the spaces related to fuel gas storage and preparation	
35	A	Hull structure heating system, if any	
36	A	Emergency shutdown system	
37	A	Fuel containment system instrumentation	Including fuel temperature monitoring system
38	A	Interbarrier space drainage, inerting and pressurisation systems if fitted	
39	A	Details of fire-extinguishing appliances and systems related to the gas installation	• Water spray system when required • Dry chemical powder • Fire Main
40	I	Specification and type-approval reference of the gas consumers	
41	A	Diagram of the gas fuel supply systems, for each gas consumer	
42	A	Arrangement of the GVUs	
43	A	Diagram of the fuel oil system	Including pilot fuel supply
44	A	Diagram of the engine lubricating oil system	
45	A	Diagram of the engine cooling system	
46	A	Diagram of the engine crankcase venting systems	
47	A	Drawings of the boilers	Including burners
48	A	Drawing of the exhaust gas ducts	
49	A	Specification of the control, monitoring and safety systems for each gas consumer	
50	A	Instrumentation list	
51	I	List of electrical equipment located in hazardous areas and respective safety certificates	
52	A	Details of electrical bonding of fuel tanks and piping	
53	A	Schematic electrical wiring diagram in hazardous areas	
54	A	Arrangement of electrical installation in hazardous areas	Including lighting system
55	I	Fuel containment system gas freeing procedure	Including emptying, inerting and aerating
56	I	Procedure for maintenance of the gas utilization units and other gas-related equipment	Including the steps to be taken prior to servicing the units
57	I	Stress analysis of the high pressure piping systems	
58	A	Fuel tank filling limits	
59	A	Bunkering procedure	
60	A	Programme of gas trials	
(1) A: To be submitted for approval; I: To be submitted for information			

5 Definitions

5.1 General

5.1.1 *Unless otherwise stated below, definitions are as defined in NR467, Part C, Chapter 4.*

5.1.2 Accident

Accident means an uncontrolled event that may entail the loss of human life, personal injuries, environmental damage or the loss of assets and financial interests.

5.1.3 Breadth (B)

Breadth (B) means the greatest moulded breadth of the ship at or below the deepest draught (summer load line draught) (refer to SOLAS regulation II-1/2.8).

5.1.4 Bunkering

Bunkering means the transfer of liquid or gaseous fuel from land based or floating facilities into a ships' permanent tanks or connection of portable tanks to the fuel supply system

Bunkering also covers the transfer of fuel vapour from the ship's tank to the bunkering facilities.

5.1.5 Certified safe type

Certified safe type means electrical equipment that is certified safe by the relevant authorities recognized by the Society for operation in a flammable atmosphere based on a recognized standard.

Note 1: Refer to IEC 60079 series, Explosive atmospheres and IEC 60092-502:1999 Electrical Installations in Ships – Tankers – Special Features.

5.1.6 CNG

CNG means compressed natural gas (see also [5.1.33]).

5.1.7 Control station

Control station means those spaces defined in SOLAS chapter II-2 and additionally for this Rule Note, the engine control room.

5.1.8 Design temperature for selection of materials

Design temperature for selection of materials is the minimum temperature at which liquefied gas fuel may be loaded or transported in the liquefied gas fuel tanks.

5.1.9 Design vapour pressure P_0

Design vapour pressure "P_0" is the maximum gauge pressure, at the top of the tank, to be used in the design of the tank

5.1.10 Double block and bleed valve

Double block and bleed valve means a set of two valves in series in a pipe and a third valve enabling the pressure release from the pipe between those two valves. The arrangement may also consist of a two-way valve and a closing valve instead of three separate valves.

Bleed valve means the valve in the double block and bleed set of valves intended for the pressure release.

5.1.11 Dual fuel engines or boilers

Dual fuel engines or boilers *means engines* or boilers *that employ fuel covered by this Rule Note, (with pilot fuel) and oil fuel. Oil fuels may include distillate and residual fuels.*

5.1.12 Enclosed space

Enclosed space means any space within which, in the absence of artificial ventilation, the ventilation will be limited and any explosive atmosphere will not be dispersed naturally.

Note 1: See also definition in IEC 60092-502:1999.

5.1.13 ESD

ESD means emergency shutdown.

5.1.14 Explosion

Explosion means a deflagration event of uncontrolled combustion.

5.1.15 Explosion pressure relief

Explosion pressure relief means measures provided to prevent the explosion pressure in a container or an enclosed space exceeding the maximum overpressure the container or space is designed for, by releasing the overpressure through designated openings.

5.1.16 Filling limit (FL)

Filling limit (FL) means the maximum liquid volume in a fuel tank relative to the total tank volume when the liquid fuel has reached the reference temperature.

5.1.17 Fuel containment system

Fuel containment system is the arrangement for the storage of fuel including tank connections. It includes where fitted, a primary and secondary barrier, associated insulation and any intervening spaces, and adjacent structure if necessary for the support of these elements. If the secondary barrier is part of the hull structure it may be a boundary of the fuel storage hold space.

The spaces around the fuel tank are defined as follows:

- *Fuel storage hold space is the space enclosed by the ship's structure in which a fuel containment system is situated. If tank connections are located in the fuel storage hold space, it will also be a tank connection space;*
- *Interbarrier space is the space between a primary and a secondary barrier, whether or not completely or partially occupied by insulation or other material; and*
- *Tank connection space is a space surrounding all tank connections and tank valves that is required for tanks with such connections in enclosed spaces.*

  A tank connection space may also contain low pressure gas valve units or other low pressure equipment intended for fuel preparation, such as vaporizers or heat exchangers. Equipment with a maximum working pressure not exceeding 2,0 MPa may also be accepted provided the risk analysis required in Ch 3, Sec 1, [2.1.5] demonstrates that the consequences of the failure of such equipment are minimized.

  Such equipment is considered to contain only potential sources of release, but not sources of ignition.

  Tank connection spaces containing a GVU are to comply with requirement of Ch 2, Sec 9, [1.1.3], Ch 2, Sec 9, [1.2.1] and Ch 2, Sec 9, [1.2.2].

For membrane tanks, the hull structure that supports the membrane may be the boundary of the fuel storage hold space.

5.1.18 Fuel gas handling system

Fuel gas handling system means the equipment necessary for processing, heating, vaporizing or compressing the LNG or gas fuel.

5.1.19 Fuel preparation room

Fuel preparation room means any space containing pumps, compressors and/or vaporizers for fuel preparation purposes.

A tank connection space which has equipment such as vaporizers or heat exchangers installed inside is not regarded as a fuel preparation room. Such equipment is considered to only contain potential sources of release, but not sources of ignition.

5.1.20 Gas

Gas means a fluid having a vapour pressure exceeding 0,28 MPa absolute at a temperature of 37,8°C.

5.1.21 Gas combustion unit (GCU)

Gas combustion unit means a system intended for the combustion of boil-off gas in excess.

5.1.22 Gas consumer

Gas consumer means any unit within the vessel using gas as a fuel

5.1.23 Gas-convertible

Gas-convertible applies to engines and boilers that are:

- designed and approved for oil fuel operation,
- capable of being subsequently converted to dual fuel operation,

and for which a conversion method has been approved by the Society.

5.1.24 Gas only engine

Gas only engine means an engine capable of operating only on gas, and not able to switch over to operation on any other type of fuel.

5.1.25 Gas-related space

Gas-related space means a space containing:

- installations or equipment intended for the storage, handling and supply of LNG or gas fuel
- gas consumers (engines, boilers or GCU).

5.1.26 Gas valve unit (GVU)

Gas valve unit (GVU) is a set of manual shut-off valves, actuated shut-off and venting valves, gas pressure sensors and transmitters, gas temperature sensors and transmitters, gas pressure control valve and gas filter used to control the gas supply to each gas consumer. It also includes a connection for inert gas purging.

5.1.27 Gas valve unit space (GVU space)

Gas valve unit space (GVU space) means a dedicated space containing one (or more) gas valve unit(s). It may be limited to a gastight enclosure.

5.1.28 Hazardous area

Hazardous area means an area in which an explosive gas atmosphere is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment.

5.1.29 High pressure (HP) / Very high pressure (VHP) / Low pressure

- *High pressure means a maximum working pressure greater than 1,0 MPa.*

  High pressure may be referred to as HP.
- Very high pressure (VHP) means a maximum working pressure greater than 2,0 MPa.
- Low pressure means a maximum working pressure lower than or equal to 1,0 MPa.

5.1.30 Independent tanks

Independent tanks are self-supporting, do not form part of the ship's hull and are not essential to the hull strength.

5.1.31 LEL

LEL means the lower explosive limit.

5.1.32 Length (L)

Length (L) is the length as defined in the International Convention on Load Lines in force.

5.1.33 LNG

LNG means liquefied natural gas.

5.1.34 Loading limit (LL)

Loading limit (LL) means the maximum allowable liquid volume relative to the tank volume to which the tank may be loaded.

5.1.35 Low-flashpoint fuel

Low-flashpoint fuel means gaseous or liquid fuel having a flashpoint lower than otherwise permitted under paragraph 2.1.1 of SOLAS regulation II-2/4.

5.1.36 Machinery spaces

Machinery spaces mean spaces as defined in NR467 Pt C, Ch 4, Sec 1 [3.23].

5.1.37 MARVS

MARVS means the maximum allowable relief valve setting

5.1.38 MAWP

MAWP means the maximum allowable working pressure of a system component or tank.

5.1.39 Membrane tanks

Membrane tanks are non-self-supporting tanks that consist of a thin liquid and gas tight layer (membrane) supported through insulation by the adjacent hull structure.

5.1.40 Multi-fuel engines

Multi-fuel engines means engines that can use two or more different fuels that are separate from each other

5.1.41 Non-hazardous area

Non-hazardous area means an area in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of equipment.

5.1.42 Open deck

Open deck means a deck having no significant fire risk that at least is open on both ends/sides, or is open on one end and is provided with adequate natural ventilation that is effective over the entire length of the deck through permanent openings distributed in the side plating or deckhea

5.1.43 Reference temperature

Reference temperature means the temperature corresponding to the vapour pressure of the fuel in a fuel tank at the set pressure of the PRVs.

5.1.44 Risk

Risk is an expression for the combination of the likelihood and the severity of the consequences.

5.1.45 Room with high fire risk

Room with high fire risk includes as a minimum, but should not be restricted to:

- cargo spaces except cargo tanks for liquids with flashpoint above 60°C and except cargo spaces exempted in accordance with SOLAS regulations II-2/10.7.1.2 or II-2/10.7.1.4;
- vehicle, ro-ro and special category spaces;
- service spaces (high risk): galleys, pantries containing cooking appliances, saunas, paint lockers and store-rooms having areas of 4 m^2 or more, spaces for the storage of flammable liquids and workshops other than those forming part of the machinery space, as provided in SOLAS regulations II-2/9.2.2.4, II-2/9.2.3.3 and II-2/9.2.4; and
- accommodation spaces of greater fire risk: saunas, sale shops, barber shops, beauty parlours and public spaces containing furniture and furnishing of other than restricted fire risk and having deck area of 50 m^2 or more, as provided in SOLAS regulation II-2/9.2.2.3.

5.1.46 Secondary barrier

Secondary barrier is the liquid-resisting outer element of a fuel containment system designed to afford temporary containment of any envisaged leakage of liquid fuel through the primary barrier and to prevent the lowering of the temperature of the ship's structure to an unsafe level.

5.1.47 Semi-enclosed space

Semi-enclosed space means a space where the natural conditions of ventilation are notably different from those on open deck due to the presence of structure such as roofs, windbreaks and bulkheads and which are so arranged that dispersion of gas may not occur.

Note 1: Refer also to IEC 60092-502:1999 Electrical Installations in Ships – Tankers – Special Features.

5.1.48 Sources of ignition

Sources of ignition include:

- electrical sources of ignition (static electricity or arcing)
- mechanical sources of ignition, such as shock or friction likely to generate sparks or hot spots
- surfaces of machinery with temperatures above 500°C
- sources of ignitions originating from cargo, such as cars or trucks on ro-ro ferries
- sources of ignitions arising from passengers.

5.1.49 Source of release

Source of release means a point or location from which a gas, vapour, mist or liquid may be released into the atmosphere so that an explosive atmosphere could be formed.

Source of release includes any point of a single walled gas fuel pipe.

Gas piping with a pressure less than 1 bar g need not be considered as a potential source of release.

5.1.50 Unacceptable loss of power

Unacceptable loss of power means that it is not possible to sustain or restore normal operation of the propulsion machinery in the event of one of the essential auxiliaries becoming inoperative, in accordance with SOLAS regulation II-1/26.3

5.1.51 Vapour pressure

Vapour pressure is the equilibrium pressure of the saturated vapour above the liquid, expressed in MPa absolute at a specified temperature.

5.1.52 Vent mast

Vent mast is a venting system to which fuel tank pressure relief valves are connected and which complies with Ch 3, Sec 5, [2.1.9].

Section 2 Risk Assessment

1 General

1.1 Application

1.1.1 *A risk assessment shall be conducted to ensure that risks arising from the use of low-flashpoint fuels affecting persons on board, the environment, the structural strength or the integrity of the ship are addressed. Consideration shall be given to the hazards associated with physical layout, operation and maintenance, following any reasonably foreseeable failure.*

1.1.2 *The risk assessment required by [1.1.1] need only be conducted where explicitly required by Ch 2, Sec 6, [2.2.5], Ch 2, Sec 8, [1.1.4], Ch 3, Sec 2, [1.1.1], Ch 3, Sec 2, [16.4.7], Ch 6, Sec 1, [2.1.1] and Ch 6, Sec 1, [3.1.2], Ch 7, Sec 3, [3.1.1], Ch 7, Sec 3, [5] and Ch 8, Sec 1, [7.1.1], item j) as well as by Ch 3, App 1, [4.1.4] and Ch 3, App 1, [6.1.8].*

1.1.3 *The risks shall be analysed using acceptable and recognized risk analysis techniques, and loss of function, component damage, fire, explosion and electric shock shall as a minimum be considered. The analysis shall ensure that risks are eliminated wherever possible. Risks which cannot be eliminated shall be mitigated as necessary. Details of risks, and the means by which they are mitigated, shall be documented to the satisfaction of the Society.*

The risk analysis is also to cover gas and liquid fuel leakage.

2 Additional requirements for risk assessment

2.1 General

2.1.1 Risk assessment is to be carried out in accordance with IACS Recommendation N° 146 “Risk assessment as required by the IGF code”.

2.1.2 An HAZID study is to be carried out for each gas-fuelled ship. It is to cover at least the following spaces, zones and systems:

- tank connection space (TCS)
- enclosed and semi-enclosed fuel preparation rooms
- enclosed and semi-enclosed bunkering stations
- spaces containing very high pressure gas or liquid fuel piping
- ESD-protected machinery spaces
- GVU spaces (except GVU enclosures)
- zones where vent lines and safety valve discharge lines are led, except where ventilation inlets to accommodation and machinery spaces are provided with gas detection arrangements (see Ch 8, Sec 1, [7.1.1]).
- Containment systems and adjacent structure (see Ch 3, Sec 2, [1.1.1] and Ch 3, Sec 2, [16.4.2]).
- The risks identified by the HAZID study may be mitigated by operational procedures (e.g. stopping ship spaces ventilation during bunkering operations to prevent gas from entering those spaces through openings).
- Gas dispersion analysis may be required to better assess the risk associated with gas venting or pressure relief.
- For vacuum-insulated type C tanks, the consequences of a loss of the vacuum, in particular in case of damage of the outer jacket, are to be analysed.

2.1.3 A FMECA analysis is to be carried out for electrical generation and distribution systems (see Ch 7, Sec 4, [1] and Ch 7, Sec 4, [2.1.4]) and equipment used for essential services.

2.1.4 An HAZOP study is to be carried out for the very high-pressure gas fuel installation to assess that process safety is implemented to limit the consequences of a single failure for persons onboard and operation of the ship.

2.1.5 A list of failure modes and relevant repair procedures for heat exchangers is to be established, when requested in Ch 3, Sec 7, [6.1.4].

2.1.6 For any risk assessment carried out in the scope of the present Rules, a detailed follow-up report of actions and mitigation measures taken in response to any analysis findings is to be submitted to the Society.

3 Limitation of explosion consequences

3.1 General

3.1.1 *An explosion in any space containing any potential sources of release and potential ignition sources shall not:*

- *cause damage to or disrupt the proper functioning of equipment/systems located in any space other than that in which the incident occurs;*
- *damage the ship in such a way that flooding of water below the main deck or any progressive flooding occur;*
- *damage work areas or accommodation in such a way that persons who stay in such areas under normal operating conditions are injured;*
- *disrupt the proper functioning of control stations and switchboard rooms necessary for power distribution;*
- *damage life-saving equipment or associated launching arrangements;*
- *disrupt the proper functioning of firefighting equipment located outside the explosion-damaged space;*
- *affect other areas of the vessel in such a way that chain reactions involving, inter alia, cargo, gas and bunker oil may arise; and*
- *prevent persons access to life saving appliances or impede escape routes.*

Note 1: Double wall fuel pipes are not considered as potential sources of release.

3.1.2 An explosion analysis is required for ESD-protected machinery spaces. It may also be required for other hazardous spaces, as a result of the risk assessment.

Explosion analyses are to demonstrate that, for the worst case scenario, the maximum pressure built-up in case of explosion does not exceed the design pressure of the space, taking into account the venting arrangement and the explosion pressure relief devices, where provided.

The worst case scenario is to assume a complete rupture of a LNG or gas pipe and to take into account the following parameters:

- maximum expected time between the pipe rupture and the leakage detection,
- time between the leakage detection and the gas supply shutoff,
- ventilation flow rate.

Where necessary, explosion pressure relief devices are to be provided.

Section 3 Functional requirements

1 General

1.1

1.1.1 *The safety, reliability and dependability of the systems shall be equivalent to that achieved with new and comparable conventional oil-fuelled main and auxiliary machinery.*

1.1.2 *The probability and consequences of fuel-related hazards shall be limited to a minimum through arrangement and system design, such as ventilation, detection and safety actions. In the event of gas leakage or failure of the risk reducing measures, necessary safety actions shall be initiated.*

1.1.3 *The design philosophy shall ensure that risk reducing measures and safety actions for the gas fuel installation do not lead to an unacceptable loss of power.*

1.1.4 *Hazardous areas shall be restricted, as far as practicable, to minimize the potential risks that might affect the safety of the ship, persons on board, and equipment.*

1.1.5 *Equipment installed in hazardous areas shall be minimized to that required for operational purposes and shall be suitably and appropriately certified.*

1.1.6 *Unintended accumulation of explosive, flammable or toxic gas concentrations shall be prevented.*

1.1.7 *System components shall be protected against external damages.*

1.1.8 *Sources of ignition in hazardous areas shall be minimized to reduce the probability of explosions.*

1.1.9 *It shall be arranged for safe and suitable, fuel supply, storage and bunkering arrangements capable of receiving and containing the fuel in the required state without leakage. Other than when necessary for safety reasons, the system shall be designed to prevent venting under all normal operating conditions including idle periods.*

1.1.10 *Piping systems, containment and over-pressure relief arrangements that are of suitable design, construction and installation for their intended application shall be provided.*

1.1.11 *Machinery, systems and components shall be designed, constructed, installed, operated, maintained and protected to ensure safe and reliable operation.*

1.1.12 *Fuel containment system and machinery spaces containing source that might release gas into the space shall be arranged and located such that a fire or explosion in either will not lead to an unacceptable loss of power or render equipment in other compartments inoperable.*

Note 1: This applies in particular to ESD protected machinery spaces.

A "source that might release gas" is to be considered as a "source of release" as defined in Sec 1, [5.1.49].

1.1.13 *Suitable control, alarm, monitoring and shutdown systems shall be provided to ensure safe and reliable operation.*

1.1.14 *Fixed gas detection suitable for all spaces and areas concerned shall be arranged.*

1.1.15 *Fire detection, protection and extinction measures appropriate to the hazards concerned shall be provided.*

1.1.16 *Commissioning, trials and maintenance of fuel systems and gas utilization machinery shall satisfy the goal in terms of safety, availability and reliability.*

1.1.17 *The technical documentation shall permit an assessment of the compliance of the system and its components with the applicable rules, guidelines, design standards used and the principles related to safety, availability, maintainability and reliability.*

1.1.18 *A single failure in a technical system or component shall not lead to an unsafe or unreliable situation.*

Appendix 1 Correspondence between Current Edition of this Rule Note, IMO IGF Code and Former Revision of NR529

1 Table of correspondence

1.1

1.1.1 The following Tables provide correspondences between the provisions of the current edition of this Rule Note, IMO IGF Code and the former edition of NR529 dated January 2025:

- Tab 1: Correspondences with Chapters 1, 2, 3 and 4 of IMO IGF Code
- Tab 2: Correspondences with Chapter 5 of IMO IGF Code
- Tab 3 to Tab 8: Correspondences with Chapter 6 of IMO IGF Code
- Tab 9: Correspondences with Chapter 7 of IMO IGF Code
- Tab 10: Correspondences with Chapters 8 and 9 of IMO IGF Code
- Tab 11: Correspondences with Chapters 10 and 11 of IMO IGF Code
- Tab 12: Correspondences with Chapters 12 and 13 of IMO IGF Code
- Tab 13: Correspondences with Chapters 14 and 15 of IMO IGF Code
- Tab 14: Correspondences with Chapter 16, 17, 18, 19 of IMO IGF Code
- Tab 15 and Tab 16: Correspondences with Annex of IMO IGF Code or Appendix 1, 2, 3 and 4 of NR529 edition January 2025.

Table 1 : Correspondence between Chapters 1, 2, 3, 4 of IMO IGF Code, NR529 (edition January 2025) and Current NR529

IGF Code	NR529 Jan. 2025	Current NR529
–	Premise	
–	P.1	–
–	P.1.1	–
–	P.1.2	–
–	P.1.3	–
–	P.1.4	–
–	P.2	–
–	P.3	–
1 Preamble		
1	1	–
2 General		
2	2	–
2.1	2.1	–
–	C2.1(a)	–
–	C2.1(b)	Sec 1, [4]
2.2	2.2	Sec 1, [5]
2.2.1	2.2.1	Sec 1, [5.1.2]
2.2.2	2.2.2	Sec 1, [5.1.3]
2.2.3	2.2.3	Sec 1, [5.1.4]
–	C2.2.3	Sec 1, [5.1.4]
2.2.4	2.2.4	Sec 1, [5.1.5]
2.2.5	2.2.5	Sec 1, [5.1.6]
2.2.6	2.2.6	Sec 1, [5.1.7]
2.2.7	2.2.7	Sec 1, [5.1.8]
2.2.8	2.2.8	Sec 1, [5.1.20]
2.2.9	2.2.9	Sec 1, [5.1.10]
–	C2.2.9	Sec 1, [5.1.10]
2.2.10	2.2.10	Sec 1, [5.1.11]
2.2.11	2.2.11	Sec 1, [5.1.12]
2.2.12	2.2.12	Sec 1, [5.1.13]

IGF Code	NR529 Jan. 2025	Current NR529
2.2.13	2.2.13	Sec 1, [5.1.14]
2.2.14	2.2.14	Sec 1, [5.1.15]
2.2.15 2.2.15.1 2.2.15.2 2.2.15.3	2.2.15 2.2.15.1 2.2.15.2 2.2.15.3	Sec 1, [5.1.17]
–	C2.2.15.3	Sec 1, [5.1.17]
–	C2.2.15	Sec 1, [5.1.17]
2.2.16	2.2.16	Sec 1, [5.1.16]
2.2.17	2.2.17	Sec 1, [5.1.19]
–	C2.2.17	Sec 1, [5.1.19]
2.2.18	2.2.18	Sec 1, [5.1.20]
2.2.19	2.2.19	Sec 1, [5.1.22]
2.2.20	2.2.20	Sec 1, [5.1.24]
2.2.21	2.2.21	Sec 1, [5.1.28]
2.2.22	2.2.22	Sec 1, [5.1.29]
–	C2.2.22	Sec 1, [5.1.29]
2.2.23	2.2.23	Sec 1, [5.1.30]
2.2.24	2.2.24	Sec 1, [5.1.31]
2.2.25	2.2.25	Sec 1, [5.1.32]
2.2.26	2.2.26	Sec 1, [5.1.33]
2.2.27	2.2.27	Sec 1, [5.1.34]
2.2.28	2.2.28	Sec 1, [5.1.35]
2.2.29	2.2.29	Sec 1, [5.1.37]
2.2.30	2.2.30	Sec 1, [5.1.38]
2.2.31	2.2.31	Sec 1, [5.1.39]
2.2.32	2.2.32	Sec 1, [5.1.40]
2.2.33	2.2.33	Sec 1, [5.1.41]
2.2.34	2.2.34	Sec 1, [5.1.42]
2.2.35	2.2.35	Sec 1, [5.1.44]

IGF Code	NR529 Jan. 2025	Current NR529
2.2.36	2.2.36	Sec 1, [5.1.43]
2.2.37	2.2.37	Sec 1, [5.1.46]
2.2.38	2.2.38	Sec 1, [5.1.47]
2.2.39	2.2.39	Sec 1, [5.1.49]
–	C2.2.39	Sec 1, [5.1.49]
2.2.40	2.2.40	Sec 1, [5.1.50]
2.2.41	2.2.41	Sec 1, [5.1.51]
–	C2.2(a)	Sec 1, [5.1.26]
–	C2.2(b)	Sec 1, [5.1.27]
–	C2.2(c)	Sec 1, [5.1.29]
–	C2.2(d)	Sec 1, [5.1.36]
–	C2.2(e)	Sec 1, [5.1.48]
–	C2.2(f)	Sec 1, [5.1.45]
–	C2.2(g)	Sec 1, [5.1.52]
–	C2.2(h)	Sec 1, [5.1.29]
2.3	2.3	–
3 Goal and Functional Requirements		
3	3	–
3.1	3.1	–
3.2	3.2	Sec 3
3.2.1	3.2.1	Sec 3, [1.1.1]
3.2.2	3.2.2	Sec 3, [1.1.2]
3.2.3	3.2.3	Sec 3, [1.1.3]
3.2.4	3.2.4	Sec 3, [1.1.4]
3.2.5	3.2.5	Sec 3, [1.1.5]
3.2.6	3.2.6	Sec 3, [1.1.6]
3.2.7	3.2.7	Sec 3, [1.1.7]
3.2.8	3.2.8	Sec 3, [1.1.8]

IGF Code	NR529 Jan. 2025	Current NR529
3.2.9	3.2.9	Sec 3, [1.1.9]
3.2.10	3.2.10	Sec 3, [1.1.10]
3.2.11	3.2.11	Sec 3, [1.1.11]
3.2.12	3.2.12	Sec 3, [1.1.12]
–	C3.2.12	Sec 3, [1.1.12]
3.2.13	3.2.13	Sec 3, [1.1.13]
3.2.14	3.2.14	Sec 3, [1.1.14]
3.2.15	3.2.15	Sec 3, [1.1.15]
3.2.16	3.2.16	Sec 3, [1.1.16]
3.2.17	3.2.17	Sec 3, [1.1.17]
3.2.18	3.2.18	Sec 3, [1.1.18]
4 General Requirements		
4	4	Sec 2
4.1	4.1	–
4.2	4.2	Sec 2, [1]
4.2.1	4.2.1	Sec 2, [1.1.1]
4.2.2	4.2.2	Sec 2, [1.1.2]
4.2.3	4.2.3	Sec 2, [1.1.3]
–	C4.2.3	Sec 2, [1.1.3]
–	C4.2(a)	Sec 2, [2]
4.3 4.3.1 4.3.2 4.3.3 4.3.4 4.3.5 4.3.6 4.3.7 4.3.8	4.3 4.3.1 4.3.2 4.3.3 4.3.4 4.3.5 4.3.6 4.3.7 4.3.8	Sec 2, [3]
–	C4.3(a)	Sec 2, [3.1.2]

Table 2 : Correspondence between Chapter 5 of IMO IGF Code, NR529 (edition January 2025) and Current NR529

IGF Code	NR529 Jan. 2025	Current NR529
5 Ship Design and Arrangement		
5	5	Chapter 2
5.1	5.1	–
5.2	5.2	Ch 2, Sec 1, [1]
5.2.1 5.2.1.1 5.2.1.2 5.2.1.3 5.2.1.4 5.2.1.5	5.2.1 5.2.1.1 5.2.1.2 5.2.1.3 5.2.1.4 5.2.1.5	Ch 2, Sec 1, [1.1.1]
–	C5.2.1.5	Ch 2, Sec 1, [1.1.1]
5.3	5.3	Ch 2, Sec 1, [2]
–	C5.3(a)	Ch 2, Sec 1, [2.1.1]
5.3.1	5.3.1	Ch 2, Sec 1, [2.1.2]
5.3.2	5.3.2	Ch 2, Sec 1, [2.1.3]
5.3.3 5.3.3.1 5.3.3.2 5.3.3.3	5.3.3 5.3.3.1 5.3.3.2 5.3.3.3	Ch 2, Sec 1, [2.1.4]
5.3.3.4 5.3.3.4.1	5.3.3.4 5.3.3.4.1	Ch 2, Sec 1, [2.1.4]
–	C5.3.3.4.1	Ch 2, Sec 1, [2.1.4]
5.3.3.4.2	5.3.3.4.2	Ch 2, Sec 1, [2.1.4]
5.3.3.5 5.3.3.6 5.3.3.7 5.3.3.8	5.3.3.5 5.3.3.6 5.3.3.7 5.3.3.8	Ch 2, Sec 1, [2.1.4]
5.3.4 5.3.4.1 5.3.4.2 5.3.4.3 5.3.4.4 5.3.4.5 5.3.4.5.1 5.3.4.5.2 5.3.4.6 5.3.4.7 5.3.4.8	5.3.4 5.3.4.1 5.3.4.2 5.3.4.3 5.3.4.4 5.3.4.5 5.3.4.5.1 5.3.4.5.2 5.3.4.6 5.3.4.7 5.3.4.8	Ch 2, Sec 1, [2.1.5]
5.3.5 5.3.5.1 5.3.5.2	5.3.5 5.3.5.1 5.3.5.2	Ch 2, Sec 1, [2.1.6]
5.4	5.4	Ch 2, Sec 2
5.4.1 5.4.1.1 5.4.1.2	5.4.1 5.4.1.1 5.4.1.2	Ch 2, Sec 2, [1.1.1]
–	C5.4.1.2	Ch 2, Sec 2, [1.1.2]
5.5	5.5	Ch 2, Sec 3
5.5.1	5.5.1	Ch 2, Sec 3, [1.1.1]
5.5.2	5.5.2	Ch 2, Sec 3, [1.1.2]
–	C5.5.2	Ch 2, Sec 3, [1.1.3]
5.6	5.6	Ch 2, Sec 4
5.6.1	5.6.1	Ch 2, Sec 4, [1.1.1]
5.6.2 5.6.2.1 5.6.2.2 5.6.2.3 5.6.2.4	5.6.2 5.6.2.1 5.6.2.2 5.6.2.3 5.6.2.4	Ch 2, Sec 4, [1.1.2]
5.6.3 5.6.3.1 5.6.3.2 5.6.3.3	5.6.3 5.6.3.1 5.6.3.2 5.6.3.3	Ch 2, Sec 4, [1.2.1]
–	C5.6.3	Ch 2, Sec 4, [1.1.6] Ch 2, Sec 4, [1.2.2]
5.6.4	5.6.4	Ch 2, Sec 4, [1.1.3]
5.6.5	5.6.5	Ch 2, Sec 4, [1.1.4]
5.6.6	5.6.6	Ch 2, Sec 4, [1.1.5]
5.6.7	5.6.7	Ch 2, Sec 4, [1.3.1]
–	C5.6(a)	Ch 2, Sec 4, [1.4.1]
5.7	5.7	Ch 5, Sec 1, [2.1]
5.7.1	5.7.1	Ch 5, Sec 1, [2.1.1]
–	C5.7.1	Ch 5, Sec 1, [2.1.2]
5.7.2	5.7.2	Ch 5, Sec 1, [2.1.3]
–	C5.7.2	Ch 5, Sec 1, [2.1.4]
5.7.3	5.7.3	Ch 5, Sec 1, [2.1.5]
–	C5.7.3	Ch 5, Sec 1, [2.1.6]
5.7.4	5.7.4	Ch 5, Sec 1, [2.1.7]
–	C5.7.4	Ch 5, Sec 1, [2.1.8]
5.7.5	5.7.5	Ch 5, Sec 1, [2.1.9]
–	C5.7.5	Ch 5, Sec 1, [2.1.10]
5.8	5.8	Ch 2, Sec 5 Ch 2, Sec 5, [1.1.1]
–	C5.8(a)	Ch 2, Sec 5, [1.1.2] Ch 2, Sec 5, [1.2]
–	C5.8(b)	Ch 2, Sec 5, [2]
5.9	5.9	Ch 2, Sec 6, [1]
5.9.1	5.9.1	Ch 2, Sec 6, [1.1.1]
–	C5.9.1	Ch 2, Sec 6, [1.1.2]
5.9.2	5.9.2	Ch 2, Sec 6, [1.1.3]
5.9.3	5.9.3	Ch 2, Sec 6, [1.1.4]
5.10	5.10	Ch 2, Sec 6, [2]
5.10.1	5.10.1	Ch 2, Sec 6, [2.1.1]
–	C5.10.1	Ch 2, Sec 6, [2.1.2]
5.10.2	5.10.2	Ch 2, Sec 6, [2.1.3]
–	C5.10.2	Ch 2, Sec 6, [2.1.4]
5.10.3	5.10.3	Ch 2, Sec 6, [2.2.1]
–	C5.10.3	Ch 2, Sec 6, [2.2.2]
5.10.4	5.10.4	Ch 2, Sec 6, [2.2.3]
–	C5.10.4	Ch 2, Sec 6, [2.2.4]
5.10.5	5.10.5	Ch 2, Sec 6, [2.2.5]
–	C5.10.5	Ch 2, Sec 6, [2.2.6]
–	C5.10(a)	Ch 2, Sec 6, [2.2.7]
5.11	5.11	Ch 2, Sec 7 Ch 2, Sec 7, [1]
5.11.1	5.11.1	Ch 2, Sec 7, [1.1.1]
5.11.2	5.11.2	Ch 2, Sec 7, [1.1.2]
5.11.3	5.11.3	Ch 2, Sec 7, [1.1.3]
–	C5.11.3	Ch 2, Sec 7, [1.1.4]
5.11.4	5.11.4	Ch 2, Sec 7, [1.1.5]
5.11.5	5.11.5	Ch 2, Sec 7, [1.1.6]
–	C5.11(a)	Ch 2, Sec 7, [1.1.7]
5.12	5.12	Ch 2, Sec 8
5.12.1	5.12.1	Ch 2, Sec 8, [1.1.1]
5.12.2	5.12.2	Ch 2, Sec 8, [1.1.2]
–	C5.12.2	Ch 2, Sec 8, [1.1.3]
5.12.3	5.12.3	Ch 2, Sec 8, [1.1.4]
–	C5.12.3	Ch 2, Sec 8, [1.1.5]
5.12.4	5.12.4	Ch 2, Sec 8, [1.1.6]
5.12.5	5.12.5	Ch 2, Sec 8, [1.1.7]
5.12.6	5.12.6	Ch 2, Sec 8, [1.1.8]
–	C5.12.6	Ch 2, Sec 8, [1.1.9]
5.12.7	5.12.7	Ch 2, Sec 8, [1.1.10]
–	C5.12.7	Ch 2, Sec 8, [1.1.11]
–	C5(a)	Ch 2, Sec 9

Table 3 : Correspondence between Chapter 6 of IMO IGF Code, NR529 (edition January 2025) and Current NR529

Continued in Table 6

IGF Code	NR529 Jan. 2025	Current NR529
6 Fuel Containment System		
6	6	Chapter 3
6.1	6.1	–
6.2	6.2	Ch 3, Sec 1, [1]
6.2.1	6.2.1	
6.2.1	6.2.1	
6.2.2	6.2.2	
6.2.3	6.2.3	
6.2.4	6.2.4	
6.2.5	6.2.5	
6.2.2	6.2.2	
6.2.3	6.2.3	
6.2.4	6.2.4	
6.3	6.3	Ch 3, Sec 1, [2]
6.3.1	6.3.1	Ch 3, Sec 1, [2.1.1]
6.3.2	6.3.2	Ch 3, Sec 1, [2.1.2]
6.3.3	6.3.3	Ch 3, Sec 1, [2.1.3]
6.3.4	6.3.4	Ch 3, Sec 1, [2.1.4]
–	C6.3.4	Ch 3, Sec 1, [2.1.5]
6.3.5	6.3.5	Ch 3, Sec 1, [2.1.6]
6.3.6	6.3.6	Ch 3, Sec 1, [2.1.7]
–	C6.3.6	Ch 3, Sec 1, [2.1.7]
6.3.7	6.3.7	Ch 3, Sec 1, [2.1.8]
–	C6.3.7	Ch 3, Sec 1, [2.1.9]
6.3.8	6.3.8	Ch 3, Sec 1, [2.1.10]
–	C6.3.8	Ch 3, Sec 1, [2.1.10]
6.3.9	6.3.9	Ch 3, Sec 1, [2.1.11]
–	C6.3.9	Ch 3, Sec 1, [2.1.12]
6.3.10	6.3.10	Ch 3, Sec 1, [2.1.13]
–	C6.3.10 (a)	Ch 3, Sec 1, [2.1.14]
–	C6.3.10 (b)	Ch 3, Sec 1, [2.1.15]
6.3.11	6.3.11	Ch 3, Sec 1, [2.1.16]

IGF Code	NR529 Jan. 2025	Current NR529
–	C6.3.11	Ch 3, Sec 1, [2.1.17]
6.3.12	6.3.12	Ch 3, Sec 1, [2.1.18]
–	C6.3.12	Ch 3, Sec 1, [2.1.19]
6.4	6.4	Ch 3, Sec 2
6.4.1	6.4.1	Ch 3, Sec 2, [1]
6.4.1.1	6.4.1.1	Ch 3, Sec 2, [1.1.1]
6.4.1.2	6.4.1.2	Ch 3, Sec 2, [1.1.2]
6.4.1.3	6.4.1.3	Ch 3, Sec 2, [1.1.3]
6.4.1.4	6.4.1.4	Ch 3, Sec 2, [1.1.4]
6.4.1.5	6.4.1.5	Ch 3, Sec 2, [1.1.5]
6.4.1.5.1	6.4.1.5.1	
6.4.1.5.2	6.4.1.5.2	
6.4.1.6	6.4.1.6	Ch 3, Sec 2, [1.1.6]
6.4.1.6.1	6.4.1.6.1	
6.4.1.6.1.1	6.4.1.6.1.1	
6.4.1.6.1.2	6.4.1.6.1.2	
6.4.1.6.1.3	6.4.1.6.1.3	
6.4.1.6.1.4	6.4.1.6.1.4	
6.4.1.6.1.5	6.4.1.6.1.5	
6.4.1.6.1.6	6.4.1.6.1.6	
6.4.1.6.1.7	6.4.1.6.1.7	
6.4.1.6.1.8	6.4.1.6.1.8	
6.4.1.6.1.9	6.4.1.6.1.9	
6.4.1.6.1.10	6.4.1.6.1.10	
6.4.1.6.2	6.4.1.6.2	
6.4.1.6.3	6.4.1.6.3	
6.4.1.6.3.1	6.4.1.6.3.1	
6.4.1.6.3.2	6.4.1.6.3.2	
6.4.1.6.3.3	6.4.1.6.3.3	
6.4.1.7	6.4.1.7	Ch 3, Sec 2, [1.1.7]
6.4.1.8	6.4.1.8	Ch 3, Sec 2, [1.1.8]
6.4.1.9	6.4.1.9	Ch 3, Sec 2, [1.1.9]
6.4.2	6.4.2	Ch 3, Sec 2, [2]
6.4.2.1	6.4.2.1	Ch 3, Sec 2, [2.1.1]
6.4.2.2	6.4.2.2	Ch 3, Sec 2, [2.1.2]

IGF Code	NR529 Jan. 2025	Current NR529
6.4.2.3	6.4.2.3	Ch 3, Sec 2, [2.1.3]
6.4.2.3.1	6.4.2.3.1	
6.4.2.3.2	6.4.2.3.2	
6.4.2.4	6.4.2.4	Ch 3, Sec 2, [2.1.4]
6.4.2.5	6.4.2.5	Ch 3, Sec 2, [2.1.5]
6.4.3	6.4.3	Ch 3, Sec 2, [3]
6.4.4	6.4.4	Ch 3, Sec 2, [4]
6.4.4.1	6.4.4.1	Ch 3, Sec 2, [4.1.1]
6.4.4.2	6.4.4.2	
6.4.4.3	6.4.4.3	
6.4.4.4	6.4.4.4	
6.4.4.5	6.4.4.5	
6.4.4.5.1	6.4.4.5.1	
6.4.4.5.2	6.4.4.5.2	
6.4.4.5.3	6.4.4.5.3	
6.4.4.5.4	6.4.4.5.4	
6.4.4.6	6.4.4.6	
–	C6.4.4	Ch 3, Sec 2, [4.1.2]
6.4.5	6.4.5	Ch 3, Sec 2, [5]
6.4.5.1	6.4.5.1	Ch 3, Sec 2, [5.1.1]
6.4.5.2	6.4.5.2	Ch 3, Sec 2, [5.1.2]
6.4.5.3	6.4.5.3	Ch 3, Sec 2, [5.1.3]
6.4.5.4	6.4.5.4	Ch 3, Sec 2, [5.1.4]
6.4.6	6.4.6	Ch 3, Sec 2, [6]
6.4.6.1	6.4.6.1	Ch 3, Sec 2, [6.1.1]
6.4.6.2	6.4.6.2	Ch 3, Sec 2, [6.1.2]
6.4.6.3	6.4.6.3	Ch 3, Sec 2, [6.1.3]
6.4.7	6.4.7	Ch 3, Sec 2, [7]
6.4.7.1	6.4.7.1	Ch 3, Sec 2, [7.1.1]
6.4.8	6.4.8	Ch 3, Sec 2, [8]
6.4.8.1	6.4.8.1	Ch 3, Sec 2, [8.1.1]
–	C6.4(a)	Ch 3, Sec 2, [9]
6.4.9	6.4.9	Ch 3, Sec 2, [10]
6.4.9.1	6.4.9.1	Ch 3, Sec 2, [10.1]

Table 4 : Correspondence between Chapter 6 of IMO IGF Code, NR529 (edition January 2025) and Current NR529

Continued from Table 5, Continued to Table 7

IGF Code	NR529 Jan. 2025	Current NR529
6.4.9.1.1	6.4.9.1.1	Ch 3, Sec 2, [10.1.1]
6.4.9.1.2	6.4.9.1.2	Ch 3, Sec 2, [10.1.2]
6.4.9.1.3	6.4.9.1.3	Ch 3, Sec 2, [10.1.3]
6.4.9.2	6.4.9.2	Ch 3, Sec 2, [10.2]
6.4.9.2.1	6.4.9.2.1	Ch 3, Sec 2, [10.2.1]
6.4.9.2.2	6.4.9.2.2	Ch 3, Sec 2, [10.2.2]
6.4.9.3	6.4.9.3	Ch 3, Sec 2, [10.3]
6.4.9.3.1	6.4.9.3.1	Ch 3, Sec 2, [10.3.1]
6.4.9.3.2	6.4.9.3.2	Ch 3, Sec 2, [10.3.2]
6.4.9.3.3	6.4.9.3.3	Ch 3, Sec 2, [10.3.3]
6.4.9.3.3.1	6.4.9.3.3.1	Ch 3, Sec 2, [10.4]
6.4.9.3.3.1.1	6.4.9.3.3.1.1	Ch 3, Sec 2, [10.4.1]
6.4.9.3.3.1.2	6.4.9.3.3.1.2	Ch 3, Sec 2, [10.4.2]
6.4.9.3.3.1.2.1	6.4.9.3.3.1.2.1	Ch 3, Sec 2, [10.4.3]
6.4.9.3.3.1.2.2	6.4.9.3.3.1.2.2	Ch 3, Sec 2, [10.4.4]
6.4.9.3.3.1.3	6.4.9.3.3.1.3	Ch 3, Sec 2, [10.4.5]
6.4.9.3.3.1.4	6.4.9.3.3.1.4	
6.4.9.3.3.1.4.1	6.4.9.3.3.1.4.1	
6.4.9.3.3.1.4.2	6.4.9.3.3.1.4.2	
6.4.9.3.3.1.4.3	6.4.9.3.3.1.4.3	
6.4.9.3.3.1.5	6.4.9.3.3.1.5	
–	C6.4.9.3.3.1	Ch 3, Sec 2, [10.4.6]
6.4.9.3.3.2	6.4.9.3.3.2	Ch 3, Sec 2, [10.5]
6.4.9.3.3.3	6.4.9.3.3.3	Ch 3, Sec 2, [10.6]
6.4.9.3.3.3.1	6.4.9.3.3.3.1	Ch 3, Sec 2, [10.6.1]
6.4.9.3.3.3.2	6.4.9.3.3.3.2	Ch 3, Sec 2, [10.6.2]
6.4.9.3.3.4	6.4.9.3.3.4	Ch 3, Sec 2, [10.7]
6.4.9.3.3.5	6.4.9.3.3.5	Ch 3, Sec 2, [10.8]
6.4.9.3.3.6	6.4.9.3.3.6	Ch 3, Sec 2, [10.9]
6.4.9.3.3.7	6.4.9.3.3.7	Ch 3, Sec 2, [10.10]
6.4.9.3.3.8	6.4.9.3.3.8	Ch 3, Sec 2, [10.11]
		Ch 3, Sec 2, [10.11.1]
–	C6.4.9.3.3.8	Ch 3, Sec 2, [10.11.2]

IGF Code	NR529 Jan. 2025	Current NR529
6.4.9.3.3.9	6.4.9.3.3.9	Ch 3, Sec 2, [10.12]
6.4.9.4	6.4.9.4	Ch 3, Sec 2, [10.13]
6.4.9.4.1	6.4.9.4.1	Ch 3, Sec 2, [10.13.1]
6.4.9.4.1.1	6.4.9.4.1.1	Ch 3, Sec 2, [10.14]
6.4.9.4.1.1.1	6.4.9.4.1.1.1	Ch 3, Sec 2, [10.14.1]
6.4.9.4.1.1.2	6.4.9.4.1.1.2	
6.4.9.4.1.1.3	6.4.9.4.1.1.3	
–	C.6.4.9.4.1.1	Ch 3, Sec 2, [10.14.2]
6.4.9.4.1.2	6.4.9.4.1.2	Ch 3, Sec 2, [10.15]
6.4.9.4.1.3	6.4.9.4.1.3	Ch 3, Sec 2, [10.16]
		Ch 3, Sec 2, [10.16.1]
–	C6.4.9.4.1.3	Ch 3, Sec 2, [10.16.2]
6.4.9.4.1.4	6.4.9.4.1.4	Ch 3, Sec 2, [10.17]
		Ch 3, Sec 2, [10.17.1]
–	C6.4.9.4.1.4	Ch 3, Sec 2, [10.17.2]
6.4.9.4.1.5	6.4.9.4.1.5	Ch 3, Sec 2, [10.18]
6.4.9.4.1.6	6.4.9.4.1.6	Ch 3, Sec 2, [10.19]
		Ch 3, Sec 2, [10.19.1]
–	C6.4.9.4.1.6	Ch 3, Sec 2, [10.19.2]
6.4.9.4.1.7	6.4.9.4.1.7	Ch 3, Sec 2, [10.20]
		Ch 3, Sec 2, [10.20.1]
–	C6.4.9.4.1.7	Ch 3, Sec 2, [10.20.2]
6.4.9.5	6.4.9.5	Ch 3, Sec 2, [10.21]
		Ch 3, Sec 2, [10.21.1]
6.4.9.5.1	6.4.9.5.1	Ch 3, Sec 2, [10.21.2]
–	C6.4.9.5.1	Ch 3, Sec 2, [10.21.2]
6.4.9.5.2	6.4.9.5.2	Ch 3, Sec 2, [10.21.3]
6.4.10	6.4.10	Ch 3, Sec 2, [11]
6.4.10.1	6.4.10.1	Ch 3, Sec 2, [11.1]
6.4.10.1.1	6.4.10.1.1	Ch 3, Sec 2, [11.1.1]
6.4.10.1.2	6.4.10.1.2	Ch 3, Sec 2, [11.1.2]
6.4.10.1.3	6.4.10.1.3	Ch 3, Sec 2, [11.1.3]

IGF Code	NR529 Jan. 2025	Current NR529
6.4.9.4	6.4.9.4	Ch 3, Sec 2, [10.13]
6.4.11	6.4.11	Ch 3, Sec 2, [12]
6.4.11.1	6.4.11.1	Ch 3, Sec 2, [12.1]
6.4.11.1.1	6.4.11.1.1	Ch 3, Sec 2, [12.1.1]
6.4.11.1.2	6.4.11.1.2	Ch 3, Sec 2, [12.1.2]
6.4.11.1.3	6.4.11.1.3	Ch 3, Sec 2, [12.1.3]
6.4.11.2	6.4.11.2	Ch 3, Sec 2, [12.2]
6.4.11.2.1	6.4.11.2.1	Ch 3, Sec 2, [12.2.1]
6.4.11.2.2	6.4.11.2.2	Ch 3, Sec 2, [12.2.2]
6.4.11.2.3	6.4.11.2.3	Ch 3, Sec 2, [12.2.3]
6.4.12	6.4.12	Ch 3, Sec 2, [13]
		Ch 3, Sec 2, [13.1.1]
–	C6.4.12	Ch 3, Sec 2, [13.1.2]
6.4.12.1	6.4.12.1	Ch 3, Sec 2, [13.2]
6.4.12.1.1	6.4.12.1.1	Ch 3, Sec 2, [13.2.1]
6.4.12.1.1.1	6.4.12.1.1.1	Ch 3, Sec 2, [13.2.2]
6.4.12.1.1.2	6.4.12.1.1.2	Ch 3, Sec 2, [13.2.3]
6.4.12.1.1.3	6.4.12.1.1.3	Ch 3, Sec 2, [13.2.4]
6.4.12.1.1.4	6.4.12.1.1.4	Ch 3, Sec 2, [13.2.5]
6.4.12.1.1.5	6.4.12.1.1.5	Ch 3, Sec 2, [13.2.6]
6.4.12.1.1.6	6.4.12.1.1.6	Ch 3, Sec 2, [13.2.7]
6.4.12.2	6.4.12.2	Ch 3, Sec 2, [13.3]
6.4.12.2.1	6.4.12.2.1	Ch 3, Sec 2, [13.3.1]
6.4.12.2.2	6.4.12.2.2	Ch 3, Sec 2, [13.3.2]
6.4.12.2.3	6.4.12.2.3	Ch 3, Sec 2, [13.3.3]
6.4.12.2.4	6.4.12.2.4	Ch 3, Sec 2, [13.3.4]
6.4.12.2.5	6.4.12.2.5	Ch 3, Sec 2, [13.3.5]
6.4.12.2.6	6.4.12.2.6	Ch 3, Sec 2, [13.3.6]
6.4.12.2.6.1	6.4.12.2.6.1	Ch 3, Sec 2, [13.3.7]
6.4.12.2.6.2	6.4.12.2.6.2	Ch 3, Sec 2, [13.3.8]
6.4.12.2.6.3	6.4.12.2.6.3	Ch 3, Sec 2, [13.3.9]
6.4.12.2.6.4	6.4.12.2.6.4	
6.4.12.2.6.5	6.4.12.2.6.5	
6.4.12.2.7	6.4.12.2.7	
6.4.12.2.8	6.4.12.2.8	
6.4.12.2.9	6.4.12.2.9	

Table 5 : Correspondence between Chapter 6 of IMO IGF Code, NR529 (edition January 2025) and Current NR529

Continued from Table 6, Continued to Table 8

IGF Code	NR529 Jan. 2025	Current NR529
–	C6.4.12.2	Ch 3, Sec 2, [13.3.10]
6.4.12.3	6.4.12.3	Ch 3, Sec 2, [13.4]
6.4.12.3.1	6.4.12.3.1	Ch 3, Sec 2, [13.4.1]
6.4.12.3.2	6.4.12.3.2	Ch 3, Sec 2, [13.4.2]
6.4.13	6.4.13	Ch 3, Sec 2, [14]
6.4.13.1	6.4.13.1	Ch 3, Sec 2, [14.1]
6.4.13.1.1	6.4.13.1.1	Ch 3, Sec 2, [14.1]
6.4.13.1.1.1 6.4.13.1.1.1.1 6.4.13.1.1.1.2 6.4.13.1.1.1.3 6.4.13.1.1.1.4 6.4.13.1.1.1.5 6.4.13.1.1.1.6 6.4.13.1.1.1.7 6.4.13.1.1.1.8 6.4.13.1.1.1.9	6.4.13.1.1.1 6.4.13.1.1.1.1 6.4.13.1.1.1.2 6.4.13.1.1.1.3 6.4.13.1.1.1.4 6.4.13.1.1.1.5 6.4.13.1.1.1.6 6.4.13.1.1.1.7 6.4.13.1.1.1.8 6.4.13.1.1.1.9	Ch 3, Sec 2, [14.1.1]
6.4.13.1.1.2	6.4.13.1.1.2	Ch 3, Sec 2, [14.1.2]
6.4.13.1.1.3 6.4.13.1.1.3.1 6.4.13.1.1.3.2	6.4.13.1.1.3 6.4.13.1.1.3.1 6.4.13.1.1.3.2	Ch 3, Sec 2, [14.1.3]
–	C6.4.13.1.1.3.2	Ch 3, Sec 2, [14.1.3]
6.4.13.1.1.3.3	6.4.13.1.1.3.3	Ch 3, Sec 2, [14.1.3]
–	C6.4.13.1.1.3	Ch 3, Sec 2, [14.1.3]
6.4.13.1.1.4 6.4.13.1.1.4.1 6.4.13.1.1.4.2 6.4.13.1.1.4.3	6.4.13.1.1.4 6.4.13.1.1.4.1 6.4.13.1.1.4.2 6.4.13.1.1.4.3	Ch 3, Sec 2, [14.1.4]
6.4.13.2	6.4.13.2	Ch 3, Sec 2, [14.2]
6.4.13.2.1	6.4.13.2.1	Ch 3, Sec 2, [14.2.1]
6.4.13.2.2	6.4.13.2.2	Ch 3, Sec 2, [14.2.2]

IGF Code	NR529 Jan. 2025	Current NR529
6.4.13.2.3 6.4.13.2.3.1 6.4.13.2.3.2 6.4.13.2.3.3 6.4.13.2.3.4 6.4.13.2.3.5 6.4.13.2.3.6 6.4.13.2.3.7 6.4.13.2.3.8 6.4.13.2.3.9	6.4.13.2.3 6.4.13.2.3.1 6.4.13.2.3.2 6.4.13.2.3.3 6.4.13.2.3.4 6.4.13.2.3.5 6.4.13.2.3.6 6.4.13.2.3.7 6.4.13.2.3.8 6.4.13.2.3.9	Ch 3, Sec 2, [14.2.3]
6.4.13.2.4	6.4.13.2.4	Ch 3, Sec 2, [14.2.4]
6.4.13.2.5	6.4.13.2.5	Ch 3, Sec 2, [14.2.5]
6.4.13.2.6	6.4.13.2.6	Ch 3, Sec 2, [14.2.6]
6.4.13.3	6.4.13.3	Ch 3, Sec 2, [14.3]
6.4.13.3.1	6.4.13.3.1	Ch 3, Sec 2, [14.3.1]
6.4.13.3.2 6.4.13.3.2.1 6.4.13.3.2.2 6.4.13.3.2.3 6.4.13.3.2.4 6.4.13.3.2.5 6.4.13.3.2.6 6.4.13.3.2.7 6.4.13.3.2.8 6.4.13.3.2.9 6.4.13.3.2.10 6.4.13.3.2.11 6.4.13.3.2.12 6.4.13.3.2.13 6.4.13.3.2.14	6.4.13.3.2 6.4.13.3.2.1 6.4.13.3.2.2 6.4.13.3.2.3 6.4.13.3.2.4 6.4.13.3.2.5 6.4.13.3.2.6 6.4.13.3.2.7 6.4.13.3.2.8 6.4.13.3.2.9 6.4.13.3.2.10 6.4.13.3.2.11 6.4.13.3.2.12 6.4.13.3.2.13 6.4.13.3.2.14	Ch 3, Sec 2, [14.3.2]
6.4.13.3.3	6.4.13.3.3	Ch 3, Sec 2, [14.3.3]
6.4.13.3.4	6.4.13.3.4	Ch 3, Sec 2, [14.3.4]
6.4.13.3.5	6.4.13.3.5	Ch 3, Sec 2, [14.3.5]
6.4.13.3.6	6.4.13.3.6	Ch 3, Sec 2, [14.3.6]
6.4.13.3.7	6.4.13.3.7	Ch 3, Sec 2, [14.3.7]
–	C6.4.13.3(a)	Ch 3, Sec 2, [14.3.8]

IGF Code	NR529 Jan. 2025	Current NR529
–	C6.4.13.3(b)	Ch 3, Sec 2, [14.3.9]
–	C6.4.13.3(c)	Ch 3, Sec 2, [14.3.10]
6.4.14	6.4.14	Ch 3, Sec 2, [15]
6.4.14.1	6.4.14.1	Ch 3, Sec 2, [15.1]
6.4.14.1.1	6.4.14.1.1	Ch 3, Sec 2, [15.1.1]
–	C6.4.14.1.1	Ch 3, Sec 2, [15.1.1]
6.4.14.1.2 6.4.14.1.2.1 6.4.14.1.2.2	6.4.14.1.2 6.4.14.1.2.1 6.4.14.1.2.2	Ch 3, Sec 2, [15.1.2]
–	C6.4.14.1	Ch 3, Sec 2, [15.1.3]
6.4.14.2	6.4.14.2	Ch 3, Sec 2, [15.2]
6.4.14.2.1	6.4.14.2.1	Ch 3, Sec 2, [15.2.1]
6.4.15	6.4.15	Ch 3, Sec 2, [16]
6.4.15.1	6.4.15.1	Ch 3, Sec 2, [16.1]
6.4.15.1.1	6.4.15.1.1	Ch 3, Sec 2, [16.1.1]
6.4.15.1.1.1	6.4.15.1.1.1	Ch 3, Sec 2, [16.1.1]
6.4.15.1.1.2	6.4.15.1.1.2	Ch 3, Sec 2, [16.1.1]
6.4.15.1.2	6.4.15.1.2	Ch 3, Sec 2, [16.1.2]
6.4.15.1.2.1	6.4.15.1.2.1	Ch 3, Sec 2, [16.1.2]
6.4.15.1.2.2	6.4.15.1.2.2	Ch 3, Sec 2, [16.1.2]
–	C6.4.15.1.2.2	Ch 3, Sec 2, [16.1.2]
6.4.15.1.2.3	6.4.15.1.2.3	Ch 3, Sec 2, [16.1.2]
–	C6.4.15.1.2.3	Ch 3, Sec 2, [16.1.2]
6.4.15.1.3	6.4.15.1.3	Ch 3, Sec 2, [16.1.3]
6.4.15.1.3.1	6.4.15.1.3.1	Ch 3, Sec 2, [16.1.3]
6.4.15.1.3.2	6.4.15.1.3.2	Ch 3, Sec 2, [16.1.3]
–	C6.4.15.1.3.2	Ch 3, Sec 2, [16.1.3]
6.4.15.1.3.3	6.4.15.1.3.3	Ch 3, Sec 2, [16.1.3]
–	C6.4.15.1.3.3	Ch 3, Sec 2, [16.1.3]
6.4.15.1.4	6.4.15.1.4	Ch 3, Sec 2, [16.1.4]
6.4.15.1.4.1	6.4.15.1.4.1	Ch 3, Sec 2, [16.1.4]
6.4.15.1.4.2	6.4.15.1.4.2	Ch 3, Sec 2, [16.1.4]
C6.4.15.1.4(a)	C6.4.15.1.4(a)	Ch 3, Sec 2, [16.1.4]

Table 6 : Correspondence between Chapter 6 of IMO IGF Code, NR529 (edition January 2025) and Current NR529

Continued from Table 7, Continued to Table 9

IGF Code	NR529 Jan. 2025	Current NR529
6.4.15.2	6.4.15.2	Ch 3, Sec 2, [16.2]
6.4.15.2.1	6.4.15.2.1	Ch 3, Sec 2, [16.2.1]
6.4.15.2.1.1	6.4.15.2.1.1	Ch 3, Sec 2, [16.2.1]
6.4.15.2.1.2	6.4.15.2.1.2	Ch 3, Sec 2, [16.2.1]
6.4.15.2.2	6.4.15.2.2	Ch 3, Sec 2, [16.2.2]
6.4.15.2.2.1 6.4.15.2.2.1.1 6.4.15.2.2.1.2 6.4.15.2.2.1.3 6.4.15.2.2.1.4	6.4.15.2.2.1 6.4.15.2.2.1.1 6.4.15.2.2.1.2 6.4.15.2.2.1.3 6.4.15.2.2.1.4	Ch 3, Sec 2, [16.2.2]
6.4.15.2.2.2	6.4.15.2.2.2	Ch 3, Sec 2, [16.2.2]
6.4.15.2.2.3	6.4.15.2.2.3	Ch 3, Sec 2, [16.2.2]
–	C6.4.15.2.2	Ch 3, Sec 2, [16.2.2]
6.4.15.2.3	6.4.15.2.3	Ch 3, Sec 2, [16.2.3] Ch 3, Sec 2, [16.2.4] Ch 3, Sec 2, [16.2.5] Ch 3, Sec 2, [16.2.6] Ch 3, Sec 2, [16.2.7] Ch 3, Sec 2, [16.2.8]
6.4.15.2.3.1 6.4.15.2.3.1.1 6.4.15.2.3.1.2 6.4.15.2.3.1.3	6.4.15.2.3.1 6.4.15.2.3.1.1 6.4.15.2.3.1.2 6.4.15.2.3.1.3	Ch 3, Sec 2, [16.2.3]
–	C6.4.15.2.3.1	Ch 3, Sec 2, [16.2.3]
–	C6.4.15.2.3.1 a)	Ch 3, Sec 2, [16.2.3]
–	C6.4.15.2.3.1 b)	Ch 3, Sec 2, [16.2.3]
6.4.15.2.3.2	6.4.15.2.3.2	Ch 3, Sec 2, [16.2.4]
–	C6.4.15.2.3.2	Ch 3, Sec 2, [16.2.4]
6.4.15.2.3.3	6.4.15.2.3.3	Ch 3, Sec 2, [16.2.5]
6.4.15.2.3.3.1	6.4.15.2.3.3.1	Ch 3, Sec 2, [16.2.5]

IGF Code	NR529 Jan. 2025	Current NR529
6.4.15.2.3.3.2	6.4.15.2.3.3.2	Ch 3, Sec 2, [16.2.5]
6.4.15.2.3.3.3	6.4.15.2.3.3.3	Ch 3, Sec 2, [16.2.5]
–	C6.4.15.2.3.3	Ch 3, Sec 2, [16.2.5]
6.4.15.2.3.4	6.4.15.2.3.4	Ch 3, Sec 2, [16.2.6]
–	C6.4.15.2.3.4(a)	Ch 3, Sec 2, [16.2.6]
6.4.15.2.3.4.1	6.4.15.2.3.4.1	Ch 3, Sec 2, [16.2.6]
6.4.15.2.3.4.2	6.4.15.2.3.4.2	Ch 3, Sec 2, [16.2.6]
6.4.15.2.3.5	6.4.15.2.3.5	Ch 3, Sec 2, [16.2.7]
6.4.15.2.3.6 6.4.15.2.3.6.1 6.4.15.2.3.6.2 6.4.15.2.3.6.3 6.4.15.2.3.6.4 6.4.15.2.3.6.5 6.4.15.2.3.6.6 6.4.15.2.3.6.7 6.4.15.2.3.6.8	6.4.15.2.3.6 6.4.15.2.3.6.1 6.4.15.2.3.6.2 6.4.15.2.3.6.3 6.4.15.2.3.6.4 6.4.15.2.3.6.5 6.4.15.2.3.6.6 6.4.15.2.3.6.7 6.4.15.2.3.6.8	Ch 3, Sec 2, [16.2.8]
6.4.15.3	6.4.15.3	Ch 3, Sec 2, [16.3]
6.4.15.3.1	6.4.15.3.1	Ch 3, Sec 2, [16.3.1]
6.4.15.3.1.1	6.4.15.3.1.1	Ch 3, Sec 2, [16.3.1]
–	C6.4.15.3.1.1	Ch 3, Sec 2, [16.3.1]
6.4.15.3.1.2	6.4.15.3.1.2	Ch 3, Sec 2, [16.3.1]
6.4.15.3.2	6.4.15.3.2	Ch 3, Sec 2, [16.3.2]
6.4.15.3.2.1 6.4.15.3.2.1.1 6.4.15.3.2.1.2 6.4.15.3.2.1.3	6.4.15.3.2.1 6.4.15.3.2.1.1 6.4.15.3.2.1.2 6.4.15.3.2.1.3	Ch 3, Sec 2, [16.3.2]
6.4.15.3.2.2	6.4.15.3.2.2	Ch 3, Sec 2, [16.3.2]
6.4.15.3.2.3	6.4.15.3.2.3	Ch 3, Sec 2, [16.3.2]

IGF Code	NR529 Jan. 2025	Current NR529
6.4.15.3.2.4	6.4.15.3.2.4	Ch 3, Sec 2, [16.3.2]
6.4.15.3.2.5 6.4.15.3.2.5.1 6.4.15.3.2.5.2 6.4.15.3.2.5.3	6.4.15.3.2.5 6.4.15.3.2.5.1 6.4.15.3.2.5.2 6.4.15.3.2.5.3	Ch 3, Sec 2, [16.3.2]
6.4.15.3.3	6.4.15.3.3	Ch 3, Sec 2, [16.3.3]
6.4.15.3.3.1	6.4.15.3.3.1	Ch 3, Sec 2, [16.3.3]
6.4.15.3.3.2	6.4.15.3.3.2	Ch 3, Sec 2, [16.3.3]
–	C6.4.15.3.3(a)	Ch 3, Sec 2, [16.3.3]
–	C6.4.15.3.3(b)	Ch 3, Sec 2, [16.3.3]
6.4.15.3.4	6.4.15.3.4	Ch 3, Sec 2, [16.3.4]
6.4.15.3.4.1	6.4.15.3.4.1	Ch 3, Sec 2, [16.3.4]
6.4.15.3.4.2	6.4.15.3.4.2	Ch 3, Sec 2, [16.3.4]
6.4.15.3.5	6.4.15.3.5	Ch 3, Sec 2, [16.3.5]
6.4.15.3.5.1	6.4.15.3.5.1	Ch 3, Sec 2, [16.3.5]
6.4.15.3.5.2	6.4.15.3.5.2	Ch 3, Sec 2, [16.3.5]
–	C6.4.15.3.5	Ch 3, Sec 2, [16.3.5]
6.4.15.3.6	6.4.15.3.6	Ch 3, Sec 2, [16.3.6]
6.4.15.4	6.4.15.4	Ch 3, Sec 2, [16.4]
6.4.15.4.1	6.4.15.4.1	Ch 3, Sec 2, [16.4.1]
6.4.15.4.1.1	6.4.15.4.1.1	Ch 3, Sec 2, [16.4.1]
6.4.15.4.1.2	6.4.15.4.1.2	Ch 3, Sec 2, [16.4.1]
6.4.15.4.1.3	6.4.15.4.1.3	Ch 3, Sec 2, [16.4.1]
6.4.15.4.1.4	6.4.15.4.1.4	Ch 3, Sec 2, [16.4.1]
6.4.15.4.1.5	6.4.15.4.1.5	Ch 3, Sec 2, [16.4.1]
6.4.15.4.1.6	6.4.15.4.1.6	Ch 3, Sec 2, [16.4.1]
6.4.15.4.1.7	6.4.15.4.1.7	Ch 3, Sec 2, [16.4.1]
6.4.15.4.2	6.4.15.4.2	Ch 3, Sec 2, [16.4.2]

Table 7 : Correspondence between Chapter 6 of IMO IGF Code, NR529 (edition January 2025) and Current NR529

Continued from Table 8, Continued to Table 10

IGF Code	NR529 Jan. 2025	Current NR529
6.4.15.4.2.1	6.4.15.4.2.1	Ch 3, Sec 2, [16.4.2]
6.4.15.4.2.1.1	6.4.15.4.2.1.1	
6.4.15.4.2.1.1.1	6.4.15.4.2.1.1.1	
6.4.15.4.2.1.1.2	6.4.15.4.2.1.1.2	
6.4.15.4.2.1.1.3	6.4.15.4.2.1.1.3	
6.4.15.4.2.1.1.4	6.4.15.4.2.1.1.4	
6.4.15.4.2.1.1.5	6.4.15.4.2.1.1.5	
6.4.15.4.2.1.1.6	6.4.15.4.2.1.1.6	
6.4.15.4.2.1.1.7	6.4.15.4.2.1.1.7	
6.4.15.4.2.1.2	6.4.15.4.2.1.2	
6.4.15.4.2.1.2.1	6.4.15.4.2.1.2.1	
6.4.15.4.2.1.2.2	6.4.15.4.2.1.2.2	
6.4.15.4.2.1.2.3	6.4.15.4.2.1.2.3	
6.4.15.4.2.1.2.4	6.4.15.4.2.1.2.4	
6.4.15.4.2.1.3	6.4.15.4.2.1.3	
6.4.15.4.2.1.3.1	6.4.15.4.2.1.3.1	
6.4.15.4.2.1.3.2	6.4.15.4.2.1.3.2	
6.4.15.4.2.1.3.3	6.4.15.4.2.1.3.3	
6.4.15.4.2.1.3.4	6.4.15.4.2.1.3.4	
6.4.15.4.2.2	6.4.15.4.2.2	Ch 3, Sec 2, [16.4.2]
6.4.15.4.3	6.4.15.4.3	Ch 3, Sec 2, [16.4.3]
6.4.15.4.4	6.4.15.4.4	Ch 3, Sec 2, [16.4.4]
6.4.15.4.4.1	6.4.15.4.4.1	Ch 3, Sec 2, [16.4.4]
6.4.15.4.4.2	6.4.15.4.4.2	Ch 3, Sec 2, [16.4.4]
6.4.15.4.4.3	6.4.15.4.4.3	Ch 3, Sec 2, [16.4.4]
6.4.15.4.5	6.4.15.4.5	Ch 3, Sec 2, [16.4.5]
6.4.15.4.5.1	6.4.15.4.5.1	Ch 3, Sec 2, [16.4.5]
6.4.15.4.5.2	6.4.15.4.5.2	Ch 3, Sec 2, [16.4.5]
6.4.15.4.5.3	6.4.15.4.5.3	Ch 3, Sec 2, [16.4.5]
–	C6.4.15.4.5	Ch 3, Sec 2, [16.4.5]
6.4.15.4.6	6.4.15.4.6	Ch 3, Sec 2, [16.4.6]
6.4.15.4.6.1	6.4.15.4.6.1	Ch 3, Sec 2, [16.4.6]
6.4.15.4.6.2	6.4.15.4.6.2	Ch 3, Sec 2, [16.4.6]
6.4.15.4.6.2.1	6.4.15.4.6.2.1	
6.4.15.4.6.2.2	6.4.15.4.6.2.2	

IGF Code	NR529 Jan. 2025	Current NR529
6.4.15.4.6.3	6.4.15.4.6.3	Ch 3, Sec 2, [16.4.6]
6.4.15.4.6.4	6.4.15.4.6.4	Ch 3, Sec 2, [16.4.6]
6.4.15.4.6.5	6.4.15.4.6.5	Ch 3, Sec 2, [16.4.6]
6.4.15.4.7	6.4.15.4.7	Ch 3, Sec 2, [16.4.7]
6.4.15.4.7.1	6.4.15.4.7.1	Ch 3, Sec 2, [16.4.7]
6.4.15.4.7.2	6.4.15.4.7.2	Ch 3, Sec 2, [16.4.7]
–	C6.4.15.4.7	Ch 3, Sec 2, [16.4.7]
6.4.16	6.4.16	Ch 3, Sec 2, [17]
6.4.16.1	6.4.16.1	Ch 3, Sec 2, [17.1.1]
6.4.16.2	6.4.16.2	Ch 3, Sec 2, [17.1.2]
6.4.16.3	6.4.16.3	Ch 3, Sec 2, [17.1.3]
6.4.16.3.1	6.4.16.3.1	
6.4.16.3.2	6.4.16.3.2	
6.4.16.3.3	6.4.16.3.3	
6.4.16.4	6.4.16.4	Ch 3, Sec 2, [17.1.4]
6.5	6.5	Ch 3, Sec 3
6.5.1	6.5.1	Ch 3, Sec 3, [1.1.1]
6.5.2	6.5.2	Ch 3, Sec 3, [1.1.2]
6.5.2.1	6.5.2.1	
6.5.2.2	6.5.2.2	
6.5.2.3	6.5.2.3	
–	C6.5.2	Ch 3, Sec 3, [1.1.3]
6.5.3	6.5.3	Ch 3, Sec 3, [1.1.4]
–	C6.5.3	Ch 3, Sec 3, [1.1.4]
6.5.4	6.5.4	Ch 3, Sec 3, [1.1.5]
6.5.5	6.5.5	Ch 3, Sec 3, [1.1.6]
–	C6.5.5	Ch 3, Sec 3, [1.1.7]
6.5.6	6.5.6	Ch 3, Sec 3, [1.1.8]
6.5.7	6.5.7	Ch 3, Sec 3, [1.1.9]
–	C6.5.7	Ch 3, Sec 3, [1.1.10]
6.5.8	6.5.8	Ch 3, Sec 3, [1.1.11]
6.5.9	6.5.9	Ch 3, Sec 3, [1.1.12]

IGF Code	NR529 Jan. 2025	Current NR529
6.5.10	6.5.10	Ch 3, Sec 3, [1.1.13]
6.5.10.1	6.5.10.1	
6.5.10.2	6.5.10.2	
6.5.10.3	6.5.10.3	
–	C6.5(a)	Ch 3, Sec 3, [1.1.14]
6.6	6.6	Ch 3, Sec 4
		Ch 3, Sec 4, [1]
6.6.1	6.6.1	Ch 3, Sec 4, [1.1.1]
6.6.2	6.6.2	Ch 3, Sec 4, [1.1.2]
6.6.3	6.6.3	Ch 3, Sec 4, [1.1.3]
6.6.4	6.6.4	Ch 3, Sec 4, [1.1.4]
6.6.4.1	6.6.4.1	
6.6.4.2	6.6.4.2	
6.6.4.3	6.6.4.3	
6.7	6.7	Ch 3, Sec 5
6.7.1	6.7.1	Ch 3, Sec 5, [1]
6.7.1.1	6.7.1.1	Ch 3, Sec 5, [1.1.1]
–	C6.7.1.1	Ch 3, Sec 5, [1.1.2]
6.7.1.2	6.7.1.2	Ch 3, Sec 5, [1.1.3]
6.7.2	6.7.2	Ch 3, Sec 5, [2]
–	C6.7.2(a)	Ch 3, Sec 5, [2.1.1]
6.7.2.1	6.7.2.1	Ch 3, Sec 5, [2.1.2]
–	C6.7.2.1	Ch 3, Sec 5, [2.1.3]
6.7.2.2	6.7.2.2	Ch 3, Sec 5, [2.1.4]
6.7.2.3	6.7.2.3	Ch 3, Sec 5, [2.1.5]
6.7.2.4	6.7.2.4	Ch 3, Sec 5, [2.1.6]
6.7.2.5	6.7.2.5	Ch 3, Sec 5, [2.1.7]
6.7.2.5.1	6.7.2.5.1	
6.7.2.5.2	6.7.2.5.2	
6.7.2.5.3	6.7.2.5.3	
6.7.2.5.4	6.7.2.5.4	

Table 8 : Correspondence between Chapter 6 of IMO IGF Code, NR529 (edition January 2025) and Current NR529

Continued from Table 9

IGF Code	NR529 Jan. 2025	Current NR529
6.7.2.6 6.7.2.6.1 6.7.2.6.2 6.7.2.6.3	6.7.2.6 6.7.2.6.1 6.7.2.6.2 6.7.2.6.3	Ch 3, Sec 5, [2.1.8]
6.7.2.7 6.7.2.7.1 6.7.2.7.2 6.7.2.7.3	6.7.2.7 6.7.2.7.1 6.7.2.7.2 6.7.2.7.3	Ch 3, Sec 5, [2.1.9]
–	C6.7.2.7	Ch 3, Sec 5, [2.1.10]
6.7.2.8 6.7.2.8.1 6.7.2.8.2	6.7.2.8 6.7.2.8.1 6.7.2.8.2	Ch 3, Sec 5, [2.1.11]
6.7.2.9	6.7.2.9	Ch 3, Sec 5, [2.1.12]
6.7.2.10	6.7.2.10	Ch 3, Sec 5, [2.1.13]
–	C6.7.2.10	Ch 3, Sec 5, [2.1.14]
6.7.2.11	6.7.2.11	Ch 3, Sec 5, [2.1.15]
6.7.2.12	6.7.2.12	Ch 3, Sec 5, [2.1.16]
6.7.2.13	6.7.2.13	Ch 3, Sec 5, [2.1.17]
6.7.3	6.7.3	Ch 3, Sec 5, [3]
6.7.3.1	6.7.3.1	Ch 3, Sec 5, [3.1]
6.7.3.1.1 6.7.3.1.1.1 6.7.3.1.1.2	6.7.3.1.1 6.7.3.1.1.1 6.7.3.1.1.2	Ch 3, Sec 5, [3.1.1]
–	C6.7.3.1.1	Ch 3, Sec 5, [3.1.2]
6.7.3.1.2	6.7.3.1.2	Ch 3, Sec 5, [3.1.3]
6.7.3.1.3	6.7.3.1.3	Ch 3, Sec 5, [3.1.4]
6.7.3.2	6.7.3.2	Ch 3, Sec 5, [3.2]
6.7.3.2.1	6.7.3.2.1	Ch 3, Sec 5, [3.2.1]
6.7.3.2.2 6.7.3.2.2.1 6.7.3.2.2.2 6.7.3.2.2.3	6.7.3.2.2 6.7.3.2.2.1 6.7.3.2.2.2 6.7.3.2.2.3	Ch 3, Sec 5, [3.2.2]
6.7.3.2.3 6.7.3.2.3.1 6.7.3.2.3.2 6.7.3.2.3.2.1 6.7.3.2.3.2.2 6.7.3.2.3.2.3	6.7.3.2.3 6.7.3.2.3.1 6.7.3.2.3.2 6.7.3.2.3.2.1 6.7.3.2.3.2.2 6.7.3.2.3.2.3	Ch 3, Sec 5, [3.2.3]
6.7.3.2.4	6.7.3.2.4	Ch 3, Sec 5, [3.2.4]
6.8	6.8	Ch 3, Sec 6 Ch 3, Sec 6, [1.1]
6.8.1	6.8.1	Ch 3, Sec 6, [1.1.1]
6.8.2	6.8.2	–
6.8.3	6.8.3	Ch 3, Sec 6, [1.1.2]
–	C6.8.3	Ch 3, Sec 6, [1.1.3]
6.9	6.9	Ch 3, Sec 7
6.9.1	6.9.1	Ch 3, Sec 7, [1]
6.9.1.1 6.9.1.1.1 6.9.1.1.2 6.9.1.1.3 6.9.1.1.4	6.9.1.1 6.9.1.1.1 6.9.1.1.2 6.9.1.1.3 6.9.1.1.4	Ch 3, Sec 7, [1.1.1]
–	C6.9.1.1	Ch 3, Sec 7, [1.1.2]
6.9.1.2	6.9.1.2	Ch 3, Sec 7, [1.1.3]
6.9.2	6.9.2	Ch 3, Sec 7, [2]
6.9.2.1	6.9.2.1	Ch 3, Sec 7, [2.1.1]
6.9.2.2	6.9.2.2	Ch 3, Sec 7, [2.1.2]
6.9.3	6.9.3	Ch 3, Sec 7, [3]
6.9.3.1	6.9.3.1	Ch 3, Sec 7, [3.1.1]
6.9.3.2 6.9.3.2.1 6.9.3.2.2 6.9.3.2.3 6.9.3.2.4	6.9.3.2 6.9.3.2.1 6.9.3.2.2 6.9.3.2.3 6.9.3.2.4	Ch 3, Sec 7, [3.1.2]
6.9.4	6.9.4	Ch 3, Sec 7, [4]
6.9.4.1	6.9.4.1	Ch 3, Sec 7, [4.1.1]
–	C6.9.4.1	Ch 3, Sec 7, [4.1.2]
6.9.5	6.9.5	Ch 3, Sec 7, [5]
6.9.5.1	6.9.5.1	Ch 3, Sec 7, [5.1.1]
6.9.6	6.9.6	Ch 3, Sec 7, [6]
6.9.6.1	6.9.6.1	Ch 3, Sec 7, [6.1.1]
–	C6.9.6.1	Ch 3, Sec 7, [6.1.2]
6.9.6.2	6.9.6.2	Ch 3, Sec 7, [6.1.3]
–	C6.9.6.2	Ch 3, Sec 7, [6.1.4]
6.10	6.10	Ch 3, Sec 8
6.10.1	6.10.1	Ch 3, Sec 8, [1.1.1]
6.10.2	6.10.2	Ch 3, Sec 8, [1.1.2]
6.10.3	6.10.3	Ch 3, Sec 8, [1.1.3]
6.10.4	6.10.4	Ch 3, Sec 8, [1.1.4]
6.11	6.11	Ch 3, Sec 9
6.11.1	6.11.1	Ch 3, Sec 9, [1.1.1]
6.11.2	6.11.2	Ch 3, Sec 9, [1.1.2]
6.12	6.12	Ch 3, Sec 10
6.12.1	6.12.1	Ch 3, Sec 10, [1.1.1]
–	C6.12.1	Ch 3, Sec 10, [1.1.2]
6.13	6.13	Ch 3, Sec 11
6.13.1	6.13.1	Ch 3, Sec 11, [1.1.1]
6.13.2	6.13.2	Ch 3, Sec 11, [1.1.2]
6.13.3	6.13.3	Ch 3, Sec 11, [1.1.3]
6.13.4	6.13.4	Ch 3, Sec 11, [1.1.4]
6.13.5	6.13.5	Ch 3, Sec 11, [1.1.5]
6.14	6.14	Ch 3, Sec 12
6.14.1	6.14.1	Ch 3, Sec 12, [1.1.1]
6.14.2	6.14.2	Ch 3, Sec 12, [1.1.2]
6.14.3	6.14.3	Ch 3, Sec 12, [1.1.3]
6.14.4	6.14.4	Ch 3, Sec 12, [1.1.4]

Table 9 : Correspondence between Chapter 7 of IMO IGF Code, NR529 (edition January 2025) and Current NR529

IGF Code	NR529 Jan. 2025	Current NR529
7 Material and General Pipe Design	7 General Pipe Design	
7	7	Chapter 4 Ch 5, Sec 1
7.1	7.1	–
7.1.1	7.1.1	–
7.2	7.2	Ch 5, Sec 1, [1.1]
7.2.1	7.2.1	Ch 5, Sec 1, [1.1.1]
7.2.1.1	7.2.1.1	Ch 5, Sec 1, [1.1.1]
7.2.1.2	7.2.1.2	Ch 5, Sec 1, [1.1.1]
7.2.1.3	7.2.1.3	Ch 5, Sec 1, [1.1.1]
7.2.1.4	7.2.1.4	Ch 5, Sec 1, [1.1.1]
–	C7.2.1	Ch 5, Sec 1, [1.1.1]
7.3	7.3	Ch 5, Sec 1
–	C7.3(a)	Ch 5, Sec 1, [1.2]
7.3.1	7.3.1	Ch 5, Sec 1, [2.2]
–	C7.3.1(a)	Ch 5, Sec 1, [2.2.1]
7.3.1.1	7.3.1.1	Ch 5, Sec 1, [2.2.2]
7.3.1.2	7.3.1.2	Ch 5, Sec 1, [2.2.3]
–	C7.3.1.2	Ch 5, Sec 1, [2.2.4]
7.3.1.3	7.3.1.3	Ch 5, Sec 1, [2.2.5]
–	C7.3.1.3	Ch 5, Sec 1, [2.2.6]
7.3.1.4	7.3.1.4	Ch 5, Sec 1, [2.2.7]
7.3.1.5	7.3.1.5	Ch 5, Sec 1, [2.2.8]
–	C7.3.1.5	Ch 5, Sec 1, [2.2.9]

IGF Code	NR529 Jan. 2025	Current NR529
7.3.2	7.3.2	Ch 5, Sec 1, [3]
7.3.2.1	7.3.2.1	Ch 5, Sec 1, [3.1.1]
7.3.2.2	7.3.2.2	Ch 5, Sec 1, [3.1.2]
7.3.3	7.3.3	Ch 5, Sec 1, [3.2]
7.3.3.1 7.3.3.1.1 7.3.3.1.2 7.3.3.1.3 7.3.3.1.4 7.3.3.1.5	7.3.3.1 7.3.3.1.1 7.3.3.1.2 7.3.3.1.3 7.3.3.1.4 7.3.3.1.5	Ch 5, Sec 1, [3.2.1]
7.3.3.2	7.3.3.2	Ch 5, Sec 1, [3.2.2]
–	C7.3.3	Ch 5, Sec 1, [3.2.3]
7.3.4	7.3.4	Ch 5, Sec 1, [3.3]
7.3.4.1	7.3.4.1	Ch 5, Sec 1, [3.3.1]
7.3.4.2	7.3.4.2	Ch 5, Sec 1, [3.3.2]
7.3.4.3	7.3.4.3	Ch 5, Sec 1, [3.3.3]
7.3.4.4 7.3.4.4.1 7.3.4.4.2 7.3.4.4.3	7.3.4.4 7.3.4.4.1 7.3.4.4.2 7.3.4.4.3	Ch 5, Sec 1, [3.3.4]
7.3.4.5	7.3.4.5	Ch 5, Sec 1, [3.3.5]
7.3.5	7.3.5	Ch 5, Sec 1, [2.3]
7.3.5.1	7.3.5.1	Ch 5, Sec 1, [2.3.1]
7.3.6	7.3.6	Ch 5, Sec 1, [4]
7.3.6.1	7.3.6.1	Ch 5, Sec 1, [4.1.1]
7.3.6.2	7.3.6.2	Ch 5, Sec 1, [4.1.2]

IGF Code	NR529 Jan. 2025	Current NR529
–	C7.3.6.2	Ch 5, Sec 1, [4.1.3]
7.3.6.3	7.3.6.3	Ch 5, Sec 1, [4.1.4]
–	C7.3.6.3	Ch 5, Sec 1, [4.1.5]
7.3.6.4 7.3.6.4.1 7.3.6.4.1.1 7.3.6.4.1.2 7.3.6.4.1.3 7.3.6.4.2 7.3.6.4.2.1 7.3.6.4.2.2 7.3.6.4.2.2.1 7.3.6.4.2.2.2 7.3.6.4.3 7.3.6.4.3.1 7.3.6.4.3.2 7.3.6.4.3.3 7.3.6.4.4	7.3.6.4 7.3.6.4.1 7.3.6.4.1.1 7.3.6.4.1.2 7.3.6.4.1.3 7.3.6.4.2 7.3.6.4.2.1 7.3.6.4.2.2 7.3.6.4.2.2.1 7.3.6.4.2.2.2 7.3.6.4.3 7.3.6.4.3.1 7.3.6.4.3.2 7.3.6.4.3.3 7.3.6.4.4	Ch 5, Sec 1, [4.1.6]
7.4	7.4	Ch 4, Sec 1
7.4.1	7.4.1	Ch 4, Sec 1
–	C.7.4.1(a)	Ch 4, Sec 1, [1.1.1]
7.4.1.1	7.4.1.1	Ch 4, Sec 1, [1.1.2]
–	C7.4.1.1	Ch 4, Sec 1, [1.1.3]
7.4.1.2	7.4.1.2	Ch 4, Sec 1, [1.1.4]
7.4.1.3	7.4.1.3	Ch 4, Sec 1, [1.1.5]
7.4.1.4	7.4.1.4	Ch 4, Sec 1, [1.1.6]
7.4.1.5	7.4.1.5	Ch 4, Sec 1, [1.1.7]

Table 10 : Correspondence between Chapters 8 and 9 of IMO IGF Code, NR529 (edition January 2025) and Current NR529

IGF Code	NR529 Jan. 2025	Current NR529
8 Bunkering		
8	8	Ch 6, Sec 1
8.1	8.1	–
8.2	8.2	Ch 6, Sec 1, [1]
8.3	8.3	Ch 6, Sec 1, [2]
8.3.1	8.3.1	Ch 6, Sec 1, [2.1]
8.3.1.1	8.3.1.1	Ch 6, Sec 1, [2.1.1]
–	C8.3.1.1	Ch 6, Sec 1, [2.1.2]
8.3.1.2	8.3.1.2	Ch 6, Sec 1, [2.1.3]
8.3.1.3	8.3.1.3	Ch 6, Sec 1, [2.1.4]
8.3.1.4	8.3.1.4	Ch 6, Sec 1, [2.1.5]
8.3.1.5	8.3.1.5	Ch 6, Sec 1, [2.1.6]
–	C8.3.1.5	Ch 6, Sec 1, [2.1.7]
8.3.1.6	8.3.1.6	Ch 6, Sec 1, [2.1.8]
–	C8.3.1(a)	Ch 6, Sec 1, [2.1.9]
8.3.2	8.3.2	Ch 6, Sec 1, [2.2]
8.3.2.1	8.3.2.1	Ch 6, Sec 1, [2.2.1]
8.3.2.2	8.3.2.2	Ch 6, Sec 1, [2.2.2]
8.4	8.4	Ch 6, Sec 1, [3]
8.4.1	8.4.1	Ch 6, Sec 1, [3.1.1]
–	C8.4.1	Ch 6, Sec 1, [3.1.4]
–	C8.4(a)	Ch 6, Sec 1, [3.1.6]
8.5	8.5	Ch 6, Sec 1, [4]
8.5.1	8.5.1	Ch 6, Sec 1, [4.1.1]
–	C8.5.1	Ch 6, Sec 1, [4.1.2]
8.5.2	8.5.2	Ch 6, Sec 1, [4.1.3]
8.5.3	8.5.3	Ch 6, Sec 1, [4.1.4]
8.5.4	8.5.4	Ch 6, Sec 1, [4.1.5]
–	C8.5.4	Ch 6, Sec 1, [4.1.6]

IGF Code	NR529 Jan. 2025	Current NR529
8.5.5	8.5.5	Ch 6, Sec 1, [4.1.7]
–	C8.5.5	Ch 6, Sec 1, [4.1.8]
8.5.6	8.5.6	Ch 6, Sec 1, [4.1.9]
8.5.7	8.5.7	Ch 6, Sec 1, [4.1.10]
8.5.8	8.5.8	Ch 6, Sec 1, [4.1.11]
–	C8.5	Ch 6, Sec 1, [4.2]
8.3	8.3	Ch 6, Sec 1, [2]
8.3.1	8.3.1	Ch 6, Sec 1, [2.1]
8.3.1.1	8.3.1.1	Ch 6, Sec 1, [2.1.1]
–	C8.3.1.1	Ch 6, Sec 1, [2.1.2]
8.3.1.2	8.3.1.2	Ch 6, Sec 1, [2.1.3]
8.3.1.3	8.3.1.3	Ch 6, Sec 1, [2.1.4]
8.5.8	8.5.8	Ch 6, Sec 1, [4.1.11]
–	C8.5	Ch 6, Sec 1, [4.2]
9 Fuel Supply to Consumers		
9	9	Ch 5, Sec 2
9.1	9.1	–
9.2	9.2	Ch 5, Sec 2, [1.1.1]
9.2.1	9.2.1	Ch 5, Sec 2, [1.1.1]
9.2.2	9.2.2	Ch 5, Sec 2, [1.1.1]
–	C9.2.2	Ch 5, Sec 2, [1.1.1]
9.2.3	9.2.3	Ch 5, Sec 2, [1.1.1]
9.3	9.3	Ch 5, Sec 2, [1.2]
9.3.1	9.3.1	Ch 5, Sec 2, [1.2.1]
9.3.2	9.3.2	Ch 5, Sec 2, [1.2.2]
9.3.3	9.3.3	Ch 5, Sec 2, [1.2.3]
9.4	9.4	Ch 5, Sec 2, [1.3]
–	C9.4(a)	Ch 5, Sec 2, [1.3.1]

IGF Code	NR529 Jan. 2025	Current NR529
9.4.1	9.4.1	Ch 5, Sec 2, [1.3.2]
–	C9.4.1	Ch 5, Sec 2, [1.3.3]
9.4.2	9.4.2	Ch 5, Sec 2, [1.3.4]
–	C9.4.2	Ch 5, Sec 2, [1.3.5]
9.4.3	9.4.3	Ch 5, Sec 2, [1.3.6]
9.4.4 9.4.4.1 9.4.4.2	9.4.4 9.4.4.1 9.4.4.2	Ch 5, Sec 2, [1.3.7]
9.4.5	9.4.5	Ch 5, Sec 2, [1.3.8]
9.4.6	9.4.6	Ch 5, Sec 2, [1.3.9]
9.4.7	9.4.7	Ch 5, Sec 2, [1.3.10]
9.4.8	9.4.8	Ch 5, Sec 2, [1.3.11]
–	C9.4.8	Ch 5, Sec 2, [1.3.12]
9.4.9	9.4.9	Ch 5, Sec 2, [1.3.13]
9.4.10	9.4.10	Ch 5, Sec 2, [1.3.14]
9.5	9.5	Ch 5, Sec 2, [2]
9.5.1	9.5.1	–
9.5.2	9.5.2	–
9.5.3	9.5.3	–
9.5.4	9.5.4	Ch 5, Sec 2, [2.1.1]
–	C9.5.4	Ch 5, Sec 2, [2.1.2]
9.5.5	9.5.5	Ch 5, Sec 2, [2.1.3]
9.5.6	9.5.6	Ch 5, Sec 2, [2.2.1]
–	C9.5.6	Ch 5, Sec 2, [2.2.2]
9.6	9.6	Ch 5, Sec 2, [3.1]
9.6.1 9.6.1.1 9.6.1.2	9.6.1 9.6.1.1 9.6.1.2	Ch 5, Sec 2, [3.1.1]
–	C9.6.1.2	Ch 5, Sec 2, [3.1.1]

IGF Code	NR529 Jan. 2025	Current NR529
9.6.1.3	9.6.1.3	Ch 5, Sec 2, [3.1.1]
9.6.2	9.6.2	Ch 5, Sec 2, [3.1.2]
9.7	9.7	Ch 5, Sec 2, [3.2]
9.7.1	9.7.1	Ch 5, Sec 2, [3.2.1]
9.7.2	9.7.2	Ch 5, Sec 2, [3.2.2]
–	C9(a)	Ch 5, Sec 2, [1.4]
9.8	9.8	Ch 5, Sec 2, [4]
–	C9.8(a)	Ch 5, Sec 2, [4.1.1]
–	C9.8(b)	Ch 5, Sec 2, [4.1.2]
9.8.1	9.8.1	Ch 5, Sec 2, [4.1.3]
9.8.2 9.8.2.1 9.8.2.2	9.8.2 9.8.2.1 9.8.2.2	Ch 5, Sec 2, [4.1.4]
9.8.3	9.8.3	Ch 5, Sec 2, [4.1.5]
9.8.4	9.8.4	Ch 5, Sec 2, [4.1.6]
–	C9.8.4	Ch 5, Sec 2, [4.1.7]
9.9	9.9	Ch 5, Sec 2, [5.1]
9.9.1	9.9.1	Ch 5, Sec 2, [5.1.1]
9.9.2 9.9.2.1 9.9.2.2 9.9.2.3 9.9.2.4	9.9.2 9.9.2.1 9.9.2.2 9.9.2.3 9.9.2.4	Ch 5, Sec 2, [5.1.2]
–	C9.9.2	Ch 5, Sec 2, [5.1.3]
9.9.3	9.9.3	Ch 5, Sec 2, [5.1.4]
–	C9.9.3	Ch 5, Sec 2, [5.1.6]
9.9.4	9.9.4	Ch 5, Sec 2, [5.1.5]
–	C9(b)	Ch 5, Sec 2, [5.2]
–	C9(c)	Ch 5, Sec 2, [6]

Table 11 : Correspondence between Chapters 10 and 11 of IMO IGF Code, NR529 (edition January 2025) and Current NR529

IGF Code	NR529 Jan. 2025	Current NR529
10 Power Generation including Propulsion and other Gas Consumers		
10	10	Ch 5, Sec 3
10.1	10.1	–
10.1.1	10.1.1	–
10.2 10.2.1 10.2.2 10.2.3 10.2.4	10.2 10.2.1 10.2.2 10.2.3 10.2.4	Ch 5, Sec 3, [1]
10.3	10.3	Ch 5, Sec 3, [2]
10.3.1	10.3.1	Ch 5, Sec 3, [2.1]
10.3.1.1	10.3.1.1	–
10.3.1.1.1	10.3.1.1.1	Ch 5, Sec 3, [2.1.1]
–	C10.3.1.1(a)	Ch 5, Sec 3, [2.1.2]
–	C10.3.1.1(b)	Ch 5, Sec 3, [2.1.3]
10.3.1.2	10.3.1.2	Ch 5, Sec 3, [2.1.4]
10.3.1.3	10.3.1.3	Ch 5, Sec 3, [2.1.5]
–	C10.3.1.3	Ch 5, Sec 3, [2.1.6]
10.3.1.4	10.3.1.4	Ch 5, Sec 3, [2.1.7]
10.3.1.5	10.3.1.5	Ch 5, Sec 3, [2.1.8]
10.3.1.6	10.3.1.6	Ch 5, Sec 3, [2.1.9]
10.3.1.7	10.3.1.7	Ch 5, Sec 3, [2.1.10]
–	C10.3.1.7	Ch 5, Sec 3, [2.1.11]
10.3.2	10.3.2	Ch 5, Sec 3, [2.2]
10.3.2.1	10.3.2.1	Ch 5, Sec 3, [2.2.1]
10.3.2.2	10.3.2.2	Ch 5, Sec 3, [2.2.2]
10.3.2.3	10.3.2.3	Ch 5, Sec 3, [2.2.3]
10.3.3	10.3.3	Ch 5, Sec 3, [2.3] Ch 5, Sec 3, [2.3.1]
10.3.4	10.3.4	Ch 5, Sec 3, [2.4]
10.3.4.1	10.3.4.1	Ch 5, Sec 3, [2.4.1]
10.3.4.2	10.3.4.2	Ch 5, Sec 3, [2.4.2]
10.4	10.4	Ch 5, Sec 3, [3]

IGF Code	NR529 Jan. 2025	Current NR529
10.4.1	10.4.1	Ch 5, Sec 3, [3.1.1]
10.4.2	10.4.2	Ch 5, Sec 3, [3.1.2]
10.4.3	10.4.3	Ch 5, Sec 3, [3.1.3]
10.4.4	10.4.4	Ch 5, Sec 3, [3.1.4]
10.4.5	10.4.5	Ch 5, Sec 3, [3.1.5]
10.4.6	10.4.6	Ch 5, Sec 3, [3.1.6]
10.4.7	10.4.7	Ch 5, Sec 3, [3.1.7]
10.4.8	10.4.8	Ch 5, Sec 3, [3.1.8]
10.4.9	10.4.9	Ch 5, Sec 3, [3.1.9]
10.4.10	10.4.10	Ch 5, Sec 3, [3.1.10]
10.4.11	10.4.11	Ch 5, Sec 3, [3.1.11]
10.5	10.5	Ch 5, Sec 3, [4]
10.5.1	10.5.1	Ch 5, Sec 3, [4.1.1]
10.5.2	10.5.2	Ch 5, Sec 3, [4.1.2]
10.5.3	10.5.3	Ch 5, Sec 3, [4.1.3]
10.5.4	10.5.4	Ch 5, Sec 3, [4.1.4]
10.5.5	10.5.5	Ch 5, Sec 3, [4.1.5]
10.5.6	10.5.6	Ch 5, Sec 3, [4.1.6]
10.5.7	10.5.7	Ch 5, Sec 3, [4.1.7]
–	C10.6	Ch 5, Sec 3, [5]
–	C10.6.1	Ch 5, Sec 3, [5.1.1]
11 Fire Safety		
11	11	Ch 7, Sec 1
11.1	11.1	–
11.2	11.2	Ch 7, Sec 1, [1]
11.3	11.3	Ch 7, Sec 1, [2]
11.3.1	11.3.1	Ch 7, Sec 1, [2.1.1]
–	C11.3.1	Ch 7, Sec 1, [2.1.1] Ch 7, Sec 1, [2.1.2]
11.3.2	11.3.2	Ch 7, Sec 1, [2.1.3]
–	C11.3.2	Ch 7, Sec 1, [2.1.4]
11.3.3	11.3.3	Ch 7, Sec 1, [2.1.5]
11.3.3.1 11.3.3.1.1 11.3.3.1.2	11.3.3.1 11.3.3.1.1 11.3.3.1.2	Ch 7, Sec 1, [2.1.6]

IGF Code	NR529 Jan. 2025	Current NR529
–	C11.3.3	Ch 7, Sec 1, [2.1.5] Ch 7, Sec 1, [2.1.7]
11.3.4	11.3.4	Ch 7, Sec 1, [2.1.8]
11.3.5	11.3.5	Ch 7, Sec 1, [2.1.9]
11.3.6	11.3.6	Ch 7, Sec 1, [2.1.10]
11.3.7	11.3.7	Ch 7, Sec 1, [2.1.11]
–	C11.3.7	Ch 7, Sec 1, [2.1.12]
11.4	11.4	Ch 7, Sec 1, [3]
11.4.1	11.4.1	Ch 7, Sec 1, [3.1.1]
11.4.2	11.4.2	Ch 7, Sec 1, [3.1.2]
11.5	11.5	Ch 7, Sec 1, [4]
11.5.1	11.5.1	Ch 7, Sec 1, [4.1.1]
–	C11.5.1	Ch 7, Sec 1, [4.1.2]
11.5.2	11.5.2	Ch 7, Sec 1, [4.1.3]
–	C11.5.2	Ch 7, Sec 1, [4.1.3]
11.5.3	11.5.3	Ch 7, Sec 1, [4.1.4]
11.5.4	11.5.4	Ch 7, Sec 1, [4.1.5]
11.5.5	11.5.5	Ch 7, Sec 1, [4.1.6]
11.5.6	11.5.6	Ch 7, Sec 1, [4.1.7]
11.5.7	11.5.7	Ch 7, Sec 1, [4.1.8]
11.5.8	11.5.8	Ch 7, Sec 1, [4.1.9]
11.6	11.6	Ch 7, Sec 1, [5]
11.6.1	11.6.1	Ch 7, Sec 1, [5.1.1]
–	C11.6.1	Ch 7, Sec 1, [5.1.2] Ch 7, Sec 1, [5.1.3]
11.6.2	11.6.2	Ch 7, Sec 1, [5.1.4]
11.7	11.7	Ch 7, Sec 1, [6]
11.7.1	11.7.1	Ch 7, Sec 1, [6.1.1]
–	C11.7.1	Ch 7, Sec 1, [6.1.2]
11.7.2	11.7.2	Ch 7, Sec 1, [6.1.3]
–	C11.7.2	Ch 7, Sec 1, [6.1.4]
11.8	11.8	Ch 7, Sec 1, [7]
11.8.1	11.8.1	Ch 7, Sec 1, [7.1.1]

Table 12 : Correspondence between Chapters 12 and 13 of IMO IGF Code, NR529 (edition January 2025) and Current NR529

IGF Code	NR529 Jan. 2025	Current NR529
12 Explosion Prevention		
12	12	Ch 7, Sec 2
12.1	12.1	–
12.2 12.2.1 12.2.2	12.2 12.2.1 12.2.2	Ch 7, Sec 2, [1]
12.3	12.3	Ch 7, Sec 2, [2.1]
12.3.1	12.3.1	Ch 7, Sec 2, [2.1.1]
12.3.2	12.3.2	Ch 7, Sec 2, [2.1.2]
12.3.3	12.3.3	Ch 7, Sec 2, [2.1.3]
12.3.3.1	12.3.3.1	Ch 7, Sec 2, [2.1.3]
12.3.3.2	12.3.3.2	Ch 7, Sec 2, [2.1.3]
–	C12.3.3	Ch 7, Sec 2, [2.1.4]
12.4	12.4	Ch 7, Sec 2, [3]
–	C12.4	Ch 7, Sec 2, [3.1.1] Ch 7, Sec 2, [3.1.2]
12.4.1	12.4.1	Ch 7, Sec 2, [3.1.3]
12.4.2	12.4.2	Ch 7, Sec 2, [3.1.4]
12.4.3	12.4.3	Ch 7, Sec 2, [3.1.5]
12.5	12.5	Ch 7, Sec 2, [4]
12.5.1	12.5.1	Ch 7, Sec 2, [4.1]
12.5.2 12.5.2.1	12.5.2 12.5.2.1	Ch 7, Sec 2, [4.2]
–	C12.5.2.1	Ch 7, Sec 2, [4.2]
12.5.2.2 12.5.2.3 12.5.2.4 12.5.2.5 12.5.2.6	12.5.2.2 12.5.2.3 12.5.2.4 12.5.2.5 12.5.2.6	Ch 7, Sec 2, [4.2]
–	C12.5.2.6	Ch 7, Sec 2, [4.2]
12.5.2.7 12.5.2.8	12.5.2.7 12.5.2.8	Ch 7, Sec 2, [4.2]
–	C12.5.2.8	Ch 7, Sec 2, [4.2]
12.5.2.9	12.5.2.9	Ch 7, Sec 2, [4.2]
12.5.3	12.5.3	Ch 7, Sec 2, [4.3]
12.5.3.1	12.5.3.1	Ch 7, Sec 2, [4.3]
12.5.3.2	12.5.3.2	Ch 7, Sec 2, [4.3]
13 Ventilation		
13	13	Ch 7, Sec 3
13.1	13.1	–
13.2	13.2	Ch 7, Sec 3, [1]
13.3	13.3	Ch 7, Sec 3, [2]
13.3.1	13.3.1	Ch 7, Sec 3, [2.1.1]
13.3.2	13.3.2	Ch 7, Sec 3, [2.1.2]
13.3.3 13.3.3.1 13.3.3.1.1 13.3.3.1.2 13.3.3.1.3 13.3.3.1.4 13.3.3.1.5 13.3.3.2 13.3.3.3	13.3.3 13.3.3.1 13.3.3.1.1 13.3.3.1.2 13.3.3.1.3 13.3.3.1.4 13.3.3.1.5 13.3.3.2 13.3.3.3	Ch 7, Sec 3, [2.1.3]
–	C13.3.3	Ch 7, Sec 3, [2.1.4]
13.3.4	13.3.4	Ch 7, Sec 3, [2.1.5]
13.3.5	13.3.5	Ch 7, Sec 3, [2.1.6]
13.3.6	13.3.6	Ch 7, Sec 3, [2.1.7]
13.3.7	13.3.7	Ch 7, Sec 3, [2.1.8]
13.3.8	13.3.8	Ch 7, Sec 3, [2.1.9]
13.3.9 13.3.9.1 13.3.9.1.1 13.3.9.1.2 13.3.9.2 13.3.9.2.1 13.3.9.2.2	13.3.9 13.3.9.1 13.3.9.1.1 13.3.9.1.2 13.3.9.2 13.3.9.2.1 13.3.9.2.2	Ch 7, Sec 3, [2.1.10]
13.3.10 13.3.10.1 13.3.10.2	13.3.10 13.3.10.1 13.3.10.2	Ch 7, Sec 3, [2.1.11]
–	C13.3.10.2	Ch 7, Sec 3, [2.1.11]
13.4	13.4	Ch 7, Sec 3, [3]
13.4.1	13.4.1	Ch 7, Sec 3, [3.1.1]
–	C13.4.1	Ch 7, Sec 3, [3.1.2] Ch 7, Sec 3, [3.1.3]
13.4.2	13.4.2	Ch 7, Sec 3, [3.1.4]
13.5	13.5	Ch 7, Sec 3, [4]
–	C13.5(a)	Ch 7, Sec 3, [4.1.1]
13.5.1	13.5.1	Ch 7, Sec 3, [4.1.2]
–	C13.5.1	Ch 7, Sec 3, [4.1.3]
13.5.2	13.5.2	Ch 7, Sec 3, [4.1.4]
13.5.3	13.5.3	Ch 7, Sec 3, [4.1.5]
13.5.4	13.5.4	Ch 7, Sec 3, [4.1.6]
13.6	13.6	Ch 7, Sec 3, [5]
13.6.1	13.6.1	Ch 7, Sec 3, [5.1.1]
13.6.2	13.6.2	Ch 7, Sec 3, [5.1.2]
13.6.3	13.6.3	Ch 7, Sec 3, [5.1.3]
–	C13.6.3	Ch 7, Sec 3, [5.1.4]
13.7	13.7	Ch 7, Sec 3, [6]
–	C13.7	Ch 7, Sec 3, [6.1.2]
13.8	13.8	Ch 7, Sec 3, [7]
13.8.1	13.8.1	Ch 7, Sec 3, [7.1.1]
–	C13.8.1	Ch 7, Sec 3, [7.1.1]
13.8.2	13.8.2	Ch 7, Sec 3, [7.1.2]
–	C13.8.2	Ch 7, Sec 3, [7.1.3]
13.8.3	13.8.3	Ch 7, Sec 3, [7.1.4]
–	C13.8.3	Ch 7, Sec 3, [7.1.5]
13.8.4	13.8.4	Ch 7, Sec 3, [7.1.6]
13.4.2	13.4.2	Ch 7, Sec 3, [3.1.4]
13.5	13.5	Ch 7, Sec 3, [4]
–	C13.5(a)	Ch 7, Sec 3, [4.1.1]
13.5.1	13.5.1	Ch 7, Sec 3, [4.1.2]
–	C13.5.1	Ch 7, Sec 3, [4.1.3]
13.5.2	13.5.2	Ch 7, Sec 3, [4.1.4]
13.5.3	13.5.3	Ch 7, Sec 3, [4.1.5]
13.5.4	13.5.4	Ch 7, Sec 3, [4.1.6]
13.6	13.6	Ch 7, Sec 3, [5]
13.6.1	13.6.1	Ch 7, Sec 3, [5.1.1]
13.6.2	13.6.2	Ch 7, Sec 3, [5.1.2]
13.6.3	13.6.3	Ch 7, Sec 3, [5.1.3]
–	C13.6.3	Ch 7, Sec 3, [5.1.4]
13.7	13.7	Ch 7, Sec 3, [6]
–	C13.7	Ch 7, Sec 3, [6.1.2]
13.8	13.8	Ch 7, Sec 3, [7]
13.8.1	13.8.1	Ch 7, Sec 3, [7.1.1]
–	C13.8.1	Ch 7, Sec 3, [7.1.1]
13.8.2	13.8.2	Ch 7, Sec 3, [7.1.2]
–	C13.8.2	Ch 7, Sec 3, [7.1.3]
13.8.3	13.8.3	Ch 7, Sec 3, [7.1.4]
–	C13.8.3	Ch 7, Sec 3, [7.1.5]
13.8.4	13.8.4	Ch 7, Sec 3, [7.1.6]

Table 13 : Correspondence between Chapters 14 and 15 of IMO IGF Code, NR529 (edition January 2025) and Current NR529

IGF Code	NR529 Jan. 2025	Current NR529
14 Electrical Installations		
14	14	Ch 7, Sec 4
14.1	14.1	–
14.2	14.2	Ch 7, Sec 4, [1]
14.3	14.3	Ch 7, Sec 4, [2]
14.3.1	14.3.1	Ch 7, Sec 4, [2.1.1]
14.3.2	14.3.2	Ch 7, Sec 4, [2.1.2]
14.3.3	14.3.3	Ch 7, Sec 4, [2.1.3]
14.3.4	14.3.4	Ch 7, Sec 4, [2.1.4]
14.3.5	14.3.5	Ch 7, Sec 4, [2.1.5]
14.3.6	14.3.6	Ch 7, Sec 4, [2.1.6]
14.3.7	14.3.7	Ch 7, Sec 4, [2.1.7]
–	C14.3.7	Ch 7, Sec 4, [2.1.7]
14.3.8	14.3.8	Ch 7, Sec 4, [2.1.8]
14.3.9	14.3.9	Ch 7, Sec 4, [2.1.9]
14.3.10	14.3.10	Ch 7, Sec 4, [2.1.10]
–	C14.3.10	Ch 7, Sec 4, [2.1.11]
15 Control, Monitoring and Safety Systems		
15	15	Chapter 8 Ch 8, Sec 1
15.1	15.1	–
15.2 15.2.1 15.2.2	15.2 15.2.1 15.2.2	Ch 8, Sec 1, [1]
–	C15.2.2	Ch 8, Sec 1, [1]
15.2.3 15.2.4 15.2.5 15.2.6	15.2.3 15.2.4 15.2.5 15.2.6	Ch 8, Sec 1, [1]
15.3	15.3	Ch 8, Sec 1, [2]
15.3.1	15.3.1	Ch 8, Sec 1, [2.1.1]
15.3.2	15.3.2	Ch 8, Sec 1, [2.1.2]
–	C15.3.2	Ch 8, Sec 1, [2.1.3]
15.3.3	15.3.3	Ch 8, Sec 1, [2.1.4]
–	C15.3(a)	Ch 8, Sec 1, [2.1.5]
15.4	15.4	Ch 8, Sec 1, [3]
15.4.1	15.4.1	Ch 8, Sec 1, [3.1]
15.4.1.1	15.4.1.1	Ch 8, Sec 1, [3.1.1]
15.4.1.2	15.4.1.2	Ch 8, Sec 1, [3.1.2]
15.4.1.3 15.4.1.3.1 15.4.1.3.2	15.4.1.3 15.4.1.3.1 15.4.1.3.2	Ch 8, Sec 1, [3.1.3]
–	C15.4.1.3	Ch 8, Sec 1, [3.1.3]
15.4.2 15.4.2.1 15.4.2.2 15.4.2.3	15.4.2 15.4.2.1 15.4.2.2 15.4.2.3	Ch 8, Sec 1, [3.2] Ch 8, Sec 1, [3.1.1] Ch 8, Sec 1, [3.2.2] Ch 8, Sec 1, [3.2.3]
–	C15.4.2.3	Ch 8, Sec 1, [3.2.3]
15.4.2.4 15.4.2.5	15.4.2.4 15.4.2.5	Ch 8, Sec 1, [3.2.4] Ch 8, Sec 1, [3.2.5]
15.4.3	15.4.3	Ch 8, Sec 1, [3.3.1]
15.4.4	15.4.4	Ch 8, Sec 1, [3.3.2]
15.4.5	15.4.5	Ch 8, Sec 1, [3.3.3]
15.4.6	15.4.6	Ch 8, Sec 1, [3.3.4]
15.4.7	15.4.7	Ch 8, Sec 1, [3.3.5]
15.4.8	15.4.8	Ch 8, Sec 1, [3.3.6]
15.4.9	15.4.9	Ch 8, Sec 1, [3.3.7]
15.4.10	15.4.10	Ch 8, Sec 1, [3.3.8]
–	C15.4.10	Ch 8, Sec 1, [3.3.8]
15.4.11	15.4.11	Ch 8, Sec 1, [3.3.9]
–	C15.4(a)	Ch 8, Sec 1, [3.4] Ch 8, Sec 1, [3.4.1]
15.5	15.5	Ch 8, Sec 1, [4]
15.5.1	15.5.1	Ch 8, Sec 1, [4.1.1]
–	C15.5.1	Ch 8, Sec 1, [4.1.2]
15.5.2	15.5.2	Ch 8, Sec 1, [4.1.3]
–	C15.5.2	Ch 8, Sec 1, [4.1.4]
15.5.3	15.5.3	Ch 8, Sec 1, [4.1.5]
–	C15.5.3	Ch 8, Sec 1, [4.1.5]
–	C15.5(a)	Ch 8, Sec 1, [4.1.6]
–	C15.5(b)	Ch 8, Sec 1, [4.1.7]
15.6	15.6	Ch 8, Sec 1, [5]
15.6.1	15.6.1	Ch 8, Sec 1, [5.1.1]
15.6.2	15.6.2	Ch 8, Sec 1, [5.1.2]
15.7 15.7.1 15.7.2	15.7 15.7.1 15.7.2	Ch 8, Sec 1, [6] Ch 8, Sec 1, [6.1.1]
15.8	15.8	Ch 8, Sec 1, [7]
15.8.1 15.8.1.1 15.8.1.2 15.8.1.3	15.8.1 15.8.1.1 15.8.1.2 15.8.1.3	Ch 8, Sec 1, [7.1.1]
–	C15.8.1.3	Ch 8, Sec 1, [7.1.1]
15.8.1.4 15.8.1.5 15.8.1.6 15.8.1.7 15.8.1.8 15.8.1.9 15.8.1.10	15.8.1.4 15.8.1.5 15.8.1.6 15.8.1.7 15.8.1.8 15.8.1.9 15.8.1.10	Ch 8, Sec 1, [7.1.1]
–	C15.8.1	Ch 8, Sec 1, [7.1.2]
15.8.2	15.8.2	Ch 8, Sec 1, [7.1.3]
15.8.3	15.8.3	Ch 8, Sec 1, [7.1.4]
15.8.4	15.8.4	Ch 8, Sec 1, [7.1.5]
–	C15.8.4	Ch 8, Sec 1, [7.1.6]
15.8.5	15.8.5	Ch 8, Sec 1, [7.1.7]
–	C15.8.5	Ch 8, Sec 1, [7.1.8]
15.8.6	15.8.6	Ch 8, Sec 1, [7.1.9]
–	C15.8.6	–
15.8.7	15.8.7	Ch 8, Sec 1, [7.1.10]
–	C15.8.7	–
15.8.8	15.8.8	Ch 8, Sec 1, [7.1.11]
15.8.9	15.8.9	Ch 8, Sec 1, [7.1.12]
15.9	15.9	Ch 8, Sec 1, [8] Ch 8, Sec 1, [8.1.1]
–	C15.9	–
15.10	15.10	Ch 8, Sec 1, [9]
15.10.1	15.10.1	Ch 8, Sec 1, [9.1.1]
–	C15.10.1	Ch 8, Sec 1, [9.1.2]
15.10.2	15.10.2	Ch 8, Sec 1, [9.1.3]
15.11	15.11	Ch 8, Sec 1, [10]
15.11.1	15.11.1	Ch 8, Sec 1, [10.1.1]
15.11.2	15.11.2	Ch 8, Sec 1, [10.1.2]
15.11.3	15.11.3	Ch 8, Sec 1, [10.1.3]
–	C15.8.7	–
15.8.8	15.8.8	Ch 8, Sec 1, [7.1.11]
15.8.9	15.8.9	Ch 8, Sec 1, [7.1.12]
15.9	15.9	Ch 8, Sec 1, [8] Ch 8, Sec 1, [8.1.1]
–	C15.9	–
15.10	15.10	Ch 8, Sec 1, [9]
15.10.1	15.10.1	Ch 8, Sec 1, [9.1.1]
–	C15.10.1	Ch 8, Sec 1, [9.1.2]
15.10.2	15.10.2	Ch 8, Sec 1, [9.1.3]
15.11	15.11	Ch 8, Sec 1, [10]
15.11.1	15.11.1	Ch 8, Sec 1, [10.1.1]
15.11.2	15.11.2	Ch 8, Sec 1, [10.1.2]
15.11.3	15.11.3	Ch 8, Sec 1, [10.1.3]
15.11.4 15.11.4.1 15.11.4.2 15.11.4.3 15.11.4.4 15.11.4.5 15.11.4.6	15.11.4 15.11.4.1 15.11.4.2 15.11.4.3 15.11.4.4 15.11.4.5 15.11.4.6	Ch 8, Sec 1, [10.1.4]

Table 14 : Correspondence between Chapters 16, 17, 18 and 19 of IMO IGF Code, NR529 (edition January 2025) and Current NR529

IGF Code	NR529 Jan. 2025	Current NR529
16 Manufacture, Workmanship and Testing		
16	16	Chapter 10
16.1	16.1	Ch 9, Sec 1
16.1.1	16.1.1	Ch 9, Sec 1, [1.1.2]
–	C16.1.1	Ch 9, Sec 1, [1.1.3]
16.1.2	16.1.2	Ch 9, Sec 1, [1.1.4]
16.2	16.2	Ch 9, Sec 1, [2]
16.2.1	16.2.1	Ch 9, Sec 1, [2.1]
16.2.1.1	16.2.1.1	Ch 9, Sec 1, [2.1.1]
16.2.1.2	16.2.1.2	Ch 9, Sec 1, [2.1.2]
16.2.2	16.2.2	Ch 9, Sec 1, [2.2.1]
16.2.2.2	16.2.2.2	Ch 9, Sec 1, [2.2.2]
–	C16.2.2.2	Ch 9, Sec 1, [2.2.3]
16.2.2.3	16.2.2.3	Ch 9, Sec 1, [2.2.4]
–	C16.2.2.3	–
16.2.2.4	16.2.2.4	Ch 9, Sec 1, [2.2.5]
16.2.3	16.2.3	Ch 9, Sec 1, [2.3]
16.2.3.1	16.2.3.1	Ch 9, Sec 1, [2.3.1]
16.2.3.2	16.2.3.2	Ch 9, Sec 1, [2.3.2]
16.2.4	16.2.4	Ch 9, Sec 1, [2.4]
16.3	16.3	Ch 9, Sec 1, [3]
16.3.1	16.3.1	Ch 9, Sec 1, [3.1]
16.3.1	16.3.1	Ch 9, Sec 1, [3.1.2]
16.3.2	16.3.2	Ch 9, Sec 1, [3.2]
16.3.3	16.3.3	Ch 9, Sec 1, [3.3]
16.3.3.1	16.3.3.1	Ch 9, Sec 1, [3.3.1]
16.3.3.2	16.3.3.2	Ch 9, Sec 1, [3.3.2]
16.3.3.3	16.3.3.3	Ch 9, Sec 1, [3.3.3]
16.3.3.4	16.3.3.4	Ch 9, Sec 1, [3.3.4]
16.3.3.5	16.3.3.5	Ch 9, Sec 1, [3.3.5]
16.3.3.6	16.3.3.6	Ch 9, Sec 1, [3.3.6]
16.3.4	16.3.4	Ch 9, Sec 1, [3.4]
16.3.5	16.3.5	Ch 9, Sec 1, [3.5]
16.3.5.1	16.3.5.1	Ch 9, Sec 1, [3.5.1]
16.3.5.2	16.3.5.2	Ch 9, Sec 1, [3.5.2]
16.3.5.3	16.3.5.3	Ch 9, Sec 1, [3.5.3]
16.3.5.4	16.3.5.4	Ch 9, Sec 1, [3.5.4]
16.3.5.5	16.3.5.5	Ch 9, Sec 1, [3.5.5]
16.3.6	16.3.6	Ch 9, Sec 1, [3.6]
16.3.6.1	16.3.6.1	Ch 9, Sec 1, [3.6.1]
–	C16.3.6.1	Ch 9, Sec 1, [3.6.2]
16.3.6.2	16.3.6.2	Ch 9, Sec 1, [3.6.3]
16.3.6.3	16.3.6.3	Ch 9, Sec 1, [3.6.4]
16.3.6.4	16.3.6.4	Ch 9, Sec 1, [3.6.5]
16.3.6.5	16.3.6.5	Ch 9, Sec 1, [3.6.6]
16.3.6.6	16.3.6.6	Ch 9, Sec 1, [3.6.7]
16.3.6.7	16.3.6.7	Ch 9, Sec 1, [3.6.8]
16.4	16.4	Ch 9, Sec 1, [4]
16.4.1	16.4.1	Ch 9, Sec 1, [4.1]
16.4.2	16.4.2	Ch 9, Sec 1, [4.2]
16.4.3	16.4.3	Ch 9, Sec 1, [4.3]
16.4.4	16.4.4	Ch 9, Sec 1, [4.4]
16.5	16.5	Ch 9, Sec 1, [5]
16.5.1	16.5.1	Ch 9, Sec 1, [5.1]
16.5.1.1	16.5.1.1	Ch 9, Sec 1, [5.1.1]
16.5.1.2	16.5.1.2	Ch 9, Sec 1, [5.1.2]
16.5.1.3	16.5.1.3	Ch 9, Sec 1, [5.1.3]
16.5.1.4	16.5.1.4	Ch 9, Sec 1, [5.1.4]
16.5.1.5	16.5.1.5	Ch 9, Sec 1, [5.1.5]
16.5.1.6	16.5.1.6	Ch 9, Sec 1, [5.1.6]
16.5.1.7	16.5.1.7	Ch 9, Sec 1, [5.1.7]
16.5.1.8	16.5.1.8	Ch 9, Sec 1, [5.1.8]
16.5.2	16.5.2	Ch 9, Sec 1, [5.2]
–	C16.5.2	Ch 9, Sec 1, [5.2.2]
16.5.3	16.5.3	Ch 9, Sec 1, [5.3]
–	C16.5.3	Ch 9, Sec 1, [5.3.2]
16.5.4	16.5.4	Ch 9, Sec 1, [5.4]
16.5.4.1	16.5.4.1	Ch 9, Sec 1, [5.4.1]
16.5.4.2	16.5.4.2	Ch 9, Sec 1, [5.4.2]
16.5.4.3	16.5.4.3	Ch 9, Sec 1, [5.4.3]
16.5.4.4	16.5.4.4	Ch 9, Sec 1, [5.4.4]
16.5.4.5	16.5.4.5	Ch 9, Sec 1, [5.4.5]
16.5.4.6	16.5.4.6	Ch 9, Sec 1, [5.4.6]
16.5.4.7	16.5.4.7	Ch 9, Sec 1, [5.4.7]
–	C16.5.4	Ch 9, Sec 1, [5.4.8]
16.5.5	16.5.5	Ch 9, Sec 1, [5.5]
16.5.5.1	16.5.5.1	Ch 9, Sec 1, [5.5.1]
16.5.5.1.1	16.5.5.1.1	Ch 9, Sec 1, [5.5.1]
16.5.5.1.2	16.5.5.1.2	Ch 9, Sec 1, [5.5.2]
16.5.5.2	16.5.5.2	Ch 9, Sec 1, [5.5.3]
–	C16.5.5	Ch 9, Sec 1, [5.5.4]
–	C16.5(a)	Ch 9, Sec 1, [5.5.5]
16.6	16.6	Ch 9, Sec 1, [6]
16.6.1	16.6.1	Ch 9, Sec 1, [6.1]
16.6.2	16.6.2	Ch 9, Sec 1, [6.2]
16.6.3	16.6.3	Ch 9, Sec 1, [6.3]
16.7	16.7	Ch 9, Sec 1, [7]
16.7.1	16.7.1	Ch 9, Sec 1, [7.1]
–	C16.7.1	Ch 9, Sec 1, [7.1.2]
16.7.2	16.7.2	Ch 9, Sec 1, [7.2]
16.7.3	16.7.3	Ch 9, Sec 1, [7.3]
16.7.3.1	16.7.3.1	Ch 9, Sec 1, [7.3.1]
16.7.3.2	16.7.3.2	Ch 9, Sec 1, [7.3.2]
–	C16.7.3.2	Ch 9, Sec 1, [7.3.3]
16.7.3.3	16.7.3.3	Ch 9, Sec 1, [7.3.4]
16.7.3.4	16.7.3.4	Ch 9, Sec 1, [7.3.5]
–	C16.7.3.4	Ch 9, Sec 1, [7.3.6]
16.7.3.5	16.7.3.5	Ch 9, Sec 1, [7.3.7]
16.7.3.6	16.7.3.6	Ch 9, Sec 1, [7.3.8]
16.7.3.7	16.7.3.7	Ch 9, Sec 1, [7.3.9]
–	C16.7(a)	Ch 9, Sec 1, [7.3.10]
17 Drills and emergency exercices		
17	–	–
18 Operation		
18	–	–
19 Training		
19	–	–

Table 15 : Correspondence between Annex of IMO IGF Code, NR529 (edition January 2025) and Current NR529

Continued in Table 16

IGF Code	NR529 Jan. 2025	Current NR529
ANNEX	ANNEX	
ANNEX	ANNEX	Ch 3, App 1
ANNEX 1	ANNEX 1	Ch 3, App 1, [1]
ANNEX 1.1	ANNEX 1.1	Ch 3, App 1, [1.1.1]
ANNEX 1.2	ANNEX 1.2	Ch 3, App 1, [1.1.2]
ANNEX 1.3 ANNEX 1.3.1 ANNEX 1.3.2 ANNEX 1.3.3	ANNEX 1.3 ANNEX 1.3.1 ANNEX 1.3.2 ANNEX 1.3.3	Ch 3, App 1, [1.1.3]
ANNEX 1.4	ANNEX 1.4	Ch 3, App 1, [1.1.4]
ANNEX 2	ANNEX 2	Ch 3, App 1, [2]
ANNEX 2.1	ANNEX 2.1	Ch 3, App 1, [2.1.1]
ANNEX 2.2	ANNEX 2.2	Ch 3, App 1, [2.1.2]
ANNEX 3	ANNEX 3	Ch 3, App 1, [3]
ANNEX 3.1	ANNEX 3.1	Ch 3, App 1, [3.1.1]
ANNEX 3.2	ANNEX 3.2	Ch 3, App 1, [3.1.2]
ANNEX 3.3	ANNEX 3.3	Ch 3, App 1, [3.1.3]
ANNEX 4	ANNEX 4	Ch 3, App 1, [4]
ANNEX 4.1	ANNEX 4.1	Ch 3, App 1, [4.1.1]
ANNEX 4.2	ANNEX 4.2	Ch 3, App 1, [4.1.2]
ANNEX 4.3	ANNEX 4.3	Ch 3, App 1, [4.1.3]
ANNEX 4.4	ANNEX 4.4	Ch 3, App 1, [4.1.4]
ANNEX 4.5	ANNEX 4.5	Ch 3, App 1, [4.1.5]
ANNEX 4.6	ANNEX 4.6	Ch 3, App 1, [4.1.6]
ANNEX 4.7	ANNEX 4.7	Ch 3, App 1, [4.1.7]
ANNEX 4.7.1	ANNEX 4.7.1	Ch 3, App 1, [4.1.7]
ANNEX 4.8	ANNEX 4.8	Ch 3, App 1, [4.1.8]
ANNEX 4.8.1	ANNEX 4.8.1	Ch 3, App 1, [4.1.8]
ANNEX 4.8.2	ANNEX 4.8.2	Ch 3, App 1, [4.1.8]
ANNEX 4.8.3	ANNEX 4.8.3	Ch 3, App 1, [4.1.8]
ANNEX 4.8.4	ANNEX 4.8.4	Ch 3, App 1, [4.1.8]
ANNEX 4.9	ANNEX 4.9	Ch 3, App 1, [4.1.9]
ANNEX 5	ANNEX 5	Ch 3, App 1, [5]
ANNEX 5.1	ANNEX 5.1	Ch 3, App 1, [5.1.1]

IGF Code	NR529 Jan. 2025	Current NR529
ANNEX 5.2	ANNEX 5.2	Ch 3, App 1, [5.1.2]
ANNEX 5.3	ANNEX 5.3	Ch 3, App 1, [5.1.3]
ANNEX 5.4	ANNEX 5.4	Ch 3, App 1, [5.1.4]
ANNEX 5.5	ANNEX 5.5	Ch 3, App 1, [5.1.5]
ANNEX 5.6	ANNEX 5.6	Ch 3, App 1, [5.1.6]
ANNEX 6	ANNEX 6	Ch 3, App 1, [6]
ANNEX 6.1	ANNEX 6.1	Ch 3, App 1, [6.1.1]
ANNEX 6.2	ANNEX 6.2	Ch 3, App 1, [6.1.2]
ANNEX 6.3	ANNEX 6.3	Ch 3, App 1, [6.1.3]
ANNEX 6.4	ANNEX 6.4	Ch 3, App 1, [6.1.4]
ANNEX 6.5	ANNEX 6.5	Ch 3, App 1, [6.1.5]
ANNEX 6.6	ANNEX 6.6	Ch 3, App 1, [6.1.6]
ANNEX 6.7	ANNEX 6.7	Ch 3, App 1, [6.1.7]
ANNEX 6.8	ANNEX 6.8	Ch 3, App 1, [6.1.8]
ANNEX 7	ANNEX 7	Ch 3, App 1, [7]
ANNEX 7.1	ANNEX 7.1	Ch 3, App 1, [7.1.1]
–	APPENDIX 1	
–	App 1, 1	Ch 2, Sec 10, [1]
–	App 1, 2	Ch 2, Sec 10, [2]
–	App 1, 2.1	Ch 2, Sec 10, [2.1]
–	App 1, 2.2	Ch 2, Sec 10, [2.2]
–	App 1, 2.2.1	Ch 2, Sec 10, [2.2.1]
–	App 1, 2.2.2	Ch 2, Sec 10, [2.2.2]
–	App 1, 2.2.3	Ch 2, Sec 10, [2.2.3]
–	App 1, 2.2.4	Ch 2, Sec 10, [2.2.4]
–	App 1, 2.3	Ch 2, Sec 10, [2.3]
–	App 1, 2.4	Ch 2, Sec 10, [2.4]
–	App 1, 3	Ch 2, Sec 10, [3]
–	App 1, 4	Ch 2, Sec 10, [4]
–	App 1, 4.1	Ch 2, Sec 10, [4.1]
–	–	Ch 2, Sec 10, [4.2]
–	APPENDIX 2	
–	App 2, 1	Ch 3, Sec 13, [1]
–	App 2, 1.1	Ch 3, Sec 13, [1.1.1]

IGF Code	NR529 Jan. 2025	Current NR529
–	App 2, 1.2	Ch 3, Sec 13, [1.1.2]
–	App 2, 1.3	Ch 3, Sec 13, [1.1.3]
–	App 2, 1.4	Ch 3, Sec 13, [1.1.4]
–	App 2, 1.5	Ch 3, Sec 13, [1.1.5]
–	App 2, 1.6	Ch 3, Sec 13, [1.1.6]
–	App 2, 2	Ch 3, Sec 13, [2]
–	App 2, 3	Ch 3, Sec 13, [3]
–	App 2, 3.1	Ch 3, Sec 13, [3.1.1]
–	App 2, 3.2	Ch 3, Sec 13, [3.1.2]
–	App 2, 3.3	Ch 3, Sec 13, [3.1.3]
–	App 2, 4	Ch 3, Sec 13, [4]
–	App 2, 4.1	Ch 3, Sec 13, [4.1]
–	App 2, 4.1.1	Ch 3, Sec 13, [4.1.1]
–	App 2, 4.1.2	Ch 3, Sec 13, [4.1.2]
–	App 2, 4.1.3	Ch 3, Sec 13, [4.1.3]
–	App 2, 4.2	Ch 3, Sec 13, [4.2]
–	App 2, 4.2.1	Ch 3, Sec 13, [4.2.1]
–	App 2, 4.2.2	Ch 3, Sec 13, [4.2.2]
–	App 2, 4.2.3	Ch 3, Sec 13, [4.2.3]
–	App 2, 4.3	Ch 3, Sec 13, [4.3]
–	App 2, 4.3.1	Ch 3, Sec 13, [4.3.1]
–	App 2, 4.3.2	Ch 3, Sec 13, [4.3.2]
–	App 2, 4.3.3	Ch 3, Sec 13, [4.3.3]
–	App 2, 4.4	Ch 3, Sec 13, [4.4]
–	App 2, 4.4.1	Ch 3, Sec 13, [4.4.1]
–	App 2, 4.5	Ch 3, Sec 13, [4.5]
–	App 2, 4.6	Ch 3, Sec 13, [4.6]
–	App 2, 4.6.1	Ch 3, Sec 13, [4.6.1]
–	App 2, 4.6.2	Ch 3, Sec 13, [4.6.2]
–	App 2, 5	Ch 3, Sec 13, [5]
–	App 2, 5.1	Ch 3, Sec 13, [5.1]
–	App 2, 6	Ch 3, Sec 13, [6]
–	App 2, 6.1	Ch 3, Sec 13, [6.1.1]
–	App 2, 6.2	Ch 3, Sec 13, [6.1.2]

Table 16 : Correspondence between Annex of IMO IGF Code, NR529 (edition January 2025) and Current NR529

Continued from Table 15

IGF Code	NR529 Jan. 2025	Current NR529	IGF Code	NR529 Jan. 2025	Current NR529	IGF Code	NR529 Jan. 2025	Current NR529
–	APPENDIX 3		–	App 3, 2.1.1	Ch 3, Sec 14, [2.1.1]	–	App 3, 2.1.4	Ch 3, Sec 14, [2.1.4]
–	App 3, 1	Ch 3, Sec 14, [1]	–	App 3, 2.1.2	Ch 3, Sec 14, [2.1.2]	–	App 3, 2.1.5	Ch 3, Sec 14, [2.1.5]
–	App 3, 1.1	Ch 3, Sec 14, [1.1.1]	–	App 3, 2.1.3	Ch 3, Sec 14, [2.1.3]	–	App 3, 2.1.6	Ch 3, Sec 14, [2.1.6]
–	App 3, 1.2	Ch 3, Sec 14, [1.1.2]	–	App 3, 1.4.3	Ch 3, Sec 14, [1.2.3]	–	App 3, 3	Ch 3, Sec 14, [3]
–	App 3, 1.3	Ch 3, Sec 14, [1.1.3]	–	App 3, 1.4.4	Ch 3, Sec 14, [1.2.4]	–	App 3, 3.1	Ch 3, Sec 14, [3.1]
–	App 3, 1.4	Ch 3, Sec 14, [1.2]	–	App 3, 1.4.5	Ch 3, Sec 14, [1.2.5]	–	App 3, 3.1.1	Ch 3, Sec 14, [3.1.1]
–	App 3, 1.4.1	Ch 3, Sec 14, [1.2.1]	–	App 3, 1.4.6	Ch 3, Sec 14, [1.2.6]	–	APPENDIX 4	
–	App 3, 1.4.2	Ch 3, Sec 14, [1.2.2]	–	App 3, 2	Ch 3, Sec 14, [2]	–	Appendix 4	Ch 10, Sec 1
–	App 3, 2.1	Ch 3, Sec 14, [2.1]						

CHAPTER 2
SHIP DESIGN, ARRANGEMENT AND STRUCTURE

Section 1	General Requirements
Section 2	Machinery Space Concepts
Section 3	Gas Safe Machinery Space
Section 4	ESD-protected Machinery Spaces
Section 5	Fuel Preparation Room Design
Section 6	Bilge and Draining Systems
Section 7	Access to Enclosed Spaces
Section 8	Airlocks
Section 9	Gas Valve Units
Section 10	Hull Scantling in way of Gas Fuel Tank

Section 1 General Requirements

1 Functional requirements

1.1 General

1.1.1 *This Section is related to functional requirements in Ch 1, Sec 3, [1.1.1] to Ch 1, Sec 3, [1.1.3], Ch 1, Sec 3, [1.1.5], Ch 1, Sec 3, [1.1.6], Ch 1, Sec 3, [1.1.8], Ch 1, Sec 3, [1.1.12] to Ch 1, Sec 3, [1.1.15] and Ch 1, Sec 3, [1.1.17]. In particular the following apply:*

a) *the fuel tank(s) shall be located in such a way that the probability for the tank(s) to be damaged following a collision or grounding is reduced to a minimum taking into account the safe operation of the ship and other hazards that may be relevant to the ship*
b) *fuel containment systems, fuel piping and other fuel sources of release shall be so located and arranged that released gas is led to a safe location in the open air*
c) *the access or other openings to spaces containing fuel sources of release shall be so arranged that flammable, asphyxiating or toxic gas cannot escape to spaces that are not designed for the presence of such gases*
d) *fuel piping shall be protected against mechanical damage*
e) *the propulsion and fuel supply system shall be so designed that safety actions after any gas leakage do not lead to an unacceptable loss of power, and*
f) *the probability of a gas explosion in a machinery space with gas or low-flashpoint fuelled machinery shall be minimized.*

2 General

2.1

2.1.1 Typical location arrangements acceptable for fuel tanks of passenger ships are given in Tab 1.

2.1.2 *Fuel storage tanks shall be protected against mechanical damage.*

2.1.3 *Fuel storage tanks and or equipment located on open deck shall be located to ensure sufficient natural ventilation, so as to prevent accumulation of escaped gas.*

2.1.4 *The fuel tank(s) shall be protected from external damage caused by collision or grounding in the following way:*

a) *The fuel tanks shall be located at a minimum distance of B/5 or 11,5 m, whichever is less, measured inboard from the ship side at right angles to the centreline at the level of the summer load line draught, where:*

   B : Greatest moulded breadth of the ship at or below the deepest draught (summer load line draught) (refer to SOLAS regulation II-1/2.8).

b) *The boundaries of each fuel tank shall be taken as the extreme outer longitudinal, transverse and vertical limits of the tank structure including its tank valves.*
c) *For independent tanks the protective distance shall be measured to the tank shell (the primary barrier of the fuel containment system). For membrane tanks the distance shall be measured to the bulkheads surrounding the tank insulation.*
d) *In no case shall the boundary of the fuel tank be located closer to the shell plating or aft terminal of the ship than as follows:*
   1) *For passenger ships: B/10 but in no case less than 0,8 m. However, this distance need not be greater than B/15 or 2 m whichever is less where the shell plating is located inboard of B/5 or 11,5 m, whichever is less, as required by item a)*

Note 1: With reference to d) 1), the transition between the minimum protective distances B/10 and B/15 is to be in compliance with Tab 1.

   2) *For cargo ships:*
      - *for $V_c \leq 1000\ m^3$:*
        0,8 m
      - *for $1000\ m^3 < V_c < 5000\ m^3$:*
        $0,75 + V_c\ .\ 0,2 / 4000$ m
      - *for $5000\ m_3 \leq V_c < 30000\ m^3$:*
        $0,8 + V_c / 25000$ m, and
      - *for $Vc \geq 30000\ m^3$:*
        2,0 m

      where:

V_c : Corresponds to 100% of the gross design volume of the individual fuel tank at 20°C, including domes and appendages.

e) The lowermost boundary of the fuel tank(s) shall be located above the minimum distance of B/15 or 2,0 m, whichever is less, measured from the moulded line of the bottom shell plating at the centreline.

f) For multihull ships the value of B may be specially considered.

g) The fuel tank(s) shall be abaft a transverse plane at 0,08 L measured from the forward perpendicular in accordance with SOLAS regulation II-1/8.1 for passenger ships, and abaft the collision bulkhead for cargo ships, where:

L : Length as defined in the International Convention on Load Lines (refer to SOLAS regulation II-1/2.5).

h) For ships with a hull structure providing higher collision and/or grounding resistance, fuel tank location regulations may be specially considered in accordance with Ch 1, Sec 1, [3].

2.1.5 As an alternative to [2.1.4], a), the following calculation method may be used to determine the acceptable location of the fuel tanks:

a) The value f_{CN} calculated as described in the following shall be less than 0,02 for passenger ships and 0,04 for cargo ships.5

Note 1: The value f_{CN} accounts for collision damages that may occur within a zone limited by the longitudinal projected boundaries of the fuel tank only, and cannot be considered or used as the probability for the fuel tank to become damaged given a collision. The real probability will be higher when accounting for longer damages that include zones forward and aft of the fuel tank.

b) f_{CN} is calculated by the following formulation:

$f_{CN} = f\ell \; f_t \; f_v$

where:

$f\ell$: Calculated by use of the formulations for factor p contained in SOLAS regulation II-1/7-1.1.1.1. The value of x1 shall correspond to the distance from the aft terminal to the aftmost boundary of the fuel tank and the value of x2 shall correspond to the distance from the aft terminal to the foremost boundary of the fuel tank

f_t : Calculated by use of the formulations for factor r contained in SOLAS regulation 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:

$ft = 1 - r(x1, x2, b)$

Note 2: When the outermost boundary of the fuel tank is outside the boundary given by the deepest subdivision waterline the value of b should be taken as 0.

f_v : Calculated by use of the formulations for factor v contained in SOLAS regulation II-1/7-2.6.1.1 and reflects the probability that the damage is extending vertically above the lowermost boundary of the fuel tank. The formulations to be used are:

$f_v = 1,0 - 0,8\,((H - d) / 7,8)$, if $(H - d) \leq 7,8$ m. f_v shall not be taken greater than 1,0

$f_v = 0,2 - (0,2\,((H - d) - 7,8) / 4,7)$ in all other cases, f_v shall not be taken less than 0

where:

H : Distance from baseline, in m, to the lowermost boundary of the fuel tank

d : Deepest draught (summer load line draught).

c) The boundaries of each fuel tank shall be taken as the extreme outer longitudinal, transverse and vertical limits of the tank structure including its tank valves.

d) For independent tanks the protective distance shall be measured to the tank shell (the primary barrier of the fuel containment system). For membrane tanks the distance shall be measured to the bulkheads surrounding the tank insulation.

e) In no case shall the boundary of the fuel tank be located closer to the shell plating or aft terminal of the ship than as follows:

1) For passenger ships: B/10 but in no case less than 0,8 m. However, this distance need not be greater than B/15 or 2,0 m whichever is less where the shell plating is located inboard of B/5 or 11,5 m, whichever is less, as required by [2.1.4], a).

2) For cargo ships:

- for $V_c \leq 1000\ m^3$:

  0,8 m

- for $1000\ m^3 < V_c < 5000\ m^3$:

  $0,75 + V_c \times 0,2/4000$ m

- for $5000\ m^3 \leq V_c < 30000\ m^3$:

  $0,8 + V_c / 25000$ m, and

- for $V_c \geq 30000\ m^3$:

  2,0 m

where:

V_c : *Corresponds to 100% of the gross design volume of the individual fuel tank at 20°C, including domes and appendages.*

f) *In case of more than one non-overlapping fuel tank located in the longitudinal direction, f_{CN} shall be calculated in accordance with item b) for each fuel tank separately. The value used for the complete fuel tank arrangement is the sum of all values for f_{CN} obtained for each separate tank.*

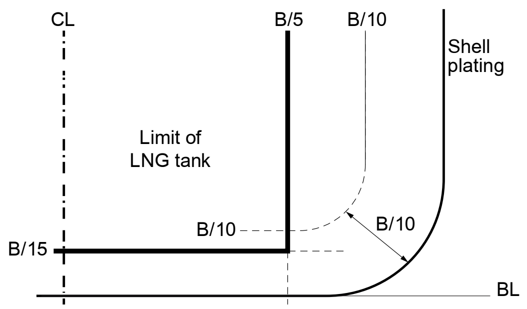
g) *In case the fuel tank arrangement is unsymmetrical about the centreline of the ship, the calculations of f_{CN} shall be calculated on both starboard and port side and the average value shall be used for the assessment. The minimum distance as set forth in item e) shall be met on both sides.*

h) *For ships with a hull structure providing higher collision and/or grounding resistance, fuel tank location regulations may be specially considered in accordance with Ch 1, Sec 1, [3].*

2.1.6 *When fuel is carried in a fuel containment system requiring a complete or partial secondary barrier:*

- *fuel storage hold spaces shall be segregated from the sea by a double bottom, and*
- *the ship shall also have a longitudinal bulkhead forming side tanks.*

Table 1 : Location of fuel storage tanks - Passenger ships

<table>
<tr><th>Prescriptive method
Requirements [2.1.4], item a) and [2.1.4], item d) 1)</th><th>Probabilistic method
Requirement [2.1.5]</th></tr>
<tr><td rowspan="2">bilge turn radius ≤ B/5

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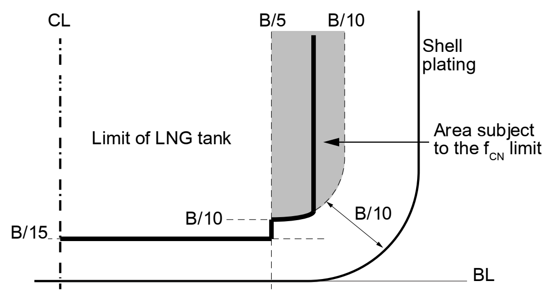
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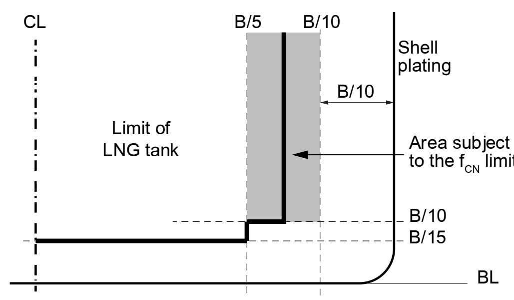
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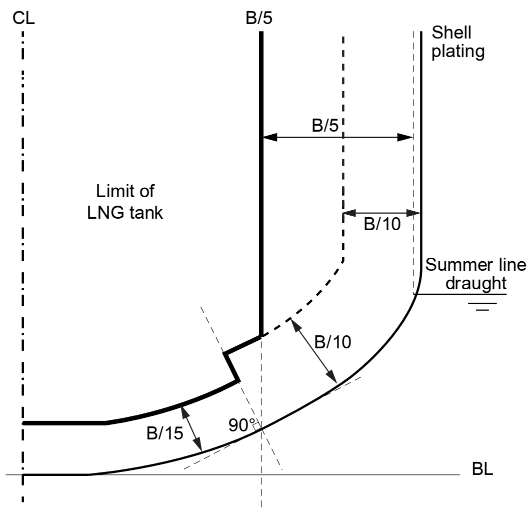
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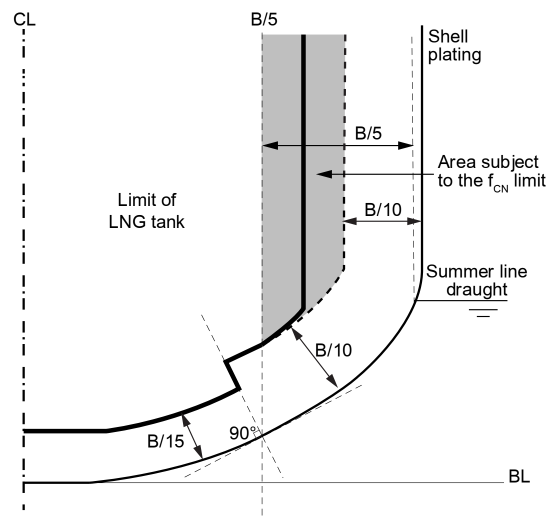
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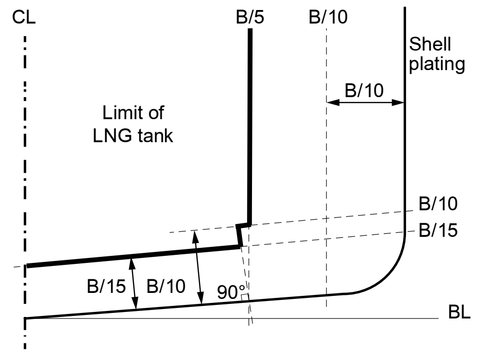

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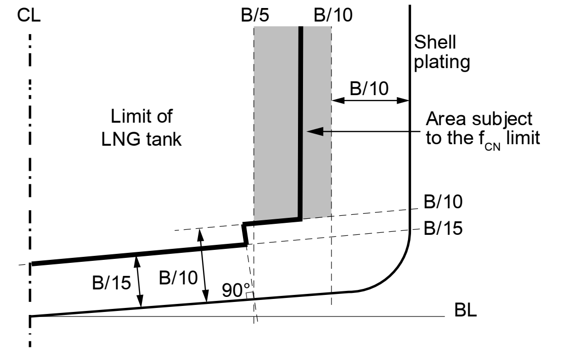

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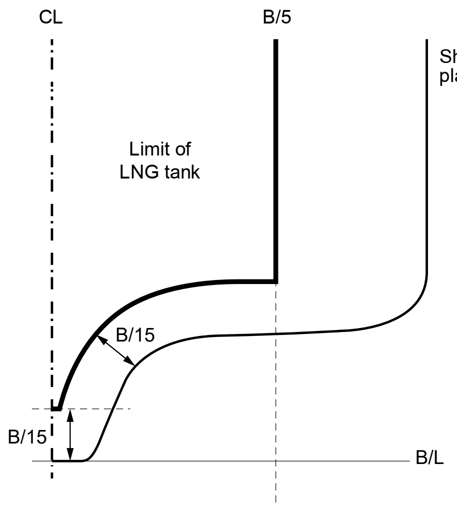

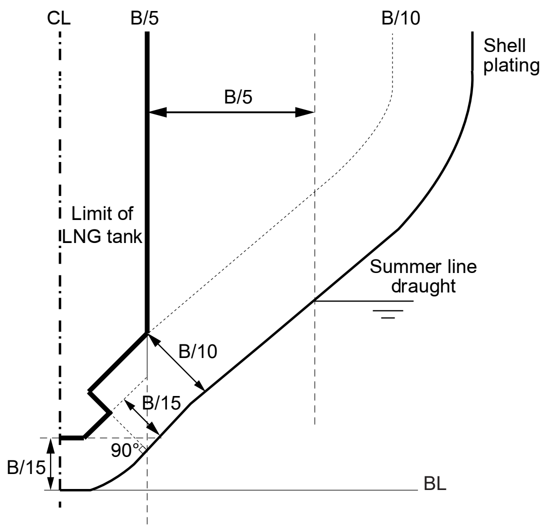

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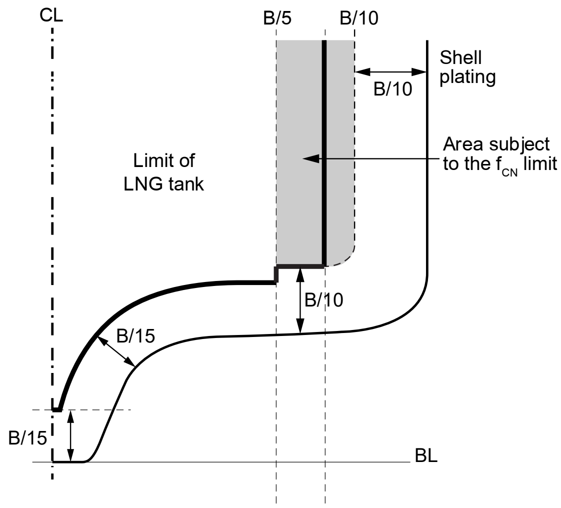

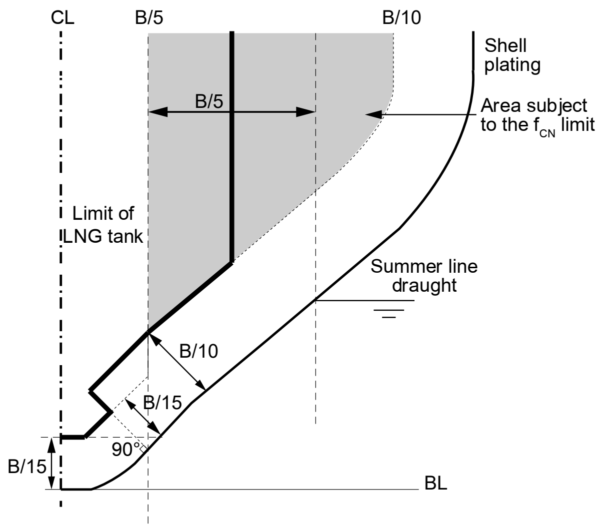

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Section 2 Machinery Space Concepts

1 Gas safe and ESD-protected machinery space concepts

1.1

1.1.1 *In order to minimize the probability of a gas explosion in a machinery space with gas-fuelled machinery one of these two alternative concepts may be applied:*

a) Gas safe machinery spaces: Arrangements in machinery spaces are such that the spaces are considered gas safe under all conditions, normal as well as abnormal conditions, i.e. inherently gas safe.

In a gas safe machinery space a single failure cannot lead to release of fuel gas into the machinery space.

b) ESD-protected machinery spaces: Arrangements in machinery spaces are such that the spaces are considered non-hazardous under normal conditions, but under certain abnormal conditions may have the potential to become hazardous. In the event of abnormal conditions involving gas hazards, emergency shutdown (ESD) of non-safe equipment (ignition sources) and machinery shall be automatically executed while equipment or machinery in use or active during these conditions shall be of a certified safe type.

In an ESD protected machinery space a single failure may result in a gas release into the space. Venting is designed to accommodate a probable maximum leakage scenario due to technical failures.

Failures leading to dangerous gas concentrations, e.g. gas pipe ruptures or blow out of gaskets are covered by explosion pressure relief devices and ESD arrangements.

1.1.2 Within the scope of the “ESD-protected machinery spaces” concept, single wall gas piping may be accepted only:

- on premixed engines using fuel gas mixed with air before the turbocharger
- on engines supplied with gas at a pressure lower than or equal to 0,5 MPa when their nominal power does not exceed 100 kW per cylinder
- for gas pipes located in gas tight GVU spaces enclosures
- for venting pipes.

Single wall gas piping is not permitted elsewhere.

Section 3 Gas Safe Machinery Space

1 Arrangement of fuel systems in gas safe machinery spaces

1.1

1.1.1 *A single failure within the fuel system shall not lead to a gas release into the machinery space.*

1.1.2 *All fuel piping within machinery space boundaries shall be enclosed in a gastight enclosure in accordance with Ch 5, Sec 2, [3].*

1.1.3 The gastight enclosure is not required for venting pipes and for gas pipes located in gas tight GVU spaces or enclosures. See Ch 5, Sec 2, Tab 1.

Section 4 ESD-protected Machinery Spaces

1 Arrangement of ESD-protected machinery spaces

1.1 General

1.1.1 *ESD protection shall be limited to machinery spaces that are certified for periodically unattended operation.*

1.1.2 *Measures shall be applied to protect against explosion, damage of areas outside of the machinery space and ensure redundancy of power supply. The following arrangement shall be provided but may not be limited to:*

- *gas detector*
- *shut off valve*
- *redundancy, and*
- *efficient ventilation.*

1.1.3 *Distribution of engines between the different machinery spaces shall be such that shutdown of fuel supply to any one machinery space does not lead to an unacceptable loss of power.*

1.1.4 *ESD protected machinery spaces separated by a single bulkhead shall have sufficient strength to withstand the effects of a local gas explosion in either space, without affecting the integrity of the adjacent space and equipment within that space.*

1.1.5 *ESD protected machinery spaces shall be designed to provide a geometrical shape that will minimize the accumulation of gases or formation of gas pockets.*

1.1.6 The "ESD-protected" concept is not acceptable for the propulsion machinery space of a ship fitted with a single engine mechanical propulsion plant.

1.2 Gas supply piping

1.2.1 *Gas supply piping within machinery spaces may be accepted without a gastight external enclosure on the following conditions:*

a) *Engines for generating propulsion power and electric power shall be located in two or more machinery spaces not having any common boundaries unless it can be documented that a single casualty will not affect both spaces.*
b) *The gas machinery space shall contain only a minimum of such necessary equipment, components and systems as are required to ensure that the gas machinery maintains its function.*
c) *A fixed gas detection system arranged to automatically shut down the gas supply, and disconnect all electrical equipment or installations not of a certified safe type, shall be fitted.*

1.2.2 Gas supply piping may be accepted without a gastight external enclosure only in the cases mentioned in Sec 2, [1.1.2], item b). In all other cases, the gas fuel piping is to be enclosed by a double pipe or duct in accordance with Ch 5, Sec 2, [3.1.1].

1.3 Ventilation

1.3.1 *The ventilation system of ESD-protected machinery spaces shall be arranged in accordance with Ch 7, Sec 3, [7].*

1.4 Gas detection

1.4.1 The gas detection equipment fitted to ESD protected machinery spaces is to comply with Ch 8, Sec 1, [7.1.6].

Section 5 Fuel Preparation Room Design

1 General

1.1 Location of fuel preparation rooms

1.1.1 *Fuel preparation rooms shall be located on an open deck, unless those rooms are arranged and fitted in accordance with the regulations of this Rule Note for tank connection spaces.*

1.1.2 Fuel preparation rooms containing low pressure systems may be located below deck. Fuel preparation rooms containing high pressure systems may be accepted below deck only if a specific analysis is submitted demonstrating that, for the worst leakage scenario, they can withstand the maximum pressure build up in the space, taking into account the pressure relief devices, where fitted.

1.2 Protection of fuel preparation rooms against cryogenic leakages

1.2.1 Fuel preparation rooms regardless of location are to be arranged to safely contain cryogenic leakages. Relevant justifications are to be submitted in accordance with the provisions of Ch 3, Sec 1, [2.1.4].

1.2.2 The material of the boundaries of the fuel preparation room is to have a design temperature corresponding with the lowest temperature it can be subject to in a probable maximum leakage scenario unless the boundaries of the space, i.e. bulkheads and decks, are provided with suitable thermal protection. Coatings approved in accordance with EN ISO 20088-1 may be considered in this respect.

1.2.3 The fuel preparation room is to be arranged to prevent the surrounding hull structure from being exposed to unacceptable cooling, in case of leakage of cryogenic liquids.

1.2.4 The fuel preparation room to be designed to withstand the maximum pressure build up during such a leakage. Alternatively, pressure relief venting to a safe location (mast) may be provided.

2 Additional requirements for fuel preparations rooms located below deck

2.1 General

2.1.1 When applying the tank connection space requirements to fuel preparation rooms located below deck, the provisions of [2.2] and [2.3] are to be considered.

2.2 Access arrangements and associated hazardous areas

2.2.1 A fuel preparation room opening into another enclosed space on the ship which is a non-hazardous space is required to be fitted with an airlock according to Sec 7, [1.1.2].

2.2.2 The bolted hatch requirement in Sec 7, [1.1.3] and the associated Zone 2 hazardous area requirement in Ch 7, Sec 2, [4.3.2] do not apply to a fuel preparation room located below deck unless that space can also be defined as a tank connection space using the definition in Ch 1, Sec 1, [5.1.17].

2.2.3 A fuel preparation room with direct access onto an open deck, or to a semi-enclosed space on deck, does not require an airlock. In the absence of an airlock, the area outside the door will be classified as a hazardous area according to Ch 7, Sec 2, [4.2.1], d) and Ch 7, Sec 2, [4.3.1].

2.3 Bilge wells

2.3.1 The bilge well requirements in Ch 8, Sec 1, [2.1.2] only apply to a fuel preparation room located below deck if that fuel preparation room handles fuel in its liquid phase.

Section 6 Bilge and Draining Systems

1 Bilge systems

1.1 General requirements

1.1.1 *Bilge systems installed in areas where fuel covered by this Rule Note can be present shall be segregated from the bilge system of spaces where fuel cannot be present.*

1.1.2 Areas where fuel can be present include:

- fuel storage hold spaces
- interbarrier spaces
- fuel preparation rooms
- GVU spaces
- ESD-protected machinery spaces.

Bilge systems serving spaces where gas may be present are to be segregated from ESD-protected machinery spaces.

1.1.3 *Where fuel is carried in a fuel containment system requiring a secondary barrier, suitable drainage arrangements for dealing with any leakage into the hold or insulation spaces through the adjacent ship structure shall be provided. The bilge system shall not lead to pumps in safe spaces. Means of detecting such leakage shall be provided.*

1.1.4 *The hold or interbarrier spaces of type A independent tanks for liquid gas shall be provided with a drainage system suitable for handling liquid fuel in the event of fuel tank leakage or rupture.*

2 Drip trays

2.1 General

2.1.1 *Drip trays shall be fitted where leakage may occur which can cause damage to the ship structure or where limitation of the area which is effected from a spill is necessary.*

2.1.2 Drip trays are to be fitted in particular in the following locations:

- in way of the fuel storage tanks located on open deck (Ch 3, Sec 1, [2.1.13] and Ch 3, Sec 3, [1.1.2])
- at the bunkering station (see Ch 6, Sec 1, [2.1.6])
- in fuel preparation rooms, in way of possible liquid fuel leakage sources including detachable pipe connections, pumps, valves and heat exchangers.

2.1.3 *Drip trays shall be made of suitable material.*

2.1.4 Suitable material means stainless steel or other material having a design temperature corresponding to the temperature of the fuel in the storage tank.

2.2 Arrangement

2.2.1 *The drip tray shall be thermally insulated from the ship's structure so that the surrounding hull or deck structures are not exposed to unacceptable cooling, in case of leakage of liquid fuel.*

2.2.2 [2.2.1] does not apply to drip trays which are:

- an integral part of the ship structure, provided that this structure is designed for low temperatures and subject to satisfactory justifications (e.g. thermal calculations), or
- located far enough from the ship's structure.

2.2.3 *Each tray shall be fitted with a drain valve to enable rain water to be drained over the ship's side.*

2.2.4 Requirement [2.2.3] applies only to drip trays located on open decks. The drain valve is to be of self-closing type and suitable for contact with liquid fuel.

2.2.5 *Each tray shall have a sufficient capacity to ensure that the maximum amount of spill according to the risk assessment can be handled.*

2.2.6 The capacity of the drip tray is to be determined on the basis of the worst expected leakage scenario and agreed by the Society.

For each case, the amount of spill is to be calculated based on the time necessary for leakage detection, ESD activation and effective shutdown of the pressure source and shutoff of the isolating valve.

2.2.7 Drip trays are to be fitted with a temperature sensor located in a small well to detect a possible leakage and activate the automatic shutdown of the concerned valves.

Section 7 Access to Enclosed Spaces

1 Arrangement of entrances and other openings

1.1 General

1.1.1 *Direct access shall not be permitted from a non-hazardous area to a hazardous area. Where such openings are necessary for operational reasons, an airlock which complies with Sec 8 shall be provided.*

1.1.2 *If the fuel preparation room is approved located below deck, the room shall, as far as practicable, have an independent access direct from the open deck. Where a separate access from deck is not practicable, an airlock which complies with Sec 8 5.12 shall be provided.*

1.1.3 *Unless access to the tank connection space is independent and direct from open deck it shall be arranged as a bolted hatch. The space containing the bolted hatch will be a hazardous space.*

1.1.4 Access to the tank connection space from the fuel storage hold space through a gastight door and an airlock complying with Sec 8 may be considered, subject to the provisions of Ch 1, Sec 1, [3].

1.1.5 *If the access to an ESD-protected machinery space is from another enclosed space in the ship, the entrances shall be arranged with an airlock which complies with Sec 8.*

1.1.6 *For inerted spaces access arrangements shall be such that unintended entry by personnel shall be prevented. If access to such spaces is not from an open deck, sealing arrangements shall ensure that leakages of inert gas to adjacent spaces are prevented.*

1.1.7 The access to GVU rooms from gas-safe machinery spaces is to be arranged through an air lock complying with Sec 8.

Section 8 Airlocks

1 Arrangement, safety and monitoring

1.1 General

1.1.1 *An airlock is a space enclosed by gastight bulkheads with two substantially gastight doors spaced at least 1,5 m and not more than 2,5 m apart. Unless subject to the requirements of the International Convention on Load Line, the sill height of the door leading to the hazardous area shall not be less than 300 mm. The doors shall be self-closing without any holding back arrangements.*

1.1.2 *Airlocks shall be mechanically ventilated at an overpressure relative to the adjacent hazardous area or space.*

1.1.3 The overpressure relative to the adjacent hazardous area or space is to be maintained whatever the pressure in that area or space. The minimum overpressure value is not to be below 25 Pa.

The overpressure in air locks for access to ESD-protected machinery space is to be maintained in all expected operating conditions of the engines, regardless of the number and load of running engines.

1.1.4 *The airlock shall be designed in a way that no gas can be released to safe spaces in case of the most critical event in the gas dangerous space separated by the airlock. The events shall be evaluated in the risk analysis according to Ch 1, Sec 2, [1].*

1.1.5 The design and arrangement of the airlock are to take into account the overpressure likely to occur in the gas dangerous space in case of rupture of a liquid or gas fuel pipe.

1.1.6 *Airlocks shall have a simple geometrical form. They shall provide free and easy passage, and shall have a deck area not less than 1,5 m^2. Airlocks shall not be used for other purposes, for instance as store rooms.*

1.1.7 *An audible and visual alarm system to give a warning on both sides of the airlock shall be provided to indicate if more than one door is moved from the closed position.*

1.1.8 *For non-hazardous spaces with access from hazardous spaces below deck where the access is protected by an airlock, upon loss of under pressure in the hazardous space access to the space is to be restricted until the ventilation has been reinstated. Audible and visual alarms shall be given at a manned location to indicate both loss of pressure and opening of the airlock doors when pressure is lost.*

1.1.9 A monitoring system is to be provided to monitor the differential pressure between the hazardous space and the air lock.

1.1.10 *Essential equipment required for safety shall not be de-energized and shall be of a certified safe type. This may include lighting, fire detection, public address, general alarms systems.*

1.1.11 Requirement [1.1.10] applies to the electrical equipment located in the air lock. It also includes the gas detection system required by Ch 8, Sec 1, [7.1.1], g).

Section 9 Gas Valve Units

1 Location of gas valve units - design and arrangement of their enclosures

1.1 Location of gas valve units

1.1.1 Gas valve units may be located in:

- the tank connection space, except for high pressure fuel systems
- the fuel preparation room
- an enclosure located within the machinery space.

1.1.2 Gas valve units may also be located in another independent space, provided it fulfils the criteria applicable to fuel preparation rooms, in particular with respect to location, access, ventilation and gas detection. See also Sec 7, [1.1.5]

1.1.3 Gas valve units are to be located as close as possible to the gas consumers so as to reduce the engine response time in case of load variation and limit the amount of gas released in case of leakage. Relevant requirements from gas consumer manufacturers are to be fulfilled.

1.2 Design and arrangement of gas valve unit enclosures

1.2.1 Where an enclosure is provided for the gas valve unit, the enclosing pipes or ducts provided for the gas fuel pipe located upstream and downstream of the gas valve unit may be connected to the enclosure.

1.2.2 Where provided, gas valve unit enclosures are to be gastight. The access to the enclosure is to be possible only through a bolted hatch, for maintenance or repair purposes. The enclosure is to be designed to withstand the maximum pressure in case of gas leakage, taking into account the pressure relief devices, where fitted. The enclosure is to be ventilated in accordance with the relevant provisions of Ch 7, Sec 3 and provided with gas detection arrangements. Manual shut off valves are to be capable of being operated from outside the enclosure.

Section 10 Hull Scantling in way of Gas Fuel Tank

1 Application

1.1 General

1.1.1 This Section applies to the hull structure in way of gas fuel tank, with the exception of the independent tank structure.

2 Primary supporting members

2.1 Finite element model

2.1.1 For the checking of the scantlings of primary supporting members in way of tank supports, a three-dimensional finite element model or 3D beam model is required.

2.2 Structural modelling

2.2.1 General

For units with independent tanks, the structural model is to include the primary supporting members of the hull and the tanks with their supporting members and key systems.

The fuel tank model is to include the following primary supporting members:

- shell plating
- bulkhead plating, including wash bulkheads if any
- bottom plating
- top plating
- transverse web frames
- horizontal stringers
- girders.

2.2.2 Modelling of supports and keys

The fuel tanks are linked to the hold by the following supports and keys, acting in one direction:

- vertical supports (Z direction)
- antipitching keys (X direction), used also as anticollision keys
- antirolling keys (Y direction)
- antiflotation keys (Z direction).

These supports and keys can be modelled by either linear elements (bar, flexible mounts, springs), or non-linear elements (gap elements).

Keys and supports not allowing tension loads and modelled with linear elements are to be deleted when in tension.

Stiffness of these elements is to be representative of the actual stiffness of the supports and keys.

2.2.3 Stiffness of supports and keys for independent tanks

The axial stiffness of elements used for the modelling of supports and keys of independent tanks is to be calculated taking into account the stiffness of:

- the support in way of tank
- the spacer
- the support in way of hull.

The stiffness K, in N/mm, of the wooden part between lower and upper parts of the support may be calculated as follows:

$K = E S / h$

where:

E : Young modulus of the wooden part, in N/mm^2

S : Sectional area of the wooden part, in mm^2

h : Height of the wooden part, in mm.

The stiffness to input in the gap or spring property is:

$K_{element} = K / N_{elements}$

with:

$N_{elements}$: Number of elements used to model the wooden part.

2.2.4 Size of the elements

The mesh size should be equal to the spacing of the longitudinal stiffeners. Each longitudinal ordinary stiffener is to be modelled. The aspect ratio of the elements should be as close to 1 as possible.

2.3 Yielding strength criteria

2.3.1 Yielding strength criteria for primary supporting members are defined in:

- NR467, Pt B, Ch 7, Sec 6 [5] for beam models,
- NR467, Part B, Chapter 8 for finite element models.

Yielding strength criteria for supporting members and keys systems are defined in NR467, Pt B, Ch 8, App 2, [3] and NR467, Pt B, Ch 8, App 2, [4].

2.4 Buckling check

2.4.1 Buckling strength criteria for primary supporting members are defined in NR467, Pt B, Ch 9, Sec 1.

3 Flooding for ships with independent tanks

3.1 General

3.1.1 In flooding condition, the lateral pressure to be considered is to be calculated according to Ch 3, Sec 2, [10.21.3].

4 Structural details for fuel storage hold space

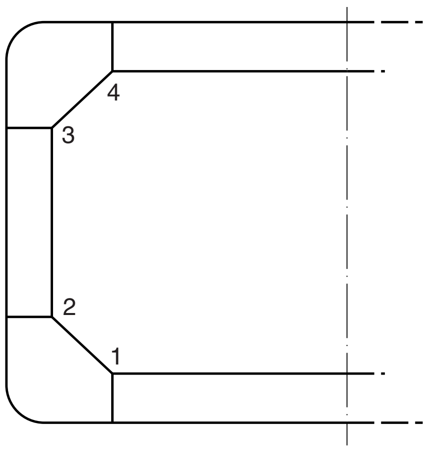
4.1 Knuckles

4.1.1 The detail arrangement of knuckles is typically to be made according to (see Fig 1):

- for position 1: Tab 36 to Tab 38 of NR467, Pt B, Ch 11, App 2
- for position 2: Tab 61 and Tab 62 of NR467, Pt B, Ch 11, App 2
- for positions 3 and 4: in a similar way to positions 1 and 2.

  Where there is no prolonging bracket in way of knuckle joints in positions 1 and/or 2, the connection of transverse webs to the inner hull and longitudinal girder plating is to be made with partial penetration welds over a length not less than 40 mm.

Figure 1 : Positions of connections



4.2 Connections of inner bottom with transverse cofferdam bulkheads

4.2.1 The thickness and material properties of the supporting floors are to be at least equal to those of the cofferdam bulkhead plating.

4.2.2 Vertical webs fitted within the cofferdam bulkhead are to be in line with the double bottom girders.

4.2.3 Manholes in double bottom floors in line with the cofferdam bulkhead plating are to be located as low as practicable and at mid-distance between two adjacent longitudinal girders.

CHAPTER 3
FUEL CONTAINMENT SYSTEM

Section 1	General Requirements
Section 2	Liquefied Gas Fuel Containment
Section 3	Portable Liquefied Gas Fuel Tanks
Section 4	CNG Fuel Containment
Section 5	Pressure Relief System
Section 6	Loading Limit for Liquefied Gas Fuel Tanks
Section 7	Maintaining of Fuel Storage Condition
Section 8	Atmospheric Control within the Fuel Containment System
Section 9	Atmosphere Control within Fuel Storage Hold Spaces (fuel containment systems other than type C independent tanks)
Section 10	Environmental Control of Spaces Surrounding Type C Independent Tanks
Section 11	Inerting
Section 12	Inert Gas Production and Storage on Board
Section 13	Independent Tank Supports
Section 14	Fatigue Requirements
Appendix 1	Standard for the Use of Limit State Methodologies in the Design of Fuel Containment Systems of Novel Configuration

Section 1 General Requirements

1 Functional requirements

1.1

1.1.1 *This Section relates to functional requirements in Ch 1, Sec 3, [1.1.1], Ch 1, Sec 3, [1.1.2], Ch 1, Sec 3, [1.1.5] and Ch 1, Sec 3, [1.1.8] to Ch 1, Sec 3, [1.1.17] . In particular the following apply:*

a) *the fuel containment system shall be so designed that a leak from the tank or its connections does not endanger the ship, persons on board or the environment. Potential dangers to be avoided include:*
   1) *exposure of ship materials to temperatures below acceptable limits*
   2) *flammable fuels spreading to locations with ignition sources*
   3) *toxicity potential and risk of oxygen deficiency due to fuels and inert gases*
   4) *restriction of access to muster stations, escape routes and life-saving appliances (LSA), and*
   5) *reduction in availability of LSA.*

b) *the pressure and temperature in the fuel tank shall be kept within the design limits of the containment system and possible carriage requirements of the fuel*

c) *the fuel containment arrangement shall be so designed that safety actions after any gas leakage do not lead to an unacceptable loss of power, and*

d) *if portable tanks are used for fuel storage, the design of the fuel containment system shall be equivalent to permanent installed tanks as described in this chapter.*

2 General

2.1

2.1.1 *Natural gas in a liquid state may be stored with a maximum allowable relief valve setting (MARVS) of up to 1,0 MPa.*

2.1.2 *The Maximum Allowable Working Pressure (MAWP) of the gas fuel tank shall not exceed 90% of the Maximum Allowable Relief Valve Setting (MARVS).*

2.1.3 *A fuel containment system located below deck shall be gas tight towards adjacent spaces.*

2.1.4 *All tank connections, fittings, flanges and tank valves must be enclosed in gas tight tank connection spaces, unless the tank connections are on open deck. The space shall be able to safely contain leakage from the tank in case of leakage from the tank connections.*

2.1.5 A tank connection space may be required also for tanks on open deck:

- for ships where restriction of hazardous areas is deemed necessary; or
- in order to provide environmental protection for essential safety equipment related to the gas fuel system like tank valves, safety valves and instrumentation; or
- as a result of the risk analysis required in Ch 1, Sec 2, [2].

The ability of the tank connection space to withstand a leakage is to be analyzed as follows:

a) A leakage scenario is to be determined and submitted to the Society. For Type C tanks, complete failure (rupture) needs to be considered only for the pipes located downstream of the first valve.

Note 1: A risk analysis may be carried out to demonstrate that the leakage scenarios are relevant.

b) The following parameters are to be evaluated:
   - amount of liquid fuel spilled and/or gaseous fuel released until the automatic closing of the valve required in Ch 5, Sec 2, [1.3.2]
   - pressure built up due to the gas leakage and/or liquid fuel vaporization, taking into account the ventilation system required in Ch 7, Sec 3, [3.1.1] and the pressure relief device fitted to the tank connection space
   - gas concentration in the tank containment space
   - temperature reached in the tank connection space and in the tank hold space.

2.1.6 *Pipe connections to the fuel storage tank shall be mounted above the highest liquid level in the tanks, except for fuel storage tanks of type C. Connections below the highest liquid level may however also be accepted for other tank types after special consideration by the Society.*

2.1.7 *Piping between the tank and the first valve which release liquid in case of pipe failure shall have equivalent safety as the type C tank, with dynamic stress not exceeding the values given in Sec 2, [16.3.1].*

In addition, the piping between the tank and the first valve is to be contained in a pipe arranged in accordance with [2.1.12].

2.1.8 *The material of the bulkheads of the tank connection space shall have a design temperature corresponding with the lowest temperature it can be subject to in a probable maximum leakage scenario. The tank connection space shall be designed to withstand the maximum pressure build up during such a leakage. Alternatively, pressure relief venting to a safe location (mast) can be provided.*

2.1.9 The steel grade of the bulkheads is to be in accordance with Ch 4, Sec 1, Tab 5 for its design temperature.

2.1.10 *The probable maximum leakage into the tank connection space shall be determined based on detail design, detection and shut down systems.*

For the probable maximum leakage and lowest temperature likely to be reached in such leakage conditions, refer to [2.1.4].

2.1.11 *If piping is connected below the liquid level of the tank it has to be protected by a secondary barrier up to the first valve.*

2.1.12 For type C tanks, the secondary barrier required in [2.1.11] is to consist of an external piping continuously enclosing the inner liquid pipe from the tank inner wall to the first valve body. The external pipe is to comply with the provisions of Ch 5, Sec 1 and Ch 4, Sec 1 and is to be provided with a venting line having gas detection arrangement. The tank outer jacket may be accepted as secondary barrier only for tanks located above the deck and provided it complies with the provisions of Sec 2, [4].

2.1.13 *If liquefied gas fuel storage tanks are located on open deck the ship steel shall be protected from potential leakages from tank connections and other sources of leakage by use of drip trays. The material is to have a design temperature corresponding to the temperature of the fuel carried at atmospheric pressure. The normal operation pressure of the tanks shall be taken into consideration for protecting the steel structure of the ship.*

2.1.14 Whether a drip tray is needed or not should be decided in accordance with the following:

a) when the tank is located on the open deck, drip trays should be provided to protect the deck from leakages from tank connections and other sources of leakage;

b) when the tank is located below the open deck but the tank connections are on the open deck, drip trays should be provided to protect the deck from leakages from tank connections and other sources of leakage; and

c) when the tank and the tank connections are located below the deck, all tank connections should be located in a tank connection space. Drip trays in this case need not be required.

2.1.15 The volume of the drip tray is to be determined in accordance with [2.1.4].

Protective screens are to be provided to avoid liquid fuel spray or spills onto surfaces not designed for cryogenic temperatures.

A gas dispersion analysis may be required, in particular as an HAZID study outcome.

2.1.16 *Means shall be provided whereby liquefied gas in the storage tanks can be safely emptied.*

2.1.17 Type C tanks may be emptied by means of inert gas pressurization.

2.1.18 *It shall be possible to empty, purge and vent fuel storage tanks with fuel piping systems. Instructions for carrying out these procedures must be available on board. Inerting shall be performed with an inert gas prior to venting with dry air to avoid an explosion hazardous atmosphere in tanks and fuel pipes. See detailed regulations in Sec 8.*

2.1.19 Arrangements are to be made to avoid any risk of gas or inert gas accumulation in the machinery spaces or gas fuel preparation room through a disconnected pipe during gas purging or inerting operations.

Section 2 Liquefied Gas Fuel Containment

1 General

1.1

1.1.1 *The risk assessment required in Ch 1, Sec 2, [2] shall include evaluation of the vessel's liquefied gas fuel containment system, and may lead to additional safety measures for integration into the overall vessel design.*

1.1.2 *The design life of fixed liquefied gas fuel containment system shall not be less than the design life of the ship or 20 years, whichever is greater.*

1.1.3 *The design life of portable tanks shall not be less than 20 years.*

1.1.4 *Liquefied gas fuel containment systems shall be designed in accordance with North Atlantic environmental conditions and relevant long-term sea state scatter diagrams for unrestricted navigation. Less demanding environmental conditions, consistent with the expected usage, may be accepted by the Society for liquefied gas fuel containment systems used exclusively for restricted navigation. More demanding environmental conditions may be required for liquefied gas fuel containment systems operated in conditions more severe than the North Atlantic environment.*

Note 1: Refer to IACS Rec.034.

Note 2: North Atlantic environmental conditions refer to wave conditions. Assumed temperatures are used for determining appropriate material qualities with respect to design temperatures and is another matter not intended to be covered in [1.1.4].

1.1.5 *Liquefied gas fuel containment systems shall be designed with suitable safety margins:*

a) *to withstand, in the intact condition, the environmental conditions anticipated for the liquefied gas fuel containment system's design life and the loading conditions appropriate for them, which shall include full homogeneous and partial load conditions and partial filling to any intermediate levels, and*
b) *being appropriate for uncertainties in loads, structural modelling, fatigue, corrosion, thermal effects, material variability, aging and construction tolerances.*

1.1.6 *The liquefied gas fuel containment system structural strength shall be assessed against failure modes, including but not limited to plastic deformation, buckling and fatigue. The specific design conditions that shall be considered for the design of each liquefied gas fuel containment system are given in [16]. There are three main categories of design conditions:*

a) *Ultimate Design Conditions - The liquefied gas fuel containment system structure and its structural components shall withstand loads liable to occur during its construction, testing and anticipated use in service, without loss of structural integrity. The design shall take into account proper combinations of the following loads:*
    1) *internal pressure*
    2) *external pressure*
    3) *dynamic loads due to the motion of the ship in all loading conditions*
    4) *thermal loads*
    5) *sloshing loads*
    6) *loads corresponding to ship deflections*
    7) *tank and liquefied gas fuel weight with the corresponding reaction in way of supports*
    8) *insulation weight*
    9) *loads in way of towers and other attachments, and*
    10) *test loads.*
b) *Fatigue Design Conditions - The liquefied gas fuel containment system structure and its structural components shall not fail under accumulated cyclic loading.*
c) *Accidental Design Conditions - The liquefied gas fuel containment system shall meet each of the following accident design conditions (accidental or abnormal events), addressed in this Rule Note:*
    1) *Collision - The liquefied gas fuel containment system shall withstand the collision loads specified in [10.21.2] without deformation of the supports or the tank structure in way of the supports likely to endanger the tank and its supporting structure.*
    2) *Fire - The liquefied gas fuel containment systems shall sustain without rupture the rise in internal pressure specified in Sec 5, [3.1] under the fire scenarios envisaged therein.*
    3) *Flooded compartment causing buoyancy on tank - The anti-flotation arrangements shall sustain the upward force, specified in [10.21.3] and there shall be no endangering plastic deformation to the hull. Plastic deformation may occur in the fuel containment system provided it does not endanger the safe evacuation of the ship.*

1.1.7 *Measures shall be applied to ensure that scantlings required meet the structural strength provisions and are maintained throughout the design life. Measures may include, but are not limited to, material selection, coatings, corrosion additions, cathodic protection and inerting.*

1.1.8 *An inspection/survey plan for the liquefied gas fuel containment system shall be developed and approved by the Society. The inspection/survey plan shall identify aspects to be examined and/or validated during surveys throughout the liquefied gas fuel containment system's life and, in particular, any necessary in-service survey, maintenance and testing that was assumed when selecting liquefied gas fuel containment system design parameters. The inspection/survey plan may include specific critical locations as per [13.3.7] or [13.3.9].*

1.1.9 *Liquefied gas fuel containment systems shall be designed, constructed and equipped to provide adequate means of access to areas that need inspection as specified in the inspection/survey plan. Liquefied gas fuel containment systems, including all associated internal equipment shall be designed and built to ensure safety during operations, inspection and maintenance.*

2 Liquefied gas fuel containment safety principles

2.1 General

2.1.1 *The containment systems shall be provided with a complete secondary liquid-tight barrier capable of safely containing all potential leakages through the primary barrier and, in conjunction with the thermal insulation system, of preventing lowering of the temperature of the ship structure to an unsafe level.*

2.1.2 The size and configuration or arrangement of the secondary barrier may be reduced or omitted where an equivalent level of safety can be demonstrated in accordance with [2.1.3] to [2.1.5] as applicable.

2.1.3 Liquefied gas fuel containment systems for which the probability for structural failures to develop into a critical state has been determined to be extremely low but where the possibility of leakages through the primary barrier cannot be excluded, shall be equipped with a partial secondary barrier and small leak protection system capable of safely handling and disposing of the leakages (a critical state means that the crack develops into unstable condition).

The arrangements shall comply with the following:

a) failure developments that can be reliably detected before reaching a critical state (e.g. by gas detection or inspection) shall have a sufficiently long development time for remedial actions to be taken, and

b) failure developments that cannot be safely detected before reaching a critical state shall have a predicted development time that is much longer than the expected lifetime of the tank.

2.1.4 *No secondary barrier is required for liquefied gas fuel containment systems, e.g. type C independent tanks, where the probability for structural failures and leakages through the primary barrier is extremely low and can be neglected.*

2.1.5 *For independent tanks requiring full or partial secondary barrier, means for safely disposing of leakages from the tank shall be arranged.*

3 Secondary barriers in relation to tank types

3.1 General

3.1.1 *Secondary barriers in relation to the tank types defined in [16] shall be provided in accordance with Tab 1.*

Table 1 :

Basic tank type		Secondary barrier requirements
Membrane		Complete secondary barrier
Independent	Type A	Complete secondary barrier
	Type B	Partial secondary barrier
	Type C	No secondary barrier required

4 Design of secondary barriers

4.1 General

4.1.1 *The design of the secondary barrier, including spray shield if fitted, shall be such that:*

a) *it is capable of containing any envisaged leakage of liquefied gas fuel for a period of 15 days unless different criteria apply for particular voyages, taking into account the load spectrum referred to in [13.3.6]*

b) *physical, mechanical or operational events within the liquefied gas fuel tank that could cause failure of the primary barrier shall not impair the due function of the secondary barrier, or vice versa*

c) *failure of a support or an attachment to the hull structure will not lead to loss of liquid tightness of both the primary and secondary barriers*

d) *it is capable of being periodically checked for its effectiveness by means of a visual inspection or other suitable means acceptable to the Society*

e) *the methods required in [4.1.1], item d) shall be approved by the Society and shall include, as a minimum:*

   1) *details on the size of defect acceptable and the location within the secondary barrier, before its liquid tight effectiveness is compromised*

   2) *accuracy and range of values of the proposed method for detecting defects in .1 above*

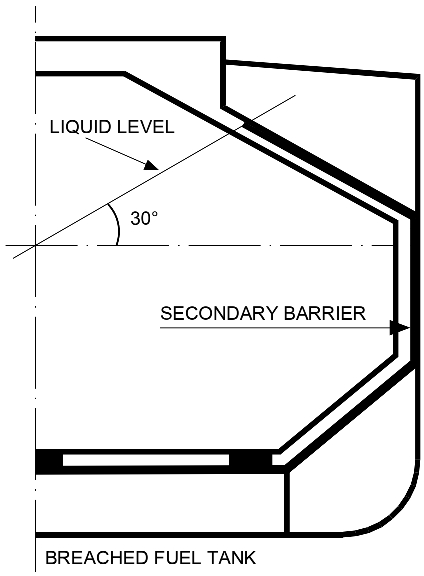
   3) *scaling factors to be used in determining the acceptance criteria if full scale model testing is not undertaken, and*

   4) *effects of thermal and mechanical cyclic loading on the effectiveness of the proposed test*

f) *the secondary barrier shall fulfil its functional requirements at a static angle of heel of 30°.*

4.1.2 The extent of the secondary barrier is to be not less than that necessary to protect the hull structures, assuming that the fuel tank is breached at a static angle of heel of 30°, with an equalisation of the liquid fuel in the tank (see Fig 1).

Figure 1 : Secondary barrier extension



5 Partial secondary barriers and primary barrier small leak protection system

5.1 General

5.1.1 *Partial secondary barriers as permitted in [2.1.3] shall be used with a small leak protection system and meet all the regulations in [4].*

The small leak protection system shall include means to detect a leak in the primary barrier, provision such as a spray shield to deflect any liquefied gas fuel down into the partial secondary barrier, and means to dispose of the liquid, which may be by natural evaporation.

5.1.2 *The capacity of the partial secondary barrier shall be determined, based on the liquefied gas fuel leakage corresponding to the extent of failure resulting from the load spectrum referred to in [13.3.6], after the initial detection of a primary leak. Due account may be taken of liquid evaporation, rate of leakage, pumping capacity and other relevant factors.*

5.1.3 *The required liquid leakage detection may be by means of liquid sensors, or by an effective use of pressure, temperature or gas detection systems, or any combination thereof.*

5.1.4 *For independent tanks for which the geometry does not present obvious locations for leakage to collect, the partial secondary barrier shall also fulfil its functional requirements at a nominal static angle of trim.*

6 Supporting arrangements

6.1 General

6.1.1 *The liquefied gas fuel tanks shall be supported by the hull in a manner that prevents bodily movement of the tank under the static and dynamic loads defined in [10.2] to [10.21], where applicable, while allowing contraction and expansion of the tank under temperature variations and hull deflections without undue stressing of the tank and the hull.*

6.1.2 *Anti-flotation arrangements shall be provided for independent tanks and capable of withstanding the loads defined in [10.21.3] without plastic deformation likely to endanger the hull structure.*

6.1.3 *Supports and supporting arrangements shall withstand the loads defined in [10.11] and [10.21], but these loads need not be combined with each other or with wave-induced loads.*

7 Associated structure and equipment

7.1 General

7.1.1 *Liquefied gas fuel containment systems shall be designed for the loads imposed by associated structure and equipment. This includes pump towers, liquefied gas fuel domes, liquefied gas fuel pumps and piping, stripping pumps and piping, N2 piping, access hatches, ladders, piping penetrations, liquid level gauges, independent level alarm gauges, spray nozzles, and instrumentation systems (such as pressure, temperature and strain gauges).*

8 Thermal insulation

8.1 General

8.1.1 *Thermal insulation shall be provided as required to protect the hull from temperatures below those allowable (see [14.1.1]) and limit the heat flux into the tank to the levels that can be maintained by the pressure and temperature control system applied in Sec 7.*

9 Use of fuel heater to raise the fuel temperature

9.1 General

9.1.1 Where a fuel heater, intended to raise the fuel temperature to a value permissible for fuel tanks, is envisaged, the following requirements are to be complied with:

- the piping and valves involved are to be suitable for the design loading temperature
- a thermometer is to be fitted at the heater outlet. It is to be set at the design temperature of the tanks and, when activated, it is to give a visual and audible alarm. This alarm is to be installed in the engine control room
- the following note is to be written on the Certificate of Fitness:

  "The minimum permissible temperature in the fuel preheater is..... °C".

10 Design loads

10.1 General

10.1.1 *This Article defines the design loads that shall be considered with regard to regulations in [11] to [13]. This includes load categories (permanent, functional, environmental and accidental) and the description of the loads.*

10.1.2 *The extent to which these loads shall be considered depends on the type of tank, and is more fully detailed in the following paragraphs.*

10.1.3 *Tanks, together with their supporting structure and other fixtures, shall be designed taking into account relevant combinations of the loads described below.*

10.2 Permanent loads

10.2.1 Gravity loads

The weight of tank, thermal insulation, loads caused by towers and other attachments shall be considered.

10.2.2 Permanent external loads

Gravity loads of structures and equipment acting externally on the tank shall be considered.

10.3 Functional loads

10.3.1 *Loads arising from the operational use of the tank system shall be classified as functional loads.*

10.3.2 *All functional loads that are essential for ensuring the integrity of the tank system, during all design conditions, shall be considered.*

10.3.3 *As a minimum, the effects from the following criteria, as applicable, shall be considered when establishing functional loads:*

- *internal pressure*
- *external pressure*
- *thermally induced loads*
- *vibration*
- *interaction loads*
- *loads associated with construction and installation*
- *test loads*
- *static heel loads*
- *weight of liquefied gas fuel*
- *sloshing*
- *wind impact, wave impacts and green sea effect for tanks installed on open deck.*

10.4 Internal pressure

10.4.1 *In all cases, including [10.4.2], P0 shall not be less than MARVS.*

10.4.2 *For liquefied gas fuel tanks where there is no temperature control and where the pressure of the liquefied gas fuel is dictated only by the ambient temperature, P0 shall not be less than the gauge vapour pressure of the liquefied gas fuel at a temperature of 45°C except as follows:*

- *Lower values of ambient temperature may be accepted by the Society for ships operating in restricted areas. Conversely, higher values of ambient temperature may be required.*
- *For ships on voyages of restricted duration, P0 may be calculated based on the actual pressure rise during the voyage and account may be taken of any thermal insulation of the tank.*

10.4.3 *Subject to special consideration by the Society and to the limitations given in [16] for the various tank types, a vapour pressure P_h higher than P0 may be accepted for site specific conditions (harbour or other locations), where dynamic loads are reduced.*

10.4.4 *Pressure used for determining the internal pressure shall be:*

- *(P_{gd})max is the associated liquid pressure determined using the maximum design accelerations.*
- *$(P_{gd\ site})$max is the associated liquid pressure determined using site specific accelerations.*
- *P_{eq} should be the greater of P_{eq1} and P_{eq2} calculated, in MPa, as follows:*

  $P_{eq1} = P_0 + (P_{gd})max$

  $P_{eq2} = P_h + (P_{gd\ site})max$

10.4.5 *The internal liquid pressures are those created by the resulting acceleration of the centre of gravity of the liquefied gas fuel due to the motions of the ship referred to in [10.14]. The value of internal liquid pressure P_{gd} resulting from combined effects of gravity and dynamic accelerations shall be calculated, in MPa, as follows:*

$$P_{gd} = \frac{\alpha_\beta Z_\beta \rho}{1,02 \cdot 10^5}$$

where:

α_β : *Dimensionless acceleration (i.e. relative to the acceleration of gravity), resulting from gravitational and dynamic loads, in an arbitrary direction; (see Fig 2).*

For large tanks, an acceleration ellipsoid, taking account of transverse vertical and longitudinal accelerations, should be used.

Z_β : *Largest liquid height (m) above the point where the pressure is to be determined measured from the tank shell in the β direction (see Fig 3).*

Tank domes considered to be part of the accepted total tank volume shall be taken into account when determining Z_β unless the total volume of tank domes V_d does not exceed the following value:

$$V_d = V_t\left(\frac{100 - FL}{FL}\right)$$

with:

V_t : Tank volume without any domes

FL : Filling limit according to Sec 6

ρ : Maximum liquefied gas fuel density, in kg/m³, at the design temperature.

The direction that gives the maximum value (P_{gd})max or $(P_{gd\,site})$max shall be considered. Where acceleration components in three directions need to be considered, an ellipsoid shall be used. The above formula applies only to full tanks.

10.4.6 The internal pressure P_{eq} defined in [10.4.4] is to be taken as follows:

- For harbour conditions:

  $P_{eq} = P_{ls}$

- For seagoing conditions:

  $P_{eq} = P_{ls} + P_{ld}$

Where:

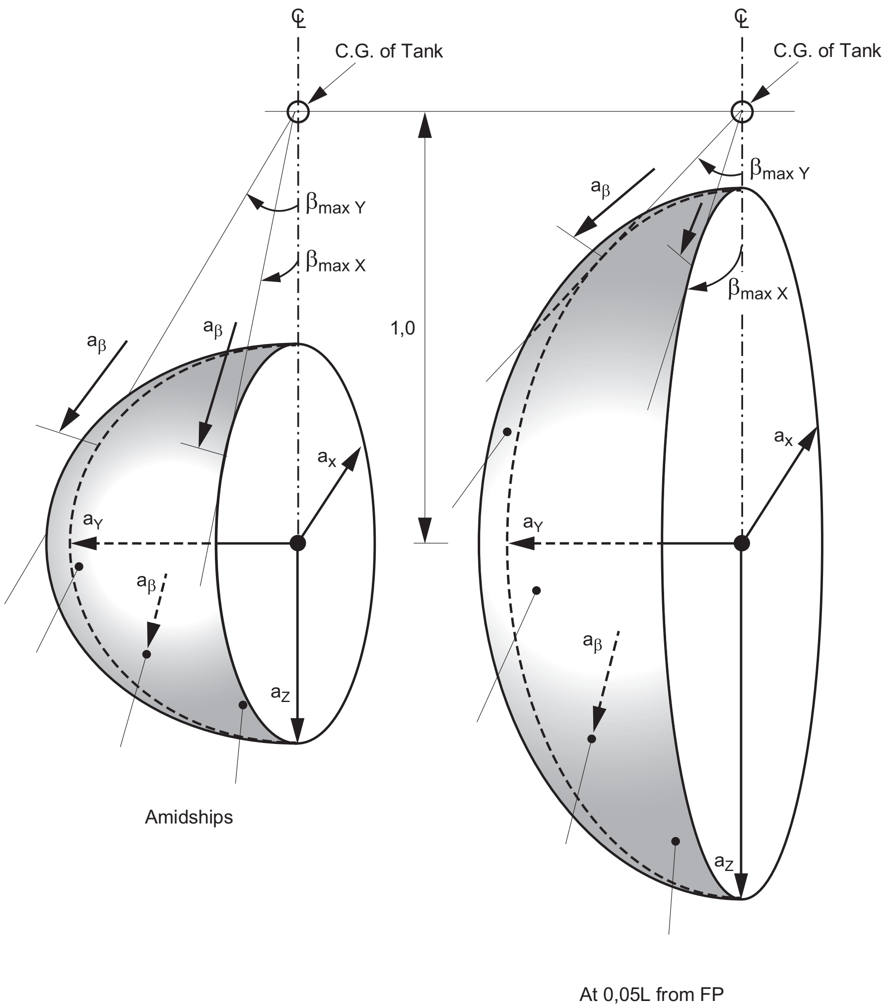
P_{ls} : Static pressure due to liquid in tank, in kN/m², as defined in NR467, Pt B, Ch 5, Sec 6, [1.2.1], with P_{pv} taken equal to P_0 or P_h, as appropriate according to respectively [10.4.2] and [10.4.3]

P_{ld} : Dynamic pressure due to liquid in tank, in kN/m², as defined in NR467, Pt B, Ch 5, Sec 6, [1.3.1].

Guidance formulae for associated dynamic liquid pressure P_{gd} are given in [10.4.5] as an alternative for seagoing conditions.

Note 1: The dynamic liquid pressure P_{gd} given in [10.4.5] includes the effect of gravity.

Figure 2 : Acceleration ellipsoid



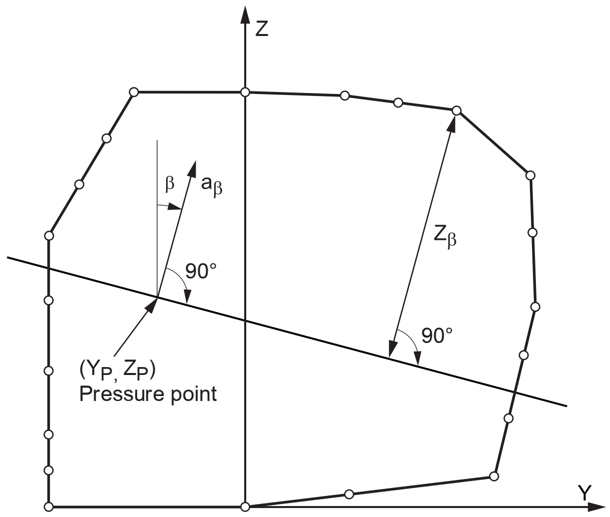
a_β : Resulting acceleration (static and dynamic) in arbitrary direction β

a_X : Longitudinal component of acceleration

a_Y : Transverse component of acceleration

a_Z : Vertical component of acceleration (refer to [10.14])

Figure 3 : Determination of internal pressure heads



10.5 External pressure

10.5.1 External design pressure loads shall be based on the difference between the minimum internal pressure and the maximum external pressure to which any portion of the tank may be simultaneously subjected.

10.6 Thermally induced loads

10.6.1 Transient thermally induced loads during cooling down periods shall be considered for tanks intended for liquefied gas fuel temperatures below minus 55°C.

10.6.2 *Stationary thermally induced loads shall be considered for liquefied gas fuel containment systems where the design supporting arrangements or attachments and operating temperature may give rise to significant thermal stresses (see Sec 7, [2]).*

10.7 Vibration

10.7.1 *The potentially damaging effects of vibration on the liquefied gas fuel containment system shall be considered.*

10.8 Interaction loads

10.8.1 *The static component of loads resulting from interaction between liquefied gas fuel containment system and the hull structure, as well as loads from associated structure and equipment, shall be considered.*

10.9 Loads associated with construction and installation

10.9.1 *Loads or conditions associated with construction and installation shall be considered, e.g. lifting.*

10.10 Test loads

10.10.1 *Account shall be taken of the loads corresponding to the testing of the liquefied gas fuel containment system referred to in Ch 9, Sec 1, [5].*

10.11 Static heel loads

10.11.1 *Loads corresponding to the most unfavourable static heel angle within the range 0° to 30° shall be considered.*

10.11.2 See Guidance to detailed calculation of pressure for a static heel angle of 30°, as given in NR467, Pt D, Ch 9, App 1, [3].

10.12 Other functional loads

10.12.1 *Any other loads not specifically addressed, which could have an effect on the liquefied gas fuel containment system, shall be taken into account.*

10.13 Environmental loads

10.13.1 *Environmental loads are defined as those loads on the liquefied gas fuel containment system that are caused by the surrounding environment and that are not otherwise classified as a permanent, functional or accidental load.*

10.14 Loads due to ship motion

10.14.1 *The determination of dynamic loads shall take into account the long-term distribution of ship motion in irregular seas, which the ship will experience during its operating life. Account may be taken of the reduction in dynamic loads due to necessary speed reduction and variation of heading. The ship's motion shall include surge, sway, heave, roll, pitch and yaw. The accelerations acting on tanks shall be estimated at their centre of gravity and include the following components:*

- *vertical acceleration: motion accelerations of heave, pitch and, possibly roll (normal to the ship base)*
- *transverse acceleration: motion accelerations of sway, yaw and roll and gravity component of roll, and*
- *longitudinal acceleration: motion accelerations of surge and pitch and gravity component of pitch.*

Methods to predict accelerations due to ship motion shall be proposed and approved by the Society.

Ships for restricted service may be given special consideration.

Note 1: Refer to section 4.28.2.1 of the IGC Code or NR467, Part D, Ch 9, App 1, [1.2.1] for guidance formulae for acceleration components.

10.14.2 The accelerations due to ship motions are to be taken as defined in NR467, Pt B, Ch 5, Sec 3.

10.15 Dynamic interaction loads

10.15.1

Account shall be taken of the dynamic component of loads resulting from interaction between liquefied gas fuel containment systems and the hull structure, including loads from associated structures and equipment.

10.16 Sloshing loads

10.16.1 *The sloshing loads on a liquefied gas fuel containment system and internal components shall be evaluated for the full range of intended filling levels.*

10.16.2 Gas fuel tanks are to be checked for several relevant partial filling levels. CFD calculation or test campaign is to be carried out for verification of sloshing pressure without any limitation on the filling level.

The sloshing loads may be disregarded for type C tanks where wash bulkheads are positioned so as to limit a risk of resonance of the cargo movements (see NR467, Pt B, Ch 11, Sec 4, [1.5]).

See guidance for calculation of sloshing pressure for membrane tanks, as given in NR467, Pt D, Ch 9, App 1, [2.2].

10.17 Snow and ice loads

10.17.1 *Snow and icing shall be considered, if relevant.*

10.17.2 For ships operating in low air temperature, unless otherwise specified, the ice loads to be considered for tanks located on exposed decks are those of NR467 Pt F, Ch 8, Sec 4, [5.2.2].

10.18 Loads due to navigation in ice

10.18.1 *Loads due to navigation in ice shall be considered for vessels intended for such service.*

10.19 Green sea loading

10.19.1 *Account shall be taken to loads due to water on deck.*

10.19.2 Water pressure due to green seas is to be calculated, for tanks located on exposed decks, in accordance with NR467, Pt B, Ch 5, Sec 5, [5.4.1].

10.20 Wind loads

10.20.1 *Account shall be taken to wind generated loads as relevant.*

10.20.2 Wind pressure is to be taken equal to 2,5 kN/m^2

10.21 Accidental loads

10.21.1 Accidental loads are defined as loads that are imposed on a liquefied gas fuel containment system and it's supporting arrangements under abnormal and unplanned conditions.

10.21.2 Collision load

a) *The collision load shall be determined based on the fuel containment system under fully loaded condition with an inertial force corresponding to “a” in Tab 2 in forward direction and “a/2” in the aft direction, where “g” is the gravitational acceleration.*

   Special consideration should be given to ships with Froude number (Fn) > 0,4.

b) The dynamic pressure p_w resulting from collision loads is to be calculated as follows:

$p_w = \rho \, a \, |x - x_b|$

where:

a : Longitudinal acceleration defined in 6.4.9.5.1, in m.s^{-2}

x_b : X co-ordinate, in m, of aft bulkhead of the tank in the case of forward acceleration, or of the fore bulkhead of the tank in the case of aftward acceleration.

ρ : Maximum fuel density, in kg.m^{-3}, at the design temperature.

Table 2 :

Ship lengh L	Desiggn acceleration a
L > 100 m	0,5 g
60 < L ≤ 100 m	$\left(2 - \frac{3(L-60)}{80}\right) g$
L ≤ 60 m	2 g

10.21.3 Loads due to flooding on ship

For independent tanks, loads caused by the buoyancy of a fully submerged empty tank shall be considered in the design of antiflotation chocks and the supporting structure in both the adjacent hull and tank structure.

11 Structural integrity

11.1 General

11.1.1 The structural design shall ensure that tanks have an adequate capacity to sustain all relevant loads with an adequate margin of safety. This shall take into account the possibility of plastic deformation, buckling, fatigue and loss of liquid and gas tightness.

11.1.2 The structural integrity of liquefied gas fuel containment systems can be demonstrated by compliance with [16], as appropriate for the liquefied gas fuel containment system type.

11.1.3 For other liquefied gas fuel containment system types, that are of novel design or differ significantly from those covered by [16], the structural integrity shall be demonstrated by compliance with [17].

12 Structural analysis

12.1 Analysis

12.1.1 *The design analyses shall be based on accepted principles of statics, dynamics and strength of materials.*

12.1.2 *Simplified methods or simplified analyses may be used to calculate the load effects, provided that they are conservative. Model tests may be used in combination with, or instead of, theoretical calculations. In cases where theoretical methods are inadequate, model or full scale tests may be required.*

12.1.3 *When determining responses to dynamic loads, the dynamic effect shall be taken into account where it may affect structural integrity.*

12.2 Load scenarios

12.2.1 For each location or part of the liquefied gas fuel containment system to be considered and for each possible mode of failure to be analysed, all relevant combinations of loads that may act simultaneously shall be considered.

12.2.2 The most unfavourable scenarios for all relevant phases during construction, handling, testing and in service conditions shall be considered.

12.2.3 *When the static and dynamic stresses are calculated separately and unless other methods of calculation are justified, the total stresses shall be calculated according to:*

$$\sigma_x = \sigma_{x \cdot st} \pm \sqrt{\sum (\sigma_{x \cdot dyn})^2}$$

$$\sigma_y = \sigma_{y \cdot st} \pm \sqrt{\sum (\sigma_{y \cdot dyn})^2}$$

$$\sigma_z = \sigma_{z \cdot st} \pm \sqrt{\sum (\sigma_{z \cdot dyn})^2}$$

$$\tau_{xy} = \tau_{xy \cdot st} \pm \sqrt{\sum (\tau_{xy \cdot dyn})^2}$$

$$\tau_{xz} = \tau_{xz \cdot st} \pm \sqrt{\sum (\tau_{xz \cdot dyn})^2}$$

$$\tau_{yz} = \tau_{yz \cdot st} \pm \sqrt{\sum (\tau_{yz \cdot dyn})^2}$$

where:

$\sigma_{x.st}$, $\sigma_{y.st}$, $\sigma_{z.st}$, $\tau_{xy.st}$, $\tau_{xz.st}$, $\tau_{yz.st}$ *:Static stresses*

$\sigma_{x.dyn}$, $\sigma_{y.dyn}$, $\sigma_{z.dyn}$, $\tau_{xy.dyn}$, $\tau_{xz.dyn}$, $\tau_{yz.dyn}$ *: Dynamic stresses.*

each shall be determined separately from acceleration components and hull strain components due to deflection and torsion.

13 Design conditions

13.1 General

13.1.1 *All relevant failure modes shall be considered in the design for all relevant load scenarios and design conditions. The design conditions are given in the earlier part of Chapter 6, and the load scenarios are covered by [12.2].*

13.1.2 Requirements for hull scantlings in way of gas fuel tanks are given in Ch 2, Sec 10.

13.2 Ultimate design condition

13.2.1 *Structural capacity may be determined by testing, or by analysis, taking into account both the elastic and plastic material properties, by simplified linear elastic analysis or by the provisions of this Rule Note:*

13.2.2 *Plastic deformation and buckling shall be considered.*

13.2.3 *Analysis shall be based on characteristic load values as follows:*

- *Permanent loads: Expected values*
- *Functional loads: Specified values*
- *Environmental loads: For wave loads: most probable largest load encountered during 10^8 wave encounters.*

13.2.4 *For the purpose of ultimate strength assessment the following material parameters apply:*

R_e : *Specified minimum yield stress at room temperature, in N/mm². If the stress-strain curve does not show a defined yield stress, the 0,2% proof stress applies*

R_m : *Specified minimum tensile strength at room temperature, in N/mm².*

For welded connections where under-matched welds, i.e. where the weld metal has lower tensile strength than the parent metal, are unavoidable, such as in some aluminium alloys, the respective R_e and R_m of the welds, after any applied heat treatment, shall be used. In such cases the transverse weld tensile strength shall not be less than the actual yield strength of the parent metal. If this cannot be achieved, welded structures made from such materials shall not be incorporated in liquefied gas fuel containment systems.

The above properties shall correspond to the minimum specified mechanical properties of the material, including the weld metal in the as fabricated condition. Subject to special consideration by the Society, account may be taken of the enhanced yield stress and tensile strength at low temperature.

13.2.5 *The equivalent stress σ_c (von Mises, Huber) shall be determined by:*

where:

σ_x : *Total normal stress in x-direction*

σ_y : *Total normal stress in y-direction*

σ_z : *Total normal stress in z-direction*

τ_{xy} : *Total shear stress in x-y plane*

τ_{xz} : *Total shear stress in x-z plane*

τ_{yz} : *Total shear stress in y-z plane.*

The above values shall be calculated as described in [12.2.3].

13.2.6 *Allowable stresses for materials other than those covered by Ch 4, Sec 1 shall be subject to approval by the Society in each case.*

13.2.7 *Stresses may be further limited by fatigue analysis, crack propagation analysis and buckling criteria.*

13.3 Fatigue design condition

13.3.1 *The fatigue design condition is the design condition with respect to accumulated cyclic loading.*

13.3.2 Where a fatigue analysis is required the cumulative effect of the fatigue load shall comply with:

$$\sum \frac{n_i}{N_i} + \frac{n_{Loading}}{N_{Loading}} \leq C_w$$

where:

n_i : Number of stress cycles at each stress level during the life of the tank

N_i : Number of cycles to fracture for the respective stress level according to the Wohler (S-N) curve

$n_{Loading}$: Number of loading and unloading cycles during the life of the tank not to be less than 1000. Loading and unloading cycles include a complete pressure and thermal cycle

$N_{Loading}$: Number of cycles to fracture for the fatigue loads due to loading and unloading

C_w : Maximum allowable cumulative fatigue damage ratio.

The fatigue damage shall be based on the design life of the tank but not less than 108 wave encounters.

13.3.3 Where required, the liquefied gas fuel containment system shall be subject to fatigue analysis, considering all fatigue loads and their appropriate combinations for the expected life of the liquefied gas fuel containment system. Consideration shall be given to various filling conditions.

13.3.4 Design S-N curves used in the analysis shall be applicable to the materials and weldments, construction details, fabrication procedures and applicable state of the stress envisioned.

The S-N curves shall be based on a 97,6% probability of survival corresponding to the mean-minus-two-standard-deviation curves of relevant experimental data up to final failure. Use of S-N curves derived in a different way requires adjustments to the acceptable C_w values specified in [13.3.7] to [13.3.9].

13.3.5 Analysis shall be based on characteristic load values as follows:

- Permanent loads: Expected values
- Functional loads: Specified values or specified history
- Environmental loads: Expected load history, but not less than 10^8 cycles

If simplified dynamic loading spectra are used for the estimation of the fatigue life, those shall be specially considered by the Society.

13.3.6 Where the size of the secondary barrier is reduced, as is provided for in [2.1.3], fracture mechanics analyses of fatigue crack growth shall be carried out to determine:

a) crack propagation paths in the structure, where necessitated by [13.3.7] to [13.3.9], as applicable

b) crack growth rate

c) the time required for a crack to propagate to cause a leakage from the tank

d) the size and shape of through thickness cracks, and

e) the time required for detectable cracks to reach a critical state after penetration through the thickness.

The fracture mechanics are in general based on crack growth data taken as a mean value plus two standard deviations of the test data. Methods for fatigue crack growth analysis and fracture mechanics shall be based on recognized standards.

In analysing crack propagation the largest initial crack not detectable by the inspection method applied shall be assumed, taking into account the allowable non-destructive testing and visual inspection criterion as applicable.

Crack propagation analysis specified in [13.3.7] the simplified load distribution and sequence over a period of 15 days may be used. Such distributions may be obtained as indicated in Fig 4. Load distribution and sequence for longer periods, such as in [13.3.8] and [13.3.9] shall be approved by the Society.

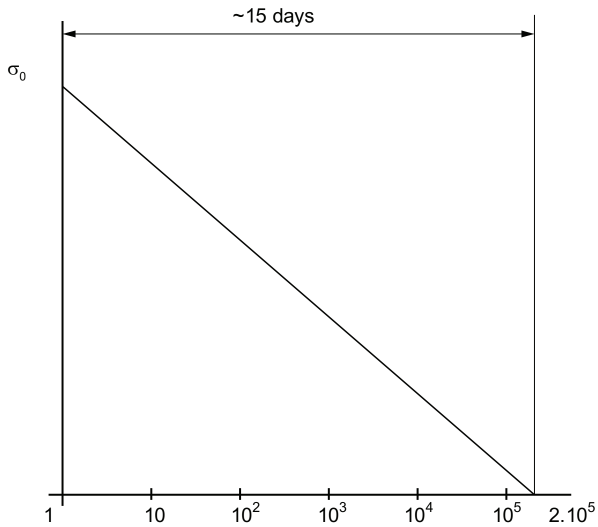
The arrangements shall comply with [13.3.7] to [13.3.9] as applicable.

13.3.7 For failures that can be reliably detected by means of leakage detection:

C_w shall be less than or equal to 0,5.

Predicted remaining failure development time, from the point of detection of leakage till reaching a critical state, shall not be less than 15 days unless different regulations apply for ships engaged in particular voyages.

Figure 4 : Simplified load distribution



Response cycles

σ_0 : Most probable maximum stress over the life of the ship

Response cycle scale is logarithmic; the value of 2×10^5 is given as an example of estimate.

13.3.8 *For failures that cannot be detected by leakage but that can be reliably detected at the time of in-service inspections:*

C_w shall be less than or equal to 0,5.

Predicted remaining failure development time, from the largest crack not detectable by in-service inspection methods until reaching a critical state, shall not be less than three (3) times the inspection interval.

13.3.9 *In particular locations of the tank where effective defect or crack development detection cannot be assured, the following, more stringent, fatigue acceptance criteria shall be applied as a minimum:*

C_w shall be less than or equal to 0,1.

Predicted failure development time, from the assumed initial defect until reaching a critical state, shall not be less than three (3) times the lifetime of the tank.

13.3.10 Details to be checked by analytical hot spot stress approach for fatigue assessment are listed in Sec 14, [3].

13.4 Accidental design condition

13.4.1 *The accidental design condition is a design condition for accidental loads with extremely low probability of occurrence.*

13.4.2 *Analysis shall be based on the characteristic values as follows:*

- *Permanent loads: Expected values*
- *Functional loads: Specified values*
- *Environmental loads: Specified values*
- *Accidental loads: Specified values or expected values*

Loads mentioned in [10.11] and [10.21] need not be combined with each other or with wave-induced loads.

14 Materials and construction

14.1 Materials forming ship structure

14.1.1 *To determine the grade of plate and sections used in the hull structure, a temperature calculation shall be performed for all tank types. The following assumptions shall be made in this calculation:*

a) *The primary barrier of all tanks shall be assumed to be at the liquefied gas fuel temperature.*

b) *In addition to a) above, where a complete or partial secondary barrier is required it shall be assumed to be at the liquefied gas fuel temperature at atmospheric pressure for any one tank only.*

c) *For worldwide service, ambient temperatures shall be taken as 5°C for air and 0°C for seawater. Higher values may be accepted for ships operating in restricted areas and conversely, lower values may be imposed by the Society for ships trading to areas where lower temperatures are expected during the winter months.*

d) *Still air and sea water conditions shall be assumed, i.e. no adjustment for forced convection.*

e) *Degradation of the thermal insulation properties over the life of the ship due to factors such as thermal and mechanical ageing, compaction, ship motions and tank vibrations as defined in [14.3.6] and [14.3.7] shall be assumed.*

f) *The cooling effect of the rising boil-off vapour from the leaked liquefied gas fuel shall be taken into account where applicable.*

g) *Credit for hull heating may be taken in accordance with [14.1.3] provided the heating arrangements are in compliance with [14.1.4].*

h) *No credit shall be given for any means of heating, except as described in [14.1.3].*

i) *For members connecting inner and outer hulls, the mean temperature may be taken for determining the steel grade.*

14.1.2 *The materials of all hull structures for which the calculated temperature in the design condition is below 0°C, due to the influence of liquefied gas fuel temperature, shall be in accordance with Ch 4, Sec 1, Tab 5. This includes hull structure supporting the liquefied gas fuel tanks, inner bottom plating, longitudinal bulkhead plating, transverse bulkhead plating, floors, webs, stringers and all attached stiffening members.*

14.1.3 *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 Ch 4, Sec 1, Tab 5. In the calculations required in [14.1.1], credit for such heating may be taken in accordance with the following principles:*

a) *for any transverse hull structure*

b) *for longitudinal hull structure referred to in [14.1.2] 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*

   The grade and thickness of the materials of manhole covers subject to lateral pressure in operation (meaning flooding excluded) are to be identical to the grade of materials of the surrounding structure.

   On a case by case basis, it might be requested to apply the same requirements to manhole covers subject to high in-plane loads.

c) *as an alternative to item 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 [14.1.1] with the heating considered, whichever is less. In this case, the ship's longitudinal strength shall comply with SOLAS regulation II-1/3-1 for both when those bulkhead(s) are considered effective and not.*

The following principle is also to be taken into consideration:

Where a hull heating system complying with [13.2.4] is installed, this system is to be contained solely within the cargo area or the drain returns from the hull heating coils in the wing tanks, cofferdams and double bottom are to be led to a degassing tank. The degassing tank is to be located in the cargo area and the vent outlets are to be located in a safe position and fitted with a flame screen.

14.1.4 *The means of heating referred to in [14.1.3] shall comply with the following:*

a) *the heating system shall be arranged so that, in the event of failure in any part of the system, standby heating can be maintained equal to no less than 100% of the theoretical heat requirement*

b) *the heating system shall be considered as an essential auxiliary. All electrical components of at least one of the systems provided in accordance with [14.1.3], item a) shall be supplied from the emergency source of electrical power, and*

c) *the design and construction of the heating system shall be included in the approval of the containment system by the Society.*

14.2 Materials of primary and secondary barriers

14.2.1 *Metallic materials used in the construction of primary and secondary barriers not forming the hull, shall be suitable for the design loads that they may be subjected to, and be in accordance with Ch 4, Sec 1, Tab 1, Ch 4, Sec 1, Tab 2 or Ch 4, Sec 1, Tab 3.*

14.2.2 *Materials, either non-metallic or metallic but not covered by Ch 4, Sec 1, Tab 1, Ch 4, Sec 1, Tab 2 and Ch 4, Sec 1, Tab 3, used in the primary and secondary barriers may be approved by the Society considering the design loads that they may be subjected to, their properties and their intended use.*

14.2.3 *Where non-metallic materials, including composites, are used for or incorporated in the primary or secondary barriers, they shall be tested for the following properties, as applicable, to ensure that they are adequate for the intended service:*

- *compatibility with the liquefied gas fuels*
- *ageing*
- *mechanical properties*
- *thermal expansion and contraction*
- *abrasion*
- *cohesion*
- *resistance to vibrations*
- *resistance to fire and flame spread, and*
- *resistance to fatigue failure and crack propagation.*

Note 1: Refer to Article [17].

14.2.4 *The above properties, where applicable, shall be tested for the range between the expected maximum temperature in service and 5°C below the minimum design temperature, but not lower than minus 196°C.*

14.2.5 *Where non-metallic materials, including composites, are used for the primary and secondary barriers, the joining processes shall also be tested as described above.*

14.2.6 *Consideration may be given to the use of materials in the primary and secondary barrier, which are not resistant to fire and flame spread, provided they are protected by a suitable system such as a permanent inert gas environment, or are provided with a fire retardant barrier.*

14.3 Thermal insulation and other materials used in liquefied gas fuel containment systems

14.3.1 *Load-bearing thermal insulation and other materials used in liquefied gas fuel containment systems shall be suitable for the design loads.*

14.3.2 *Thermal insulation and other materials used in liquefied gas fuel containment systems shall have the following properties, as applicable, to ensure that they are adequate for the intended service:*

- *compatibility with the liquefied gas fuels*
- *solubility in the liquefied gas fuel*
- *absorption of the liquefied gas fuel*
- *shrinkage*
- *ageing*
- *closed cell content*
- *density*
- *mechanical properties, to the extent that they are subjected to liquefied gas fuel and other loading effects, thermal expansion and contraction*
- *abrasion*
- *cohesion*
- *thermal conductivity*
- *resistance to vibrations*
- *resistance to fire and flame spread, and*
- *resistance to fatigue failure and crack propagation.*

14.3.3 *The above properties, where applicable, shall be tested for the range between the expected maximum temperature in service and 5°C below the minimum design temperature, but not lower than minus 196°C.*

14.3.4 *Due to location or environmental conditions, thermal insulation materials shall have suitable properties of resistance to fire and flame spread and shall be adequately protected against penetration of water vapour and mechanical damage. Where the thermal insulation is located on or above the exposed deck, and in way of tank cover penetrations, it shall have suitable fire resistance properties in accordance with a recognized standard or be covered with a material having low flame spread characteristics and forming an efficient approved vapour seal.*

14.3.5 *Thermal insulation that does not meet recognized standards for fire resistance may be used in fuel storage hold spaces that are not kept permanently inerted, provided its surfaces are covered with material with low flame spread characteristics and that forms an efficient approved vapour seal.*

14.3.6 *Testing for thermal conductivity of thermal insulation shall be carried out on suitably aged samples.*

14.3.7 *Where powder or granulated thermal insulation is used, measures shall be taken to reduce compaction in service and to maintain the required thermal conductivity and also prevent any undue increase of pressure on the liquefied gas fuel containment system.*

14.3.8 The materials for insulation are to be approved by the Society. The approval of bonding materials, sealing materials, lining constituting a vapour barrier or mechanical protection is to be considered by the Society on a case-by-case basis. In any event, these materials are to be chemically compatible with the insulation material.

A particular attention is to be paid to the continuity of the insulation in way of tank supports.

14.3.9 Before applying the insulation, the surfaces of the tank structures or of the hull are to be carefully cleaned.

When the insulation is sprayed or foamed, the minimum steel temperature at the time of application is to be not less than the temperature given in the specification of the insulation.

14.3.10 Where applicable, the insulation system is to be suitable to be visually examined at least on one side.

15 Construction processes

15.1 Weld joint design

15.1.1 *All welded joints of the shells of independent tanks shall be of the in-plane butt weld full penetration type. For dome-to-shell connections only, tee welds of the full penetration type may be used depending on the results of the tests carried out at the approval of the welding procedure. Except for small penetrations on domes, nozzle welds are also to be designed with full penetration.*

Small penetrations are those intended for instrumentation lines and accessory lines with a diameter of less than 25 mm.

15.1.2 *Welding joint details for type C independent tanks, and for the liquid-tight primary barriers of type B independent tanks primarily constructed of curved surfaces, shall be as follows:*

- *All longitudinal and circumferential joints shall be of butt welded, full penetration, double vee or single vee type. Full penetration butt welds shall be obtained by double welding or by the use of backing rings. If used, backing rings shall be removed except from very small process pressure vessels. Other edge preparations may be permitted, depending on the results of the tests carried out at the approval of the welding procedure. For connections of tank shell to a longitudinal bulkhead of type C bilobe tanks, tee welds of the full penetration type may be accepted.*

Note 1: For vacuum insulated tanks without manhole, the longitudinal and circumferential joints should meet the aforementioned requirements, except for the erection weld joint of the outer shell, which may be a one-side welding with backing rings.

- *The bevel preparation of the joints between the tank body and domes and between domes and relevant fittings shall be designed according to a standard acceptable to the Society. All welds connecting nozzles, domes or other penetrations of the vessel and all welds connecting flanges to the vessel or nozzles shall be full penetration welds.*

15.1.3 The following provisions apply to independent tanks:

- Tracing, cutting and shaping are to be carried out so as to prevent, at the surface of the pieces, the production of defects detrimental to their use. In particular, marking the plates by punching and starting welding arcs outside the welding zone are to be avoided.
- Before welding, the edges to be welded are to be carefully examined, with possible use of non-destructive examination, in particular when chamfers are carried out.
- In all cases, the working units are to be efficiently protected against bad weather.
- The execution of provisional welds, where any, is to be subjected to the same requirements as the constructional welds. After elimination of the fillets, the area is to be carefully ground and inspected (the inspection is to include, if necessary, a penetrant fluid test).
- All welding consumables are subject to agreement. Welders are also to be agreed.

15.2 Design for gluing and other joining processes

15.2.1 *The design of the joint to be glued (or joined by some other process except welding) shall take account of the strength characteristics of the joining process.*

16 Tank types

16.1 Type A independent tanks

16.1.1 Design basis

a) *Type A independent tanks are tanks primarily designed using classical ship-structural analysis procedures in accordance with the requirements of the Society. Where such tanks are primarily constructed of plane surfaces, the design vapour pressure P_0 shall be less than 0,07 MPa.*

b) *A complete secondary barrier is required as defined in [4]. The secondary barrier shall be designed in accordance with [4]*

16.1.2 Structural analysis

a) *A structural analysis shall be performed taking into account the internal pressure as indicated in [10.4], and the interaction loads with the supporting and keying system as well as a reasonable part of the ship's hull.*

b) *For parts, such as structure in way of supports, not otherwise covered by the regulations in this Rule Note, stresses shall be determined by direct calculations, taking into account the loads referred to in [10.2] to [10.21]as far as applicable, and the ship deflection in way of supports.*

Note 1: See Ch 2, Sec 10

c) *The tanks with supports shall be designed for the accidental loads specified in [10.21]. These loads need not be combined with each other or with environmental loads.*

Note 2: See Ch 2, Sec 10

16.1.3 Ultimate design condition

a) *For tanks primarily constructed of plane surfaces, the nominal membrane stresses for primary and secondary members (stiffeners, web frames, stringers, girders), when calculated by classical analysis procedures, shall not exceed the lower of R_m/ 2,66 or R_e/1,33 for nickel steels, carbon-manganese steels, austenitic steels and aluminium alloys, where R_m and R_e are defined in [13.2.4]. However, if detailed calculations are carried out for the primary members, the equivalent stress σ_c, as defined in [13.2.5], may be increased over that indicated above to a stress acceptable to the Society. Calculations shall take into account the effects of bending, shear, axial and torsional deformation as well as the hull/liquefied gas fuel tank interaction forces due to the deflection of the hull structure and liquefied gas fuel tank bottoms.*

b) *Tank boundary scantlings shall meet at least the requirements of the Society for deep tanks taking into account the internal pressure as indicated in [10.4] and any corrosion allowance required by [1.1.7].*

The scantlings of the gas fuel tank are to comply with the following requirements:

1) Plating

- The net thickness of plating subjected to lateral pressure, in mm, is to be checked according to NR467, Pt B, Ch 7, Sec 4, [1.1.1], considering:

  $P = P_{eq}$

  $$C_a = C_{a\text{-}max} \min\left[1;\frac{R_m}{1,50R_{eH}}\right]$$

  where:

  P_{eq} : Internal lateral pressure in the tank, in kN/m², as defined in [10.4.6].

- The net thickness of plating subjected to testing pressure, in mm, is to be checked according to NR467, Pt B, Ch 7, Sec 4, [1.1.1], considering:

  $P = p_{ST}$

  $$C_a = \min\left[1;\frac{R_m}{1,50R_{eH}}\right]$$

  where:

  p_{ST} : Testing pressure, in kN/m², obtained according to Ch 9, Sec 1, [5.2]

- For sloshing loads:
  - The net thickness of plating subjected to sloshing pressure is to be checked according to NR467, Pt B, Ch 11, Sec 4, [2.1.1] considering:

    $$C_a = C_{a\text{-}max} \min\left[1;\frac{R_m}{1,50R_{eH}}\right]$$

  - The net thickness of plating subjected to sloshing impact pressure is to be checked according to NR467, Pt B, Ch 7, Sec 4, [4.1.1], considering:

    $$C_a = \min\left[1;\frac{R_m}{1,50R_{eH}}\right]$$

2) Ordinary stiffeners

- The net section modulus Z, in cm³, and the net web thickness t_w, in mm, of ordinary stiffeners subjected to lateral pressure are to be checked according to NR467, Pt B, Ch 7, Sec 5, [1.1] considering:

  $P = P_{eq}$

  $$C_s = C_t = \min\left[\frac{1}{1,33};\frac{R_m}{2,66R_{eH}}\right]$$

  where:

  P_{eq} : Internal lateral pressure in the tank, in kN/m², as defined in [10.4.6].

- The net section modulus Z, in cm³, and the net web thickness t_w, in mm, of ordinary stiffeners subjected to testing pressure are to be checked according to NR467, Pt B, Ch 7, Sec 5, [1.1] considering:

  $P = p_{ST}$

  $$C_s = C_t = \min\left[\frac{1}{1,33};\frac{R_m}{2,66R_{eH}}\right]$$

  where:

  p_{ST} : Testing pressure, in kN/m², obtained according to Ch 9, Sec 1, [5.2].

- For sloshing loads:
  - The net section modulus Z, in cm³ of ordinary stiffeners subjected to sloshing pressure, including longitudinals, is to be checked according to NR467, Pt B, Ch 11, Sec 4, [2.2.1] considering:

    $$C_s = \min\left[\frac{1}{1,33};\frac{R_m}{2,66R_{eH}}\right]$$

- The net plastic section modulus Z_{pl}, in cm^3, and the net web thickness t_w, in mm, of ordinary stiffeners subjected to sloshing impact pressure are to be checked according to NR467, Pt B, Ch 7, Sec 5, [1.3.1], considering:

$$C_s = C_t = \min\left[\frac{1}{1,33};\frac{R_m}{2,66R_{eH}}\right]$$

3) Primary supporting members

- The scantlings of primary supporting members are to be not less than those obtained considering the lateral pressure Peq defined in [10.4.6], and checking criteria specified below.

  When calculating the internal pressure, the tank dome part to be considered in the accepted total tank volume is to be calculated according to NR467, Ch 9, App 1, [1.1.2].

- Checking criteria for:

  - Primary supporting members analysed through beam model:

    It is to be checked that the combined stress, in N/mm^2, is in compliance with the following formula:

    $\sigma_C \le \sigma_{ALL}$

    $$\sigma_{ALL} = \min\left[\frac{R_m}{2,66};\frac{R_{eH}}{1,33}\right]$$

    where:

    σ_{ALL} : Allowable stress, in N/mm^2, to be taken as:

  - Primary supporting members analysed through finite element model:

    The yield criteria are those corresponding to AC-1 or AC-2 acceptance criteria defined in NR467, Pt B, Ch 8, App 1, [5.2.3] and NR467, Pt B, Ch 8, App 2, [4.1.3] considering R_y as follows for the determination of λ_y and λ_f:

    $$R_y = \min\left[R_{eH};\frac{R_m}{1,50}\right]$$

c) The liquefied gas fuel tank structure shall be reviewed against potential buckling.

The scantlings of cargo tank structure of type A independent tanks are to comply with the buckling requirements given in NR467, Pt B, Ch 9, Sec 1 for the AC-1 or AC-2 acceptance criteria, as applicable.

16.1.4 Accidental design condition

The tanks and the tank supports shall be designed for the accidental loads and design conditions specified in [10.21] and [1.1.6], item c), as relevant.

When subjected to the accidental loads specified in [10.21], the stress shall comply with the acceptance criteria specified in [16.1.3], modified as appropriate taking into account their lower probability of occurrence.

Provisions for collision condition and heel condition are detailed in item a) to item e):

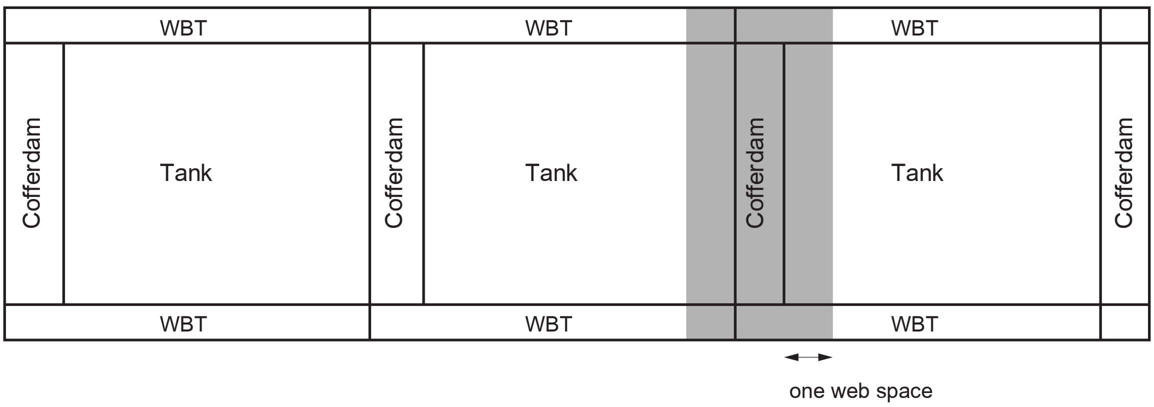
a) Collision condition

For collision loads, the lateral pressure to be considered is to be calculated according to [10.21.2].

The verification is to be carried out for structural members of transverse bulkhead up to the first adjacent web frame, as shown in Fig 5

Buckling check is not required for collision condition.

Figure 5 : Extent of structural assessment for collision condition



b) Heel condition

For static heel loads, the lateral pressure to be considered is to be calculated according to [10.11].

Buckling check is not required for heel condition.

c) Plating

Plating is to be checked according to the requirements given in NR467, Pt B, Ch 7, Sec 4, considering:

$$C_a = \min\left[1; \frac{R_m}{1,50 R_{eH}}\right]$$

d) Ordinary stiffeners

Ordinary stiffeners are to be checked according to the requirements given in NR467, Pt B, Ch 7, Sec 5, considering:

$$C_s = C_t = C_{comb} = \min\left[1; \frac{R_m}{1,50 R_{eH}}\right]$$

e) Primary supporting members

Primary structural members analyzed by means of beam model are to be checked according to the requirements given in NR467, Part B, Chapter 7, Section 6, considering:

$$C_s = C_t = C_{comb} = \min\left[0,90; \frac{0,90 R_m}{1,50 R_{eH}}\right]$$

For primary supporting members analysed through finite element model, the yield criteria are those corresponding to the acceptance criteria AC-3 defined in NR467, Pt B, Ch 8, App 1, [5.2.3] and NR467, Pt B, Ch 8, App 2, [4.1.3], considering R_y as follows for the determination of λ_y, λ_{yperm}, λ_f and λ_{fperm}:

$$R_y = \min\left[R_{eH}; \frac{R_m}{1,50}\right]$$

16.2 Type B independent tanks

16.2.1 Design basis

a) *Type B independent tanks are tanks designed using model tests, refined analytical tools and analysis methods to determine stress levels, fatigue life and crack propagation characteristics. Where such tanks are primarily constructed of plane surfaces (prismatic tanks) the design vapour pressure P_0 shall be less than 0,07 MPa.*

b) *A partial secondary barrier with a protection system is required as defined in [3]. The small leak protection system shall be designed according to [5].*

16.2.2 Structural analysis

a) *The effects of all dynamic and static loads shall be used to determine the suitability of the structure with respect to:*
- *plastic deformation*
- *buckling*
- *fatigue failure, and*
- *crack propagation.*

Finite element analysis or similar methods and fracture mechanics analysis or an equivalent approach, shall be carried out.

b) *A three-dimensional analysis shall be carried out to evaluate the stress levels, including interaction with the ship's hull. The model for this analysis shall include the liquefied gas fuel tank with its supporting and keying system, as well as a reasonable part of the hull.*

c) *A complete analysis of the particular ship accelerations and motions in irregular waves, and of the response of the ship and its liquefied gas fuel tanks to these forces and motions, shall be performed unless the data is available from similar ships.*

d) The following additional requirements are applicable to the structural analysis:

1) Analysis criteria

The analysis of the primary supporting members of the tank subjected to lateral pressure based on a three dimensional model is to be carried out according to the following requirements:
- the structural modelling is to comply with the requirements in NR467, Pt B, Ch 8, App 1, [2.4]
- the stress calculation is to comply with the requirements in NR467, Pt B, Ch 8, App 1, [5.2.1]
- the model extension is to comply with the following item d) 2)
- the wave hull girder loads and the wave pressures to be applied on the model are to comply with item c) and the following item d)3)
- the inertial loads to be applied on the model are to comply with [10.4].

2) Model extension

The longitudinal extension of the structural model is to comply with NR467, Pt B, Ch 8, App 1, [2.2.1]. In any case, the structural model is to include the hull and the tank with its supporting and keying system.

3) Wave hull girder loads and wave pressures

Wave hull girder loads and wave pressures are to be obtained as the most probable the ship may experience during its operating life, for a probability level of 10^{-8}. Calculation are to be submitted to the Society for approval, unless these data are available from similar ships.

16.2.3 Ultimate design condition - plastic deformation

a) *For type B independent tanks, primarily constructed of bodies of revolution, the allowable stresses shall not exceed:*

$\sigma_m \leq 1,0\ f$

$\sigma_L \leq 1,5\ f$

$\sigma_b \leq 1,5\ F$

$\sigma_L + \sigma_b \leq 1,5\ F$

$\sigma_m + \sigma_b \leq 1,5\ F$

$\sigma_m + \sigma_b + \sigma_g \leq 3,0\ F$

$\sigma_L + \sigma_b + \sigma_g \leq 3,0\ F$

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 : *The lesser of (Rm /A) or (Re /B)*

F : *The lesser of (Rm /C) or (Re /D)*

with R_m and Re as defined in [13.2.4]. With regard to the stresses σ_m , σ_L , σ_g and σ_b , see also the definition of stress categories in [16.2.8].

The values A and B shall have at least the following minimum values defined in Tab 3.

The above figures may be altered considering the design condition considered in acceptance with the Society. For type B independent tanks, primarily constructed of plane surfaces, the allowable membrane equivalent stresses applied for finite element analysis shall not exceed:

- *for nickel steels and carbon-manganese steels, the lesser of R_m /2,0 or R_e /1,2*
- *for austenitic steels, the lesser of R_m /2,5 or R_e /1,2, and*
- *for aluminium alloys, the lesser of R_m /2,5 or R_e /1,2.*

The above figures may be amended considering the locality of the stress, stress analysis methods and design condition considered in acceptance with the Society.

The thickness of the skin plate and the size of the stiffener shall not be less than those required for type A independent tanks.

b) Strength criteria

The following criteria are applicable for strength assessment of type B independent tanks:

- Primarily constructed of bodies of revolution, including the cylindrical skirt:

  The equivalent stresses of their primary supporting members are to comply with the following formula:

  $\sigma_E \leq \sigma_{ALL}$

  where:

  σ_E : Equivalent stress, in N/mm², to be obtained from the formula in [13.2.5], for each of the following stress categories, defined in:
  - primary general membrane stress
  - primary local membrane stress
  - primary bending stress
  - secondary stress

  σ_{ALL} : Allowable stress defined as follows:
  - for finite element analysis based on standard mesh models in sea going condition:

    See [16.2.3] (case of type B independent tanks primarily constructed of bodies of revolution)
  - for finite element analysis based on fine mesh models or other design conditions:

    The allowable stress defined in [16.2.3] (case of type B independent tanks primarily constructed of bodies of revolution) is to be multiplied by the factors defined in Tab 4.

  Note 1: Standard mesh and fine mesh are defined in NR467, Part B, Chapter 8.

- Primarily constructed of plane surfaces:

  The equivalent stresses of their primary supporting members are to comply with the following formula:

  $\sigma_E \leq \sigma_{ALL}$

  where:

  σ_E : Equivalent stress, in N/mm$_2$, to be obtained from the formulae in NR467, Pt B, Ch 8, App 1, [5.2.1], as a result of direct calculations carried out in accordance with [16.2.2], *item d) 1)*

  σ_{ALL} : Allowable stress defined as follows:

  - for finite element analysis based on standard mesh models in sea going condition:

    See [16.2.3] (case of type B independent tanks primarily constructed of plane surfaces)

  - for finite element analysis based on fine mesh models or other design conditions:

    The allowable stresses σ_{ALL} is to be taken equal to:

    $\sigma_{ALL} = \min (\alpha R_m; \beta R_e)$

    where:

    α and β are defined in Tab 5.

Note 2: Standard mesh and fine mesh are defined in NR467, Part B, Chapter 8.

Table 3 : Nominal yield stress parameters

	Nickel steels and carbon manganese steels	Austenitic steels	Aluminium alloys
A	3,0	3,5	4,0
B	2,0	1,6	1,5
C	3,0	3,0	3,0
D	1,5	1,5	1,5

Table 4 : Finite element allowable stresses factors for spherical type B independent tanks

Design condition	Type of finite element model	
	Global standard mesh	Local fine mesh (only applicable to the supporting skirt)
Harbour (AC-1)	0,80	• Elements not adjacent to welding: 1,36 • Elements adjacent to welding: 1,20
Ultimate (AC-2)	1,00	• Elements not adjacent to welding: 1,70 • Elements adjacent to welding: 1,50
Accidental (AC-3)	1,20	• Elements not adjacent to welding: 2,00 • Elements adjacent to welding: 1,80

Table 5 : Finite element allowable stresses coefficients for prismatic type B independent tanks

Design condition	Materials	Type of finite element model					
		Global standard mesh		Local fine mesh			
				Elements not adjacent to welding		Elements adjacent to welding	
		α	β	α	β	α	β
Harbour (AC-1)	nickel steels and carbon-manganese steels	0,40	0,67	0,68	1,13	0,60	1,00
	austenitic steels, aluminium alloys	0,32	0,67	0,54	1,13	0,48	1,00
Ultimate (AC-2)	nickel steels and carbon-manganese steels	0,5	0,83	0,85	1,42	0,75	1,25
	austenitic steels, aluminium alloys	0,40	0,83	0,68	1,42	0,6	1,25
Accidental (AC-3)	nickel steels and carbon-manganese steels	0,59	1,00	1,00	1,70	0,88	1,50
	austenitic steels, aluminium alloys	0,50	1,00	0,85	1,70	0,75	1,50

16.2.4 Ultimate design condition - buckling

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

b) The scantlings of plating and ordinary stiffeners of type B independent tanks are to comply with the buckling requirements given in NR467, Pt B, Ch 9, Sec 1 for the AC-1 or AC-2 acceptance criteria, as applicable respectively for harbour and seagoing conditions.

   A local buckling check is to be carried out according to NR467, Pt B, Ch 9, Sec 1 for plate panels which constitute primary upporting members for the AC-1 or AC-2 acceptance criteria, as applicable respectively for harbour and seagoing conditions.

   In performing this check, the stresses in the plate panels are to be obtained from direct calculations to be carried out in accordance with [16.2.2], *item d) 1)*.

16.2.5 Fatigue design condition

a) *Fatigue and crack propagation assessment shall be performed in accordance with the provisions of [13.3]. The acceptance criteria shall comply with [13.3.7], [13.3.8] or [13.3.9], depending on the detectability of the defect.*

b) *Fatigue analysis shall consider construction tolerances.*

c) *Where deemed necessary by the Society, model tests may be required to determine stress concentration factors and fatigue life of structural elements.*

Requirements for fatigue and crack propagation assessment are given in Sec 14.

16.2.6 Accidental design condition

a) Collision and heel conditions

   The tank plating and ordinary stiffeners are to be checked for collision and heel loads using pressures and criteria defined in [16.1.4].

   The tank primary supporting members are to be checked for collision and heel loads using pressures defined in respectively [10.21.2] and [10.11.2] according to the AC-3 criteria defined in [16.2.3] for accidental design conditions.

b) *The tanks and the tank supports shall be designed for the accidental loads and design conditions specified in [10.21] and [1.1.6], item c), as relevant.*

c) *When subjected to the accidental loads specified in [10.21], the stress shall comply with the acceptance criteria specified in [16.2.3] to [16.2.4], modified as appropriate, taking into account their lower probability of occurrence.*

16.2.7 Marking

Any marking of the pressure vessel shall be achieved by a method that does not cause unacceptable local stress raisers.

16.2.8 Stress categories

For the purpose of stress evaluation, stress categories are defined in [16] as follows:

a) *Normal stress is the component of stress normal to the plane of reference.*

b) *Membrane stress is the component of normal stress that is uniformly distributed and equal to the average value of the stress across the thickness of the section under consideration.*

c) *Bending stress is the variable stress across the thickness of the section under consideration, after the subtraction of the membrane stress.*

d) *Shear stress is the component of the stress acting in the plane of reference.*

e) *Primary stress is a stress produced by the imposed loading, which is necessary to balance the external forces and moments. The basic characteristic of a primary stress is that it is not self-limiting. Primary stresses that considerably exceed the yield strength will result in failure or at least in gross deformations.*

f) *Primary general membrane stress is a primary membrane stress that is so distributed in the structure that no redistribution of load occurs as a result of yielding.*

g) *Primary local membrane stress arises where a membrane stress produced by pressure or other mechanical loading and associated with a primary or a discontinuity effect produces excessive distortion in the transfer of loads for other portions of the structure. Such a stress is classified as a primary local membrane stress, although it has some characteristics of a secondary stress. A stress region may be considered as local, if:*

   $(S_1 \le 0,5\sqrt{Rt})$ and

   $S_2 \ge 2,5\sqrt{Rt}$

   where:

   S_1 : *Distance in the meridional direction over which the equivalent stress exceeds 1,1 f*

   S_2 : *Distance in the meridional direction to another region where the limits for primary general membrane stress are exceeded*

   R : *Mean radius of the vessel*

t : *Wall thickness of the vessel at the location where the primary general membrane stress limit is exceeded*

f : *Allowable primary general membrane stress.*

h) *Secondary stress is a normal stress or shear stress developed by constraints of adjacent parts or by self-constraint of a structure. The basic characteristic of a secondary stress is that it is self-limiting. Local yielding and minor distortions can satisfy the conditions that cause the stress to occur.*

16.3 Type C independent tanks

16.3.1 Design basis

a) *The design basis for type C independent tanks is based on pressure vessel criteria modified to include fracture mechanics and crack propagation criteria. The minimum design pressure defined in [16.3.1] is intended to ensure that the dynamic stress is sufficiently low so that an initial surface flaw will not propagate more than half the thickness of the shell during the lifetime of the tank.*

b) Design of the outer shell

For vacuum insulated tanks, the design of the outer shell is to be in accordance with a recognized standard such as EN 13530-2.

c) *The design vapour pressure, in MPa, shall not be less than:*

$$P_0 = 0,2 + AC(\rho_r)^{1,5}$$

where:

A : *Taken equal to:*

$$A = 0,00185\left(\frac{\sigma_m}{\Delta\sigma_A}\right)^2$$

with:

σ_m : *Design primary membrane stress*

$\Delta\sigma_A$: *Allowable dynamic membrane stress (double amplitude at probability level $Q = 10^{-8}$) and equal to:*

- *55 N/mm^2 for ferritic-perlitic, martensitic and austenitic steels*
- *25 N/mm^2 for aluminium alloys (5083-O)*

C : *A characteristic tank dimension to be taken as the greatest of the following:*

$C = Max (h ; 0,75 b ; 0,45 \ell)$

with:

h : *Height of tank, in m (dimension in ship's vertical direction)*

b : *Width of tank, in m (dimension in ship's transverse direction)*

ℓ : *Length of tank, in m (dimension in ship's longitudinal direction).*

ρ_r : *The relative density of the fuel (ρ_r = 1,0 for fresh water) at the design temperature.*

16.3.2 Shell thickness

a) *In considering the shell thickness the following apply:*

1) *for pressure vessels, the thickness calculated according to [16.3.2] shall be considered as a minimum thickness after forming, without any negative tolerance*
2) *for pressure vessels, the minimum thickness of shell and heads including corrosion allowance, after forming, shall not be less than 5 mm for carbon manganese steels and nickel steels, 3 mm for austenitic steels or 7 mm for aluminium alloys, and*
3) *the welded joint efficiency factor to be used in the calculation according to [16.3.2] shall be 0,95 when the inspection and the non-destructive testing referred to in Ch 9, Sec 1, [3.6.5] are carried out. This figure may be increased up to 1,0 when account is taken of other considerations, such as the material used, type of joints, welding procedure and type of loading. For process pressure vessels the Society may accept partial non-destructive examinations, but not less than those of Ch 9, Sec 1, [3.6.5], depending on such factors as the material used, the design temperature, the nil ductility transition temperature of the material as fabricated and the type of joint and welding procedure, but in this case an efficiency factor of not more than 0,85 shall be adopted. For special materials the above-mentioned factors shall be reduced, depending on the specified mechanical properties of the welded joint.*

b) *The design liquid pressure defined in [10.4] shall be taken into account in the internal pressure calculations.*

c) *The design external pressure P_e , in MPa, used for verifying the buckling of the pressure vessels, shall not be less than that given by:*

$$P_e = P_1 + P_2 + P_3 + P_4$$

where:

P_1 : *Setting value of vacuum relief valves. For vessels not fitted with vacuum relief valves P_1 shall be specially considered, but shall not in general be taken as less than 0,025 MPa*

P_2 : *The set pressure of the pressure relief valves (PRVs) for completely closed spaces containing pressure vessels or parts of pressure vessels; elsewhere $P_2 = 0$*

P_3 : *Compressive actions in or on the shell due to the weight and contraction of thermal insulation, weight of shell including corrosion allowance and other miscellaneous external pressure loads to which the pressure vessel may be subjected. These include, but are not limited to, weight of domes, weight of towers and piping, effect of product in the partially filled condition, accelerations and hull deflection. In addition, the local effect of external or internal pressures or both shall be taken into account*

P_4 : *External pressure due to head of water for pressure vessels or part of pressure vessels on exposed decks; elsewhere* $P_4 = 0$.

d) *Scantlings based on internal pressure shall be calculated as follows:*

The thickness and form of pressure-containing parts of pressure vessels, under internal pressure, as defined in [10.4], including flanges, shall be determined. These calculations shall in all cases be based on accepted pressure vessel design theory. Openings in pressure-containing parts of pressure vessels shall be reinforced in accordance with a recognized standard acceptable to the Society.

e) *Stress analysis in respect of static and dynamic loads shall be performed as follows:*

- *pressure vessel scantlings shall be determined in accordance with [16.3.2] and [16.3.3]*
- *calculations of the loads and stresses in way of the supports and the shell attachment of the support shall be made. Loads referred to in [10.2] to [10.21] shall be used, as applicable. Stresses in way of the supports shall be to a recognized standard acceptable to the Society. In special cases a fatigue analysis may be required by the Society, and*
- *if required by the Society, secondary stresses and thermal stresses shall be specially considered.*

16.3.3 Ultimate design condition

a) *Plastic deformation*

For type C independent tanks, the allowable stresses shall not exceed:

$\sigma_m \leq f$

$\sigma_L \leq 1,5\ f$

$\sigma_b \leq 1,5\ f$

$\sigma_L + \sigma_b \leq 1,5\ f$

$\sigma_m + \sigma_b \leq 1,5\ f$

$\sigma_m + \sigma_b + \sigma_g \leq 3,0\ f$

$\sigma_L + \sigma_b + \sigma_g \leq 3,0\ f$

where:

σ_m : *Equivalent primary general membrane stress*

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 : *The lesser of* (R_m / A) *or* (R_e / B),

with R_m *and* R_e *as defined in [13.2.4]. With regard to the stresses* σ_m, σ_L, σ_g *and* σ_b, *see also the definition of stress categories in [16.2.8].*

The values A and B shall have at least the following minimum values defined in Tab 6

b) *Buckling criteria shall be as follows:*

- *The thickness and form of pressure vessels subject to external pressure and other loads causing compressive stresses shall be based on calculations using accepted pressure vessel buckling theory and shall adequately account for the difference in theoretical and actual buckling stress as a result of plate edge misalignment, ovality and deviation from true circular form over a specified arc or chord length.*
- *Type C independent gas fuel tanks are to comply with the requirements of NR467, Pt C, Ch 1, Sec 3 related to class 1 pressure vessels. The allowable stresses are defined in [16.3.3].*
- *Stiffening rings in way of tank supports:*

  The following requirements are applicable for the scantling of stiffening rings in way of tanks supports:

  - *1/ Structural model*

    The stiffening rings in way of supports of horizontal cylindrical tanks are to be modelled as circumferential beams constituted by web, flange, doubler plate, if any, and plating attached to the stiffening rings.

  - *2/ Width of attached plating*

    On each side of the web, the width of the attached plating to be considered for the yielding and buckling checks of the stiffening rings, as in item 5/ and item 6/, respectively, is to be obtained, in mm, from the following formulae:

    - *for cylindrical shell:*

$$b = 0,78\sqrt{r \cdot t}$$

- *for longitudinal bulkheads (case of lobe tanks):*
  $b = 20\ t_b$

where:

r : *Mean radius of the cylindrical shell, in mm*

t : *Shell thickness, in mm*

t_b : *Bulkhead thickness, in mm.*

A doubler plate, if any, may be considered as belonging to the attached plating.

- *3/ Boundary conditions*

  The boundary conditions of the stiffening ring are to be modelled as follows:

  - *circumferential forces applied on each side of the ring, the resultant of which is equal to the shear force in the tank and calculated through the bi-dimensional shear flow theory*
  - *reaction forces in way of tank supports, to be obtained according to Sec 13*

- *4/ Lateral pressure*

  The lateral pressure to be considered for the check of the stiffening rings is to be obtained from [10.4].

- *5/ Yielding check*

  The equivalent stress in stiffening rings in way of supports is to comply with the following formula:

  $\sigma_E \leq \sigma_{ALL}$

  where:

  σ_E : *Equivalent stress in stiffening rings, in N/mm², calculated for the load cases defined in [6.1.3] and to be obtained from the following formula:*

  $$\sigma_E = \sqrt{(\sigma_N + \sigma_B)^2 + 3\tau^2}$$

  σ_N : *Normal stress, in N/mm², in the circumferential direction of the stiffening ring*

  σ_B : *Bending stress, in N/mm², in the circumferential direction of the stiffening ring*

  τ : *Shear stress, in N/mm², in the stiffening ring*

  σ_{ALL} : *Allowable stress, in N/mm², to be taken equal to:*

  $\sigma_{ALL} = Min\ (0{,}57 \cdot R_m\ ;\ 0{,}85 \cdot R_{eH})$

- *6/ Buckling check*

  The buckling strength of the stiffening rings is to be checked in compliance with the applicable formulae in NR467, Pt B, Ch 9, Sec 1.

Table 6 : Nominal yield stress parameters

	Nickel steels and carbon manganese steels	Austenitic steels	Aluminium alloys
A	3,0	3,5	4,0
B	1,5	1,5	1,5

16.3.4 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 [16.3.1], regarding static and dynamic stress depending on the tank size, the configuration of the tank and arrangement of its supports and attachments.*

b) *For vacuum insulated tanks special attention shall be made to the fatigue strength of the support design and special considerations shall also be made to the limited inspection possibilities between the inside and outer shell.*

16.3.5 Accidental design condition

The tanks and the tank supports shall be designed for the accidental loads and design conditions specified in [10.21] and [1.1.6], item c), as relevant.

When subjected to the accidental loads specified in [10.21], the stress shall comply with the acceptance criteria specified in [16.3.3], item a), modified as appropriate taking into account their lower probability of occurrence.

Provisions for collision condition and heel condition are detailed in item a) and item b):

a) Collision condition

   The structure of the tank is to be checked for collision loads using pressure and criteria defined in [16.1.4], item a)

b) Heel condition

   The structure of the tank is to be checked for heel loads using pressure and criteria defined in [16.1.4], item b).

16.3.6 Marking

The required marking of the pressure vessel shall be achieved by a method that does not cause unacceptable local stress raisers.

16.4 Membrane tanks

16.4.1 Design basis

a) *The design basis for membrane containment systems is that thermal and other expansion or contraction is compensated for without undue risk of losing the tightness of the membrane.*

b) *A systematic approach, based on analysis and testing, shall be used to demonstrate that the system will provide its intended function in consideration of the identified in service events as specified in [16.4.2].*

c) *A complete secondary barrier is required as defined in [3]. The secondary barrier shall be designed according to [4].*

d) *The design vapour pressure P_0 shall not normally exceed 0,025 MPa. If the hull scantlings are increased accordingly and consideration is given, where appropriate, to the strength of the supporting thermal insulation, P_0 may be increased to a higher value but less than 0,070 MPa.*

e) *The definition of membrane tanks does not exclude designs such as those in which non-metallic membranes are used or where membranes are included or incorporated into the thermal insulation.*

f) *The thickness of the membranes shall normally not exceed 10 mm.*

g) *The circulation of inert gas throughout the primary and the secondary insulation spaces, in accordance with Sec 9, [1.1.1] shall be sufficient to allow for effective means of gas detection.*

16.4.2 Design considerations

a) *Potential incidents that could lead to loss of fluid tightness over the life of the membranes shall be evaluated. These include, but are not limited to:*

   1) *Ultimate design events:*
      - *tensile failure of membranes*
      - *compressive collapse of thermal insulation*
      - *thermal ageing*
      - *loss of attachment between thermal insulation and hull structure*
      - *loss of attachment of membranes to thermal insulation system*
      - *structural integrity of internal structures and their associated supporting structures, and*
      - *failure of the supporting hull structure.*
   2) *Fatigue design events:*
      - *fatigue of membranes including joints and attachments to hull structure*
      - *fatigue cracking of thermal insulation*
      - *fatigue of internal structures and their associated supporting structures, and*
      - *fatigue cracking of inner hull leading to ballast water ingress.*
   3) *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) *The necessary physical properties (mechanical, thermal, chemical, etc.) of the materials used in the construction of the liquefied gas fuel containment system shall be established during the design development in accordance with [16.4.1].*

16.4.3 Loads, load combinations

Particular consideration shall be paid to the possible loss of tank integrity due to either an overpressure in the interbarrier space, a possible vacuum in the liquefied gas fuel tank, the sloshing effects, to hull vibration effects, or any combination of these events.

16.4.4 Structural analyses

a) *Structural analyses and/or testing for the purpose of determining the ultimate strength and fatigue assessments of the liquefied gas fuel containment and associated structures and equipment noted in [7] shall be performed. The structural analysis shall provide the data required to assess each failure mode that has been identified as critical for the liquefied gas fuel containment system.*

b) *Structural analyses of the hull shall take into account the internal pressure as indicated in [10.4]. Special attention shall be paid to deflections of the hull and their compatibility with the membrane and associated thermal insulation.*

c) *The analyses referred to in item a) and item b) shall be based on the particular motions, accelerations and response of ships and liquefied gas fuel containment systems.*

16.4.5 Ultimate design condition

a) *The structural resistance of every critical component, sub-system, or assembly, shall be established, in accordance with [16.4.1], for in-service conditions.*

b) *The choice of strength acceptance criteria for the failure modes of the liquefied gas fuel containment system, its attachments to the hull structure and internal tank structures, shall reflect the consequences associated with the considered mode of failure.*

c) *The inner hull scantlings shall meet the regulations for deep tanks, taking into account the internal pressure as indicated in [10.16.2] and the specified appropriate regulations for sloshing load as defined in [10.16]*

d) Scantlings and structural details of hull structures forming gas fuel tank boundaries:

   With reference to [16.4.5], the following requirements are applicable:

   1) Specific allowable hull girder stresses and/or deflections, indicated by the designer, are to be taken into account for the determination of the scantlings.

   2) The net scantlings of:

      - plating and ordinary stiffeners of membrane tanks are to be not less than those obtained from NR467, Part B, Chapter 7. The hull girder loads and internal pressure to be considered are to be calculated according to NR467, Part B, Chapter 5.
      - primary supporting members of membrane tanks are to be not less than those obtained from NR467, Part B, Chapter 7, where the hull girder loads and the internal pressure are to be calculated according to NR467, Part B, Chapter 5.

   3) The net thicknesses of plating subject to sloshing pressure are to be checked using the formula given in NR467, Pt B, Ch 7, Sec 4, [4] with P_{sl} to be taken equal to P_{sl} given in NR467, Pt D, Ch 9, App 1, [2.2]

      No buckling check is required.

      Areas to be checked for sloshing pressure are defined in NR467, Pt D, Ch 9, App 1, [2.2].

   4) The net section modulus of ordinary stiffeners subject to sloshing pressure, including longitudinals, are to be checked using the formulae given in NR467, Pt B, Ch 7, Sec 5, [1.3] with P_{sl} to be taken equal to P_{sl} given in NR467, Pt D, Ch 9, App 1, [2.2].

      Areas to be checked for sloshing pressure are defined in NR467, Pt D, Ch 9, App 1, [2.2].

      No buckling check is required.

   5) For ordinary stiffeners located below the upper deck level and subject to sloshing loads, cut-outs made in inner hull and cofferdam bulkhead for their passage through the vertical webs are to be closed by collar plates welded to the inner hull or transverse bulkhead plating.

      Where deemed necessary, adequate reinforcements are to be fitted in the double hull and transverse cofferdams at connection of the cargo containment system to the hull structure. Details of the connection are to be submitted to the Society for approval.

Note 1: Unusual structure arrangement are to be considered on a case by case basis.

16.4.6 Fatigue design condition

a) *Fatigue analysis shall be carried out for structures inside the tank, i.e. pump towers, and for parts of membrane and pump tower attachments, where failure development cannot be reliably detected by continuous monitoring.*

b) *The fatigue calculations shall be carried out in accordance with [13.3] with relevant regulations depending on:*

   - *the significance of the structural components with respect to structural integrity, and*
   - *availability for inspection.*

c) *For structural elements for which it can be demonstrated by tests and/or analyses that a crack will not develop to cause simultaneous or cascading failure of both membranes, C_w shall be less than or equal to 0,5.*

d) *Structural elements subject to periodic inspection, and where an unattended fatigue crack can develop to cause simultaneous or cascading failure of both membranes, shall satisfy the fatigue and fracture mechanics regulations stated in [13.3.8].*

e) *Structural element not accessible for in-service inspection, and where a fatigue crack can develop without warning to cause simultaneous or cascading failure of both membranes, shall satisfy the fatigue and fracture mechanics regulations stated in [13.3.9].*

16.4.7 Accidental design condition

a) *The containment system and the supporting hull structure shall be designed for the accidental loads specified in [10.21]. These loads need not be combined with each other or with environmental loads.*

b) *Additional relevant accidental scenarios shall be determined based on a risk analysis. Particular attention shall be paid to securing devices inside of tanks.*

c) The supporting hull structure is to be checked for collision loads using the pressure defined in [16.1.4] and the general scantling criteria associated to the AC-3 acceptance criteria, as defined in:

   - NR467, Pt B, Ch 7 for plating, stiffeners and primary supporting members
   - NR467, Pt B, Ch 8 for direct strength analysis.

17 Limit state design for novel concepts

17.1 General

17.1.1 *Fuel containment systems that are of a novel configuration that cannot be designed using Article [16] shall be designed using this Section and Article [1] to [16], as applicable. Fuel containment system design according to this Section shall be based on the principles of limit state design which is an approach to structural design that can be applied to established design solutions as well as novel designs. This more generic approach maintains a level of safety similar to that achieved for known containment systems as designed using article [16].*

17.1.2 *The 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 [1.1.6]. A limit state can be defined as a condition beyond which the structure, or part of a structure, no longer satisfies the regulations.*

17.1.3 *For each failure mode, one or more limit states may be relevant. By consideration of all relevant limit states, the limit load for the structural element is found as the minimum limit load resulting from all the relevant limit states. The limit states are divided into the three following categories:*

a) *Ultimate limit states (ULS), which correspond to the maximum load-carrying capacity or, in some cases, to the maximum applicable strain or deformation; under intact (undamaged) conditions.*

b) *Fatigue limit states (FLS), which correspond to degradation due to the effect of time varying (cyclic) loading.*

c) *Accident limit states (ALS), which concern the ability of the structure to resist accidental situations.*

17.1.4 *The procedure and relevant design parameters of the limit state design shall comply with the Standards for the Use of limit state methodologies in the design of fuel containment systems of novel configuration (LSD Standard), as set out in App 1.*

Section 3 Portable Liquefied Gas Fuel Tanks

1 General

1.1

1.1.1 *The design of the tank shall comply with Sec 2, [16.3]. The tank support (container frame or truck chassis) shall be designed for the intended purpose.*

1.1.2 *Portable fuel tanks shall be located in dedicated areas fitted with:*

- *mechanical protection of the tanks depending on location and cargo operations*
- *if located on open deck: spill protection and water spray systems for cooling, and*
- *if located in an enclosed space: the space is to be considered as a tank connection space.*

1.1.3 With reference to [1.1.2], a drip tray and protective arrangements against liquid fuel spray and spillage are to be provided in accordance with Sec 1, [2.1.13]

1.1.4 *Portable fuel tanks shall be secured to the deck while connected to the ship systems. The arrangement for supporting and fixing the tanks shall be designed for the maximum expected static and dynamic inclinations, as well as the maximum expected values of acceleration,* corresponding to a return period of 25 years (probability level of approximately 10^{-8})*, taking into account the ship characteristics and the position of the tanks.*

Note 1: Where the applicable Rules do not specify 25-year accelerations, the Rules accelerations may be corrected in order to reflect a 25-year return period.

Supporting and fixing arrangements are to be designed with a safety factor of 2,5 with respect to the Maximum Securing Load (MSL). The safety factor may be reduced to 1 for accidental loads. The admissible stresses for the supports and fixing pieces are to be the same as for the adjacent ship structure.

When storage consists of stacked-up tank-containers, the fixation or lashing arrangements are to be such as to avoid detrimental displacement of such containers (or other adjacent containers) in particular in case of rough sea. Standard lashing arrangement may not provide sufficient fixation.

Note 2: See NI429 "Guidelines for the preparation of the cargo securing manual" for lashing calculations".

1.1.5 *Consideration shall be given to the strength and the effect of the portable fuel tanks on the ship's stability.*

1.1.6 *Connections to the ship's fuel piping systems shall be made by means of approved flexible hoses or other suitable means designed to provide sufficient flexibility.*

1.1.7 Flexible hoses containing liquid or gas fuel are to be type-approved by the Society according to the requirements of NR467, Pt C, Ch 1, Sec 10.

1.1.8 *Arrangements shall be provided to limit the quantity of fuel spilled in case of inadvertent disconnection or rupture of the non-permanent connections.*

1.1.9 *The pressure relief system of portable tanks shall be connected to a fixed venting system.*

1.1.10 The fixed venting system (vent mast) is to comply with the provisions of [1.1.8].

1.1.11 *Control and monitoring systems for portable fuel tanks shall be integrated in the ship's control and monitoring system. Safety system for portable fuel tanks shall be integrated in the ship's safety system (e.g. shut-down systems for tank valves, leak/gas detection systems).*

1.1.12 *Safe access to tank connections for the purpose of inspection and maintenance shall be ensured.*

1.1.13 *After connection to the ship's fuel piping system,*

- *with the exception of the pressure relief system in [1.1.8] each portable tank shall be capable of being isolated at any time*
- *isolation of one tank shall not impair the availability of the remaining portable tanks, and*
- *the tank shall not exceed its filling limits as given in Sec 6.*

1.1.14 Additional requirements for portable tanks

a) The risk analysis required in Ch 1, Sec 2, [2] is to cover the specific risks arising from the use of portable tanks. At least the following events and failures are to be addressed:
- handling of the tank
- connection / disconnection of the detachable piping systems
- overfilling / over pressurization due to intercommunication of tanks, in case of multi-tanks arrangement
- failure of the tank fixation / lashing
- rupture of a pipe between the tank and the shut-off valve
- rupture of flexible hose
- inadvertent disconnection of a non-permanent connection

b) Bunkering by means of a tanker truck boarded on the ship only for bunkering purposes may be accepted subject to special examination by the Society, only if the relevant risks are properly analysed and deemed acceptable.

Section 4 CNG Fuel Containment

1 Regulations for CNG fuel containment

1.1

1.1.1 *The storage tanks to be used for CNG shall be certified and approved by the Society.*

1.1.2 *Tanks for CNG shall be fitted with pressure relief valves with a set point below the design pressure of the tank and with outlet located as required in Sec 5, [2.1.9] and Sec 5, [2.1.11]*

1.1.3 *Adequate means shall be provided to depressurize the tank in case of a fire which can affect the tank.*

1.1.4 *Storage of CNG in enclosed spaces is normally not acceptable, but may be permitted after special consideration and approval by the Society provided the following is fulfilled in addition to Sec 1, [2.1.4] to Sec 1, [2.1.7]:*

- *adequate means are provided to depressurize and inert the tank in case of a fire which can affect the tank*
- *all surfaces within such enclosed spaces containing the CNG storage are provided with suitable thermal protection against any lost high-pressure gas and resulting condensation unless the bulkheads are designed for the lowest temperature that can arise from gas expansion leakage, and*
- *a fixed fire-extinguishing system is installed in the enclosed spaces containing the CNG storage. Special consideration should be given to the extinguishing of jet-fires.*

Section 5 Pressure Relief System

1 General

1.1

1.1.1 *All fuel storage tanks shall be provided with a pressure relief system appropriate to the design of the fuel containment system and the fuel being carried. Fuel storage hold spaces, interbarrier spaces and tank connection spaces, which may be subject to pressures beyond their design capabilities, shall also be provided with a suitable pressure relief system. Pressure control systems specified in Sec 7 shall be independent of the pressure relief systems.*

1.1.2 Pressure relief valves fitted to fuel tanks are to be type approved through design assessment and prototype testing in accordance with Ch 9, Sec 1, [7.1].

Pressure relief discharges and vent outlets are to be arranged in accordance with Ch 5, Sec 2, [6.1].

For the venting of tank connection spaces, refer also to Sec 1, [2.1.8].

For the venting of interbarrier spaces, refer also to [2.1.5].

Pressure relief systems are not required for tank cofferdams containing fuel pipes protected by a secondary enclosure.

1.1.3 *Fuel storage tanks which may be subject to external pressures above their design pressure shall be fitted with vacuum protection systems.*

2 Pressure relief systems for liquefied gas fuel tanks

2.1

2.1.1 The arrangement of relief valve discharge and vent outlets is defined in Ch 5, Sec 2, [6.1].

2.1.2 *If fuel release into the vacuum space of a vacuum insulated tank cannot be excluded, the vacuum space shall be protected by a pressure relief device which shall be connected to a vent system if the tanks are located below deck. On open deck a direct release into the atmosphere may be accepted by the Society for tanks not exceeding the size of a 40 ft container if the released gas cannot enter safe areas.*

2.1.3 See also Ch 5, Sec 2, [6.1]

The provisions of [2.1.2] should be applied as follows:

For vacuum insulated type C tanks where pipes led through the vacuum space are protected by a secondary barrier complying with Sec 1, [2.1.12], the vacuum space need not be protected by a pressure relief device.

For vacuum insulated type C tanks where pipes led through the vacuum space are not protected by a secondary barrier, the vacuum space is to be protected by a pressure relief device arranged as follows:

when the tank is located below deck, the pressure relief device is to be connected to the vent mast,

when the tank is located on open deck and has a capacity exceeding 40 m^3, the pressure relief device is to be connected to the vent mast,

when the tank is located on open deck and has a capacity not exceeding that 40 m^3, the pressure relief device may discharge into the atmosphere, subject to satisfactory gas dispersion analysis.

2.1.4 *Liquefied gas fuel tanks shall be fitted with a minimum of 2 pressure relief valves (PRVs) allowing for disconnection of one PRV in case of malfunction or leakage.*

2.1.5 *Interbarrier spaces shall be provided with pressure relief devices. For membrane systems, the designer shall demonstrate adequate sizing of interbarrier space PRVs.*

Note 1: Refer to IACS Unified Interpretation GC9 entitled Guidance for sizing pressure relief systems for interbarrier spaces, 1988.

2.1.6 *The setting of the PRVs shall not be higher than the vapour pressure that has been used in the design of the tank. Valves comprising not more than 50% of the total relieving capacity may be set at a pressure up to 5% above MARVS to allow sequential lifting, minimizing unnecessary release of vapour.*

2.1.7 *The following temperature regulations apply to PRVs fitted to pressure relief systems:*

a) *PRVs on fuel tanks with a design temperature below 0°C shall be designed and arranged to prevent their becoming inoperative due to ice formation*
b) *the effects of ice formation due to ambient temperatures shall be considered in the construction and arrangement of PRVs*
c) *PRVs shall be constructed of materials with a melting point above 925°C. Lower melting point materials for internal parts and seals may be accepted provided that fail-safe operation of the PRV is not compromised, and*
d) *sensing and exhaust lines on pilot operated relief valves shall be of suitably robust construction to prevent damage.*

2.1.8 *In the event of a failure of a fuel tank PRV a safe means of emergency isolation shall be available.*

a) *procedures shall be provided and included in the operation manual*
b) *the procedures shall allow only one of the installed PRVs for the liquefied gas fuel tanks to be isolated, physical interlocks shall be included to this effect, and*
c) *isolation of the PRV shall be carried out under the supervision of the master. This action shall be recorded in the ship's log, and at the PRV.*

2.1.9 *Each pressure relief valve installed on a liquefied gas fuel tank shall be connected to a venting system, which shall be:*

a) *so constructed that the discharge will be unimpeded and normally be directed vertically upwards at the exit*
b) *arranged to minimize the possibility of water or snow entering the vent system, and*
c) *arranged such that the height of vent exits shall normally not be less than B/3 or 6 m, whichever is the greater, above the weather deck and 6 m above working areas and walkways. However, vent mast height could be limited to lower value according to special consideration by the Society.*

2.1.10 The venting system mentioned in [2.1.2]and [2.1.9] includes the vent headers (see [3.2.3]) and the vent mast (see Sec 1, [2.1.8], [2.1.9], item c) and [3.2.3]).

Very high pressure vent systems and other vent systems are to be separate up to the vent mast outlet.

2.1.11 *The outlet from the pressure relief valves shall normally be located at least 10 m from the nearest:*

a) *air intake, air outlet or opening to accommodation, service and control spaces, or other non-hazardous area, and*
b) *exhaust outlet from machinery installations.*

2.1.12 *All other fuel gas vent outlets shall also be arranged in accordance with [2.1.9] to [2.1.11]. Means shall be provided to prevent liquid overflow from gas vent outlets, due to hydrostatic pressure from spaces to which they are connected.*

2.1.13 *In the vent piping system, means for draining liquid from places where it may accumulate shall be provided. The PRVs and piping shall be arranged so that liquid can, under no circumstances, accumulate in or near the PRVs.*

2.1.14 Draining pipe discharging to the deck may be accepted provided it is fitted with a self-closing valve and a manual shutoff valve.

2.1.15 *Suitable protection screens of not more than 13 mm square mesh shall be fitted on vent outlets to prevent the ingress of foreign objects without adversely affecting the flow.*

2.1.16 *All vent piping shall be designed and arranged not to be damaged by the temperature variations to which it may be exposed, forces due to flow or the ship's motions.*

2.1.17 *PRVs shall be connected to the highest part of the fuel tank. PRVs shall be positioned on the fuel tank so that they will remain in the vapour phase at the filling limit (FL) as given in 6.8, under conditions of 15° list and 0,015 L trim, where L is defined in Ch 1, Sec 1, [5.1.32].*

3 Sizing of pressure relieving system

3.1 Sizing of pressure relief valves

3.1.1 *The pressure relief system for each liquefied gas fuel tank shall be designed so that, regardless of the state of any one PRV, the capacity of the residual PRVs meets the combined relieving capacity requirements of the system. The combined relieving capacity shall be the greater of the following, with no more than 20% rise in liquefied gas fuel tank pressure above the MARVS. The tank shall not be loaded until the full relieving capacity is restored:*

a) *The maximum capacity of the liquefied gas fuel tank inerting system if the maximum attainable working pressure of the liquefied gas fuel tank inerting system exceeds the MARVS of the liquefied gas fuel tanks, or*
b) *Vapours generated under fire exposure computed using the following formula:*

   $Q = F\ G\ A^{0,82}$

   where:

   Q : Minimum required rate of discharge of air, in m3/s, at standard conditions of 273,15 Kelvin (K) and 0,1013 MPa

Fire exposure factor for different liquefied gas fuel tank types:

F : *F = 1,0 for tanks without insulation located on deck*

- *F = 0,5 for tanks above the deck when insulation is approved by the Society (Approval will be based on the use of a fireproofing material, the thermal conductance of insulation, and its stability under fire exposure)*
- *F = 0,5 for uninsulated independent tanks installed in holds*
- *F = 0,2 for insulated independent tanks in holds (or uninsulated independent tanks in insulated holds)*
- *F = 0,1 for insulated independent tanks in inerted holds (or uninsulated independent tanks in inerted, insulated holds), and*
- *F = 0,1 for membrane tanks.*

For independent tanks partly protruding through the weather decks, the fire exposure factor shall be determined on the basis of the surface areas above and below deck

G : *Gas factor according to formula:*

$$G = \frac{12,4}{LD}\sqrt{\frac{ZT}{M}}$$

where:

T : *Temperature in Kelvin at relieving conditions, i.e. 120% of the pressure at which the pressure relief valve is set*

L : *Latent heat of the material being vaporized at relieving conditions, in kJ/kg*

D : *A constant based on relation of specific heats k and is calculated as follows:*

$$D = \sqrt{k\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}}$$

where:

k : *Ratio of specific heats at relieving conditions, and the value of which is between 1,0 and 2,2. If k is not known, D = 0,606 shall be used*

Z : *Compressibility factor of the gas at relieving conditions; if not known, Z = 1,0 shall be used*

M : *Molecular mass of the product.*

The gas factor of each liquefied gas fuel to be carried is to be determined and the highest value shall be used for PRV sizing.

A : *External surface area of the tank, in m², as for different tank types, as shown in Fig 1.*

3.1.2

a) In addition to the provisions of [3.1.1], the relieving capacity of the PRVs is to be sufficient to discharge the vapours generated by the pressure build up heat exchanger, where fitted, at its maximum capacity.

b) External surface area of the tank for determining sizing of pressure relief valve (see [3.1.3] and Fig 1)

For prismatic tanks

1) L_{min}, for non-tapered tanks, is the smaller of the horizontal dimensions of the flat bottom of the tank. For tapered tanks, as would be used for the forward tank, Lmin is the smaller of the length and the average width.

2) For prismatic tanks whose distance between the flat bottom of the tank and bottom of the hold space is equal to or less than $L_{min}/10$:

   A : External surface area minus flat bottom surface area.

3) For prismatic tanks whose distance between the flat bottom of the tank and bottom of the hold space is greater than $L_{min}/10$:

   A : External surface area.

3.1.3 *For vacuum insulated tanks in fuel storage hold spaces and for tanks in fuel storage hold spaces separated from potential fire loads by coffer dams or surrounded by ship spaces with no fire load the following applies:*

If the pressure relief valves have to be sized for fire loads the fire factors according may be reduced to the following values:

F = 0,50 to F = 0,25

F = 0,20 to F = 0,10

The minimum fire factor is F = 0,10.

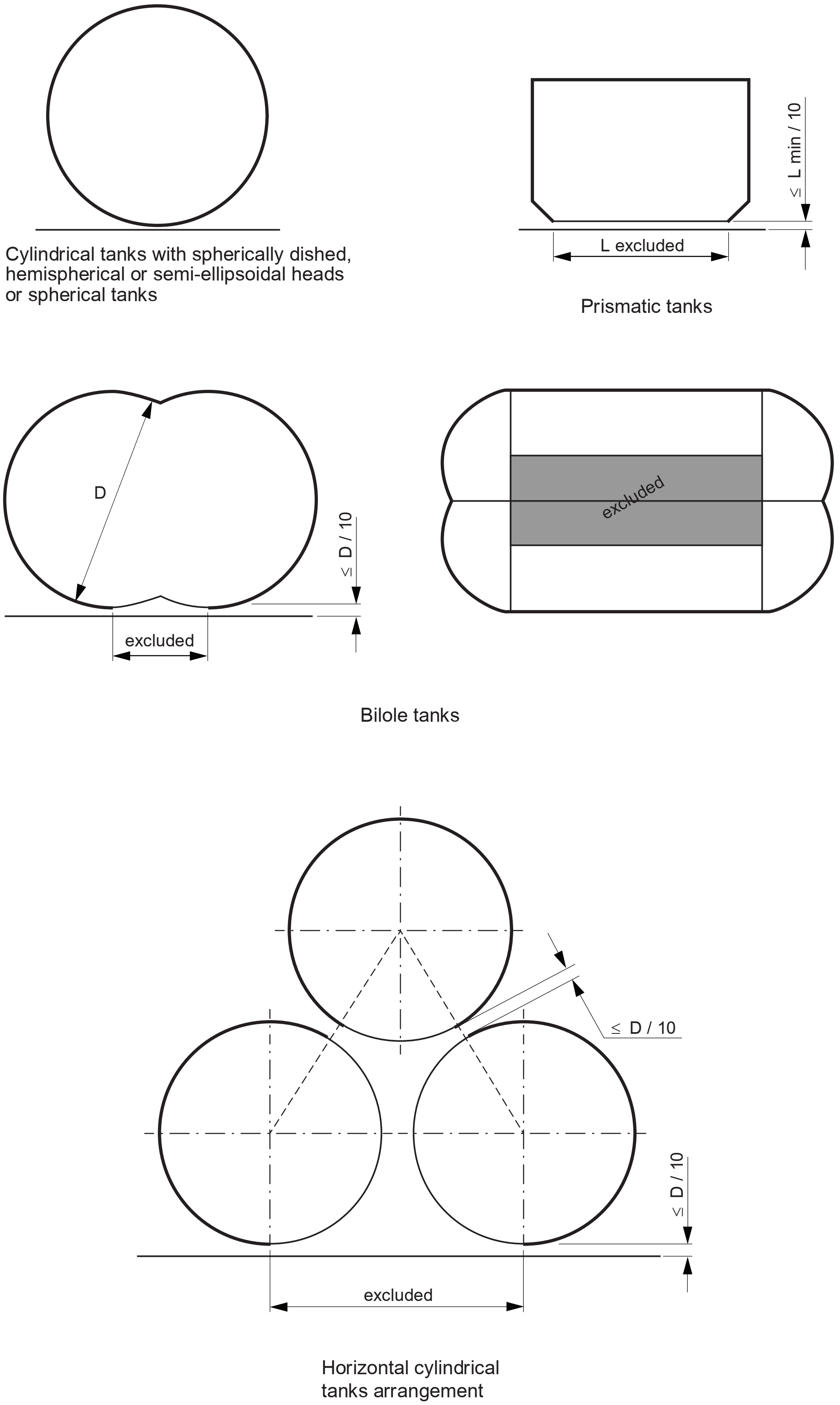
3.1.4 *The required mass flow of air at relieving conditions, in kg/s, is given by:*

$$M_{air} = Q\,\rho_{air}$$

where:

ρ_{air} : *Density of air, equal to 1,293 kg/m³ (air at 273,15 K and 0,1013 MPa).*

Figure 1 :


Cylindrical tanks with spherically dished, hemispherical or semi-ellipsoidal heads or spherical tanks
≤ L min / 10
L excluded
Prismatic tanks
D
≤ D / 10
excluded
excluded
Bilole tanks
≤ D / 10
≤ D / 10
excluded
Horizontal cylindrical tanks arrangement

3.2 Sizing of vent pipe system

3.2.1 *Pressure losses upstream and downstream of the PRVs, shall be taken into account when determining their size to ensure the flow capacity required by [3.1].*

3.2.2

a) The pressure drop in the vent line from the tank to the PRV inlet shall not exceed 3% of the valve set pressure at the calculated flow rate, in accordance with [3.1].

b) Pilot-operated PRVs shall be unaffected by inlet pipe pressure losses when the pilot senses directly from the tank dome, and

c) Pressure losses in remotely sensed pilot lines shall be considered for flowing type pilots.

3.2.3 Downstream pressure losses

a) Where common vent headers and vent masts are fitted, calculations shall include flow from all attached PRVs.

b) The built-up back pressure in the vent piping from the PRV outlet to the location of discharge to the atmosphere, and including any vent pipe interconnections that join other tanks, shall not exceed the following values:

- *for unbalanced PRVs:*
  0% of MARVS
- *for balanced PRVs:*
  30% of MARVS
- *for pilot operated PRVs:*
  50% of MARVS.

Alternative values provided by the PRV manufacturer may be accepted.

3.2.4 *To ensure stable PRV operation, the blow-down shall not be less than the sum of the inlet pressure loss and 0,02 MARVS at the rated capacity.*

Section 6 Loading Limit for Liquefied Gas Fuel Tanks

1 Regulations on loading limit for liquefied gas fuel tanks

1.1

1.1.1 *Storage tanks for liquefied gas shall not be filled to more than a volume equivalent to 98% full at the reference temperature as defined in Ch 1, Sec 1, [5.1.43].*

A loading limit curve for actual fuel loading temperatures shall be prepared from the following formula:

$LL = FL\ \rho_R / \rho_L$

where:

LL	:	*Loading limit as defined in Ch 1, Sec 1, [5.1.34], expressed in per cent*
FL	:	*Filling limit as defined in Ch 1, Sec 1, [5.1.16] expressed in per cent, here 98%*
ρ_R	:	*Relative density of fuel at the reference temperature*
ρ_L	:	*Relative density of fuel at the loading temperature.*

1.1.2 *In cases where the tank insulation and tank location make the probability very small for the tank contents to be heated up due to an external fire, special considerations may be made to allow a higher loading limit than calculated using the reference temperature, but never above 95%.*

1.1.3 The alternative loading limit option given under [1.1.1] is understood to be an alternative to [1.1.2] and should only be applicable when the calculated loading limit using the formulae in [1.1.1] gives a lower value than 95%.

Section 7 Maintaining of Fuel Storage Condition

1 Control of tank pressure and temperature

1.1

1.1.1 *With the exception of liquefied gas fuel tanks designed to withstand the full gauge vapour pressure of the fuel under conditions of the upper ambient design temperature, liquefied gas fuel tanks' pressure and temperature shall be maintained at all times within their design range by means acceptable to the Society, e.g. by one or more of the following methods:*

a) reliquefaction of vapours

b) thermal oxidation of vapours

c) pressure accumulation, and

d) liquefied gas fuel cooling.

The method chosen shall be capable of maintaining tank pressure below the set pressure of the tank pressure relief valves for a period of 15 days assuming full tank at normal service pressure and the ship in idle condition, i.e. only power for domestic load is generated.

1.1.2

a) Liquefied gas fuel tanks' pressure and temperature is to be controlled and maintained within the design range at all times including after activation of the safety system required in Ch 8, Sec 1, [1.1.1], item b) for a period of minimum 15 days.

b) The activation of the safety system alone is not deemed as an emergency situation.

c) Safe return to port (SRtP):

On ships to be assigned the additional service feature **SRTP**, the following systems are to remain operational after any flooding or fire casualty not exceeding the thresholds defined in SOLAS II-2/21.3 and SOLAS II-1/8-1.2:

- Propulsion, where the propulsion relies only on gas as fuel, and
- Safety systems supporting the gas installation

The exact list of the safety systems supporting the gas installation is to be defined based on the general philosophy adopted to keep the gas system safe during the SRtP voyage, taking into account the foreseen status of the gas installation during the SRtP voyage and whether the SRtP voyage is intended to be performed using conventional fuel or gas as fuel. The safety systems supporting the gas installation are expected to include, at least:

- Gas detection in hazardous areas
- ESD functions as necessary
- LNG containment system and associated systems (inert gas system, ventilation, hull heating systems as necessary), including boil-off gas management

SRtP scenarios are to be analyzed taking into account the requirements of NR598.

1.1.3 *Venting of fuel vapour for control of the tank pressure is not acceptable except in emergency situations.*

2 Design of systems

2.1

2.1.1 *For worldwide service, the upper ambient design temperature shall be sea 32°C and air 45°C. For service in particularly hot or cold zones, these design temperatures shall be increased or decreased, to the satisfaction of the Society.*

2.1.2 *The overall capacity of the system shall be such that it can control the pressure within the design conditions without venting to atmosphere.*

3 Reliquefaction systems

3.1

3.1.1 *The reliquefaction system shall be designed and calculated according to [3.1.2]. The system has to be sized in a sufficient way also in case of no or low consumption.*

3.1.2 *The reliquefaction system shall be arranged in one of the following ways:*

a) *a direct system where evaporated fuel is compressed, condensed and returned to the fuel tanks*

b) *an indirect system where fuel or evaporated fuel is cooled or condensed by refrigerant without being compressed*

c) *a combined system where evaporated fuel is compressed and condensed in a fuel/refrigerant heat exchanger and returned to the fuel tanks, and*

d) *if the reliquefaction system produces a waste stream containing methane during pressure control operations within the design conditions, these waste gases shall, as far as reasonably practicable, be disposed of without venting to atmosphere.*

4 Thermal oxidation systems

4.1

4.1.1 *Thermal oxidation can be done by either consumption of the vapours according to the regulations for consumers described in this Rule Note or in a dedicated gas combustion unit (GCU). It shall be demonstrated that the capacity of the oxidation system is sufficient to consume the required quantity of vapours. In this regard periods of slow steaming and/or no consumption from propulsion or other services of the vessel shall be considered.*

4.1.2 Gas combustion units are to comply with the provisions of NR467, Pt C, Ch 1, Sec 3.

Where high pressure vapours are intended to be consumed in a suitable consumer or in a dedicated GCU, and direct consumption of vapours is not possible, a buffer tank is to be installed.

5 Comptability

5.1

5.1.1 *Refrigerants or auxiliary agents used for refrigeration or cooling of fuel shall be compatible with the fuel they may come in contact with (not causing any hazardous reaction or excessively corrosive products). In addition, when several refrigerants or agents are used, these shall be compatible with each other.*

6 Availability of systems

6.1

6.1.1 *The availability of the system and its supporting auxiliary services shall be such that in case of a single failure (of mechanical non-static component or a component of the control systems) the fuel tank pressure and temperature can be maintained by another service/system.*

6.1.2 A FMEA analysis is to be submitted accordingly.

6.1.3 *Heat exchangers that are solely necessary for maintaining the pressure and temperature of the fuel tanks within their design ranges shall have a standby heat exchanger unless they have a capacity in excess of 25% of the largest required capacity for pressure control and they can be repaired on board without external sources.*

6.1.4 The provisions of [6.1.3] apply to coolers used in vapour reliquefaction systems and in liquefied gas fuel cooling systems and to heaters used for thermal oxidation systems.

Where heat exchangers referred to in [6.1.3] have no standby unit, an analysis is to be submitted containing the following information:

- list of failure modes of the heat exchanger,
- repair procedure for each failure mode, including downtime.

Failure of a heat exchanger within the boil-off gas management system is not to result in a reduction of the capacity thereof.

Section 8 Atmospheric Control within the Fuel Containment System

1 General

1.1

1.1.1 *A piping system shall be arranged to enable each fuel tank to be safely gas-freed, and to be safely filled with fuel from a gas-free condition. The system shall be arranged to minimize the possibility of pockets of gas or air remaining after changing the atmosphere.*

1.1.2 *The system shall be designed to eliminate the possibility of a flammable mixture existing in the fuel tank during any part of the atmosphere change operation by utilizing an inerting medium as an intermediate step.*

1.1.3 *Gas sampling points shall be provided for each fuel tank to monitor the progress of atmosphere change.*

1.1.4 *Inert gas utilized for gas freeing of fuel tanks may be provided externally to the ship.*

Section 9 Atmosphere Control within Fuel Storage Hold Spaces (fuel containment systems other than type C independent tanks)

1 General

1.1

1.1.1 *Interbarrier and fuel storage hold spaces associated with liquefied gas fuel containment systems requiring full or partial secondary barriers shall be inerted with a suitable dry inert gas and kept inerted with make-up gas provided by a shipboard inert gas generation system, or by shipboard storage, which shall be sufficient for normal consumption for at least 30 days. Shorter periods may be considered by the Society depending on the ship's service.*

1.1.2 *Alternatively, the spaces referred to in [1.1.1] requiring only a partial secondary barrier may be filled with dry air provided that the ship maintains a stored charge of inert gas or is fitted with an inert gas generation system sufficient to inert the largest of these spaces, and provided that the configuration of the spaces and the relevant vapour detection systems, together with the capability of the inerting arrangements, ensures that any leakage from the liquefied gas fuel tanks will be rapidly detected and inerting effected before a dangerous condition can develop. Equipment for the provision of sufficient dry air of suitable quality to satisfy the expected demand shall be provided.*

Section 10 Environmental Control of Spaces Surrounding Type C Independent Tanks

1 General

1.1

1.1.1 *Spaces surrounding liquefied gas fuel tanks shall be filled with suitable dry air and be maintained in this condition with dry air provided by suitable air drying equipment. This is only applicable for liquefied gas fuel tanks where condensation and icing due to cold surfaces is an issue.*

1.1.2 The provisions of [1.1.1] do not apply to vacuum insulated type C tanks.

For tanks on open decks, special attention is to be paid to condensation and icing in way of supports.

Section 11 Inerting

1 General

1.1

1.1.1 *Arrangements to prevent back-flow of fuel vapour into the inert gas system shall be provided as specified below.*

1.1.2 *To prevent the return of flammable gas to any non-hazardous spaces, the inert gas supply line shall be fitted with two shutoff valves in series with a venting valve in between (double block and bleed valves). In addition a closable non-return valve shall be installed between the double block and bleed arrangement and the fuel system. These valves shall be located outside non-hazardous spaces.*

1.1.3 *Where the connections to the fuel piping systems are non-permanent, two non-return valves may be substituted for the valves required in [1.1.2].*

1.1.4 *The arrangements shall be such that each space being inerted can be isolated and the necessary controls and relief valves, etc. shall be provided for controlling pressure in these spaces.*

1.1.5 *Where insulation spaces are continually supplied with an inert gas as part of a leak detection system, means shall be provided to monitor the quantity of gas being supplied to individual spaces.*

Section 12 Inert Gas Production and Storage on Board

1 General

1.1

1.1.1 *The equipment shall be capable of producing inert gas with oxygen content at no time greater than 5% by volume. A continuous-reading oxygen content meter shall be fitted to the inert gas supply from the equipment and shall be fitted with an alarm set at a maximum of 5% oxygen content by volume.*

1.1.2 *An inert gas system shall have pressure controls and monitoring arrangements appropriate to the fuel containment system.*

1.1.3 *Where a nitrogen generator or nitrogen storage facilities are installed in a separate compartment outside of the engine-room, the separate compartment shall be fitted with an independent mechanical extraction ventilation system, providing a minimum of 6 air changes per hour. A low oxygen alarm shall be fitted.*

1.1.4 *Nitrogen pipes shall only be led through well ventilated spaces. Nitrogen pipes in enclosed spaces shall:*

- *be fully welded*
- *have only a minimum of flange connections as needed for fitting of valves, and*
- *be as short as possible.*

Section 13 Independent Tank Supports

1 Supporting arrangement

1.1 General

1.1.1 The liquefied gas fuel tanks are to be supported by the hull in a manner that prevents bodily movement of the tank under the static and dynamic loads defined in Sec 2, [10.2] to Sec 2, [10.21], where applicable, while allowing contraction and expansion of the tank under temperature variations and hull deflections without undue stressing of the tank and the hull.

1.1.2 Supports and supporting arrangements are to be able to withstand the loads defined in Sec 2, [10.11] and Sec 2, [10.21], but these loads need not be combined with each other or with wave-induced loads. The reaction forces in way of the tank supports are to be transmitted as directly as possible to the hull primary supporting members, minimising stress concentrations.

1.1.3 Where the reaction forces are not in the plane of the primary supporting members, web plates and brackets are to be provided in order to transmit these loads by means of shear stresses.

1.1.4 Special attention is to be paid to the continuity of structure between the circular tank supports and the primary supporting members of the ship.

1.1.5 The openings in tank supports and hull structures in way of tank supports are to be minimized and local strengthening may be required.

1.1.6 The insulating materials for tank supports are to be type-approved by the Society.

Note 1: In addition to the justification of mechanical properties, the water absorption of the insulating materials should not be more than 6% when determined in accordance with DIN 53 495.

2 Calculation of reaction forces in way of tank supports

2.1 General

2.1.1 The reaction forces in way of tank supports are to be obtained from the structural analysis of the tank or stiffening rings in way of tank supports, considering the loads specified in Sec 2, [10.2] to Sec 2, [10.21].

The final distribution of the reaction forces at the supports is not to show any tensile forces.

3 Checking criteria

3.1 General

3.1.1 The supports of independent tanks of type A and type B which are primarily constructed of plane surfaces are to be checked in accordance with Articles [3] to [5] and the following criteria:

- For supports analysed through beam model, it is to be checked that the combined stress σ_C, in N/mm², is in compliance with the following formula:

  $\sigma_C \leq \sigma_{ALL}$

  where:

  σ_{ALL} : Allowable stress, in N/mm², defined in Table 1 for each acceptance criteria.

- For supports analysed through finite element model, the yield criteria, defined in NR467, Pt B, Ch 8, App 1, [5.2.3] for standard mesh size or in NR467, Pt B, Ch 8, App 2, [4.1.3] for fine mesh models, are to be checked.

3.1.2 The supports of independent tanks of type C are to be checked in accordance with [6] and the criteria given in [3.1].

3.1.3 The cylindrical skirts supporting independent tanks of type B which are primarily constructed of bodies of revolution are to be checked in accordance with [5] and the criteria given in Sec 2, [16.2.3], a) and Sec 2, [16.2.6].

Table 1 : Beam model: Allowable stresses σ_{ALL}, in N/mm^2 in all types of supports

Acceptance criteria **(1)**	AC-1	AC-2	AC-3 **(2)**
σ_{ALL}, in N/mm^2	The lower of: • 0,9 R_m / 2,66 • 0,9 R_{eH} / 1,33	The lower of: • R_m / 2,66 • R_{eH} / 1,33	0,85 Ry
(1) Acceptance criteria are defined in NR467, Pt B, Ch 1, Sec 2, [3.4] **(2)** Flooding, static heel 30° and collision conditions are to be checked considering AC-3 criteria **Note 1:** R_{eH} : Specified minimum yield stress, as defined in NR467 Pt B, Ch 1, Sec 3 R_m : Specified minimum tensile strength, as defined in NR467 Pt B, Ch 1, Sec 3 R_Y : Nominal yield stress, as defined in NR467 Pt B, Ch 1, Sec 3			

4 Supports of independent tanks of type A and type B primarily constructed of plane surfaces

4.1 General

4.1.1 For parts such as supporting structures, the stresses are to be determined by direct calculations, taking into account the loads referred to in Sec 2, [10.2] to Sec 2, [10.21], as far as applicable, and the ship deflection in way of the supporting structures.

4.1.2 The tanks with supports are to be designed for the accidental loads specified in Sec 2, [10.21]. These loads need not be combined with each other or with environmental loads.

4.1.3 Moreover the tanks with supports are also to be designed for a static angle of heel of 30°.

4.2 Vertical supports

4.2.1 The structure of the tank and of the ship is to be reinforced in way of the vertical supports so as to withstand the reactions and the corresponding moments.

4.2.2 For the purpose of this assessment, the frictional coefficient of the vertical supports is to be taken equal to 0,3 unless duly justified.

4.2.3 Dam plates, fitted to secure the wood, are to be designed to withstand, in all seagoing load cases and assuming a failure of the resin holding the wood, an horizontal force taken equal to the minimum between:

- 10% of the vertical reaction on the support
- the horizontally accelerated weight of the tank in a direction perpendicular to the dam plates and distributed among all the vertical supports.

4.3 Antirolling supports

4.3.1 Antirolling supports are to be checked under transverse and vertical reactions, as defined in [2] for the inclined ship conditions, and applied on the maximum weight of the full tank.

4.3.2 Antirolling supports are also to be checked for a static angle of heel of 30°.

4.3.3 For the purpose of this assessment, the frictional coefficient of the vertical supports is to be taken equal to 0,1 unless duly justified.

4.4 Antipitching supports

4.4.1 Antipitching supports are to be checked under longitudinal and vertical reactions, as defined in [2] for the upright ship conditions, and applied on the maximum weight of the full tank.

4.5 Anticollision supports

4.5.1 Anticollision supports are to be provided to withstand a collision force acting on the tank taken respectively equal to:

- One half of the weight of the tank and cargo in the forward direction
- One quarter of the weight of the tank and cargo in the aft direction.

Antipitching supports may be combined with anticollision supports.

4.6 Antiflotation supports

4.6.1 Antiflotation arrangements, capable of withstanding the loads defined in Sec 2, [10.21.3] without plastic deformation likely to endanger the hull structure, are to be provided for independent tanks.

4.6.2 Adequate clearance between the tanks and the hull structures is to be provided in all the operating conditions.

4.6.3 Antiflotation supports, suitable to withstand an upward force caused by an empty tank in a hold space flooded to the summer load draught of the ship, are to be provided.

5 Supports of independent tanks of type B primarily constructed of bodies of revolution

5.1 Cylindrical skirt

5.1.1 Cylindrical skirts supporting spherical independent tanks of type B are to be checked under longitudinal, transverse and vertical reactions, as defined in [2] for the upright and inclined conditions, and applied on the tank assumed full.

Antipitching supports are also to be checked for the following accidental conditions:

- Static angle of heel of 30°
- Collision force acting on the tank taken respectively equal to:
  - One half of the weight of the tank and cargo in the forward direction
  - One quarter of the weight of the tank and cargo in the aft direction.
- Flooding loads defined in Sec 2, [10.21.3].

6 Supports of type C independent tanks

6.1 General

6.1.1 The tanks with supports are to be designed for the accidental loads specified in Sec 2, [10.21] and Sec 2, [1.1.6], c). These loads need not be combined with each other or with environmental loads.

6.1.2 Moreover the tanks with supports are also to be designed for a static angle of heel of 30°.

Section 14 Fatigue Requirements

1 Fatigue design condition

1.1 General

1.1.1 Fatigue and crack propagation assessment shall be performed in accordance with Sec 2, [13.3]. The acceptance criteria shall comply with Sec 2, [13.3.7] to Sec 2, [13.3.9] depending on the detectability of the defect.

1.1.2 Fatigue analysis shall consider construction tolerances.

1.1.3 Where deemed necessary by the Society, model tests may be required to determine stress concentration factors and fatigue life of structural elements.

1.2 Fatigue analysis

1.2.1 General

The fatigue analysis is to be performed for areas where high wave induced stresses or large stress concentrations are expected, for welded joints and parent material. Such areas are to be defined by the Designer and agreed by the Society on a case-by-case basis.

1.2.2 Material properties

The material properties affecting fatigue of the items checked are to be documented. Where this documentation is not available, the Society may request to obtain these properties from experiments performed in accordance with recognised standards.

1.2.3 Wave loads

In upright and inclined ship conditions, the wave loads to be considered for the fatigue analysis of the tank include:

- maximum and minimum wave hull girder loads and wave pressures, to be obtained from a complete analysis of the ship motion and accelerations in irregular waves, and to be submitted to the Society for approval, unless these data are available from similar ships. These loads are to be obtained as the most probable the ship may experience during its operating life, for a probability level of 10^{-8}.
- maximum and minimum inertial pressures, to be obtained from the formulae in Sec 2, [10.3] as a function of the arbitrary direction β.

1.2.4 Simplified stress distribution for fatigue analysis

The simplified long-term distribution of wave loads indicated in Sec 2, [13.3.6], may be represented by means of eight stress ranges, each characterised by an alternating stress $\pm \sigma_i$ and a number of cycles n_i (see Fig 4). The corresponding values of σ_i and n_i are to be obtained from the following formulae:

$$\sigma_i = \sigma_0\left(1{,}0625 - \frac{i}{8}\right)$$

$$n_i = 0{,}9 \cdot 10^i$$

where:

σ_i : Stress (i = 1, 2,..., 8), in N/mm² (see Fig 1)

σ_0 : Most probable maximum stress over the life of the ship, in N/mm², for a probability level of 10^{-8}

n_i : Number of cycles for each stress σ_i considered (i = 1, 2,..., 8).

1.2.5 Conventional cumulative damage

For each structural detail for which the fatigue analysis is to be carried out, the conventional cumulative damage is to be calculated according to the following procedure:

- The long-term value of hot spot stress range $\Delta\sigma_{S,0}$ is to be obtained from the following formula:

  $$\Delta\sigma_{S,0} = |\sigma_{S,MAX} - \sigma_{S,MIN}|$$

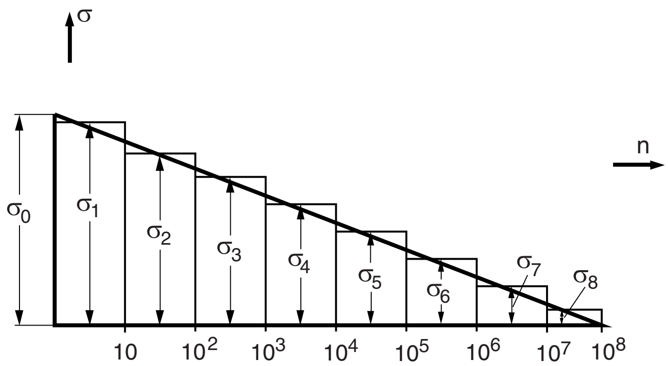
  where:

  $\sigma_{S,MAX}$, $\sigma_{S,MIN}$: Maximum and minimum hot spot stresses to be obtained from a structural analysis carried out in accordance with NR467, Pt B, Ch 8, App 1 or NR467, Pt B, Ch 8, App 2, as applicable, where the wave loads are those defined in [1.4.3].
- The long-term value of the notch stress range $\Delta\sigma_{N,0}$ is obtained from the formulae in NR467, Pt B, Ch 10, Sec 1 as a function of the hot spot stress range $\Delta\sigma_{S,0}$
- The long-term distribution of notch stress ranges $\Delta\sigma_{N,I}$ is to be calculated. Each stress range $\Delta\sigma_{N,I}$ of the distribution, corresponding to n_i stress cycles, is obtained from the formulae in [1.4.4], where σ_0 is taken equal to $\Delta\sigma_{N,0}$.

- For each notch stress range $\Delta\sigma_{N,I}$, the number of stress cycles N_I which cause the fatigue failure is to be obtained by means of S-N curves corresponding to the as-rolled condition (see Fig 2). The criteria adopted for obtaining the S-N curves are to be documented.

  Where this documentation is not available, the Society may require the curves to be obtained from experiments performed in accordance with recognised standards.
- The conventional cumulative damage for the i notch stress ranges $\Delta\sigma_{N,I}$ is to be obtained from the formula in Sec 2, [13.4].

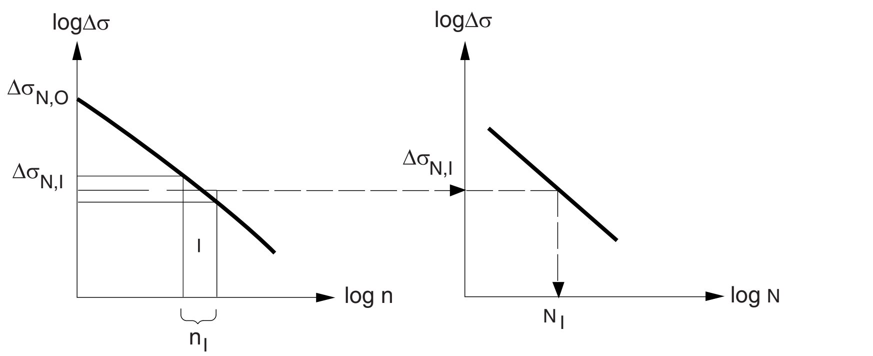
Figure 1 : Simplified stress distribution for fatigue analysis



1.2.6 Check criteria

The conventional cumulative damage, to be calculated according to [1.4.5], is to be not greater than C_W defined in Part A1 [6.4.12.2].

Figure 2 : Fatigue check based on conventional cumulative damage method



2 Crack propagation analysis

2.1 General

2.1.1 The crack propagation analysis is to be carried out for highly stressed areas. The latter are to be defined by the Designer and agreed by the Society on a case-by-case basis. Propagation rates in the parent material, weld metal and heat-affected zone are to be considered.

The following checks are to be carried out:

- crack propagation from an initial defect, in order to check that the defect will not grow and cause a brittle fracture before the defect is detected; this check is to be carried out according to [2.1.4]
- crack propagation from an initial through thickness defect, in order to check that the defect, resulting in a leakage, will not grow and cause a brittle fracture less than 15 days after its detection; this check is to be carried out according to [2.1.5].

2.1.2 Material properties

The material fracture mechanical properties used for the crack propagation analysis, i.e. the properties relating to the crack propagation rate to the stress intensity range at the crack tip, are to be documented for the various thicknesses of parent material and weld metal alike.

Where this documentation is not available, the Society may request to obtain these properties from experiments performed in accordance with recognised standards.

2.1.3 Simplified stress distribution for crack propagation analysis

The simplified wave load distribution indicated in Part A1, 6.4.12.2.6 may be represented over a period of 15 days by means of five stress ranges, each characterised by an alternating stress ± σ_i and number of cycles n_i (see Fig 3). The corresponding values of σ_i and n_i are to be obtained from the following formulae:

$$\sigma_i = \sigma_0\left(1{,}1 - \frac{i}{5{,}3}\right)$$

$$n_i = 0{,}913 \cdot 10^i$$

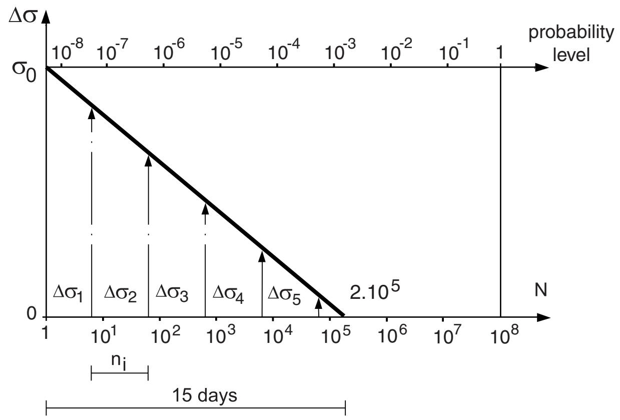
where:

σ_i : Stress (i = 1,06; 2,12; 3,18; 4,24; 5,30), in N/mm² (see Fig 3)

σ_0 : Defined in [1.4.4]

n_i : Number of cycles for each stress σ_i considered (i = 1,06; 2,12; 3,18; 4,24; 5,30).

Figure 3 : Simplified stress distribution for crack propagation analysis



2.1.4 Crack propagation analysis from an initial defect

It is to be checked that an initial crack will not grow, under wave loading based on the stress distribution in [1.4.4], beyond the allowable crack size.

The initial size and shape of the crack are to be considered by the Society on a case-by-case basis, taking into account the structural detail and the inspection method.

The allowable crack size is to be considered by the Society on a case-by-case basis; in any event, it is to be taken less than that which may lead to a loss of effectiveness of the structural element considered.

2.1.5 Crack propagation analysis from an initial through-thickness defect

It is to be checked that an initial through-thickness crack will not grow, under dynamic loading based on the stress distribution in [2.1.3], beyond the allowable crack size.

The initial size of the through-thickness crack is to be taken not less than the crack through which the minimum flow size that can be detected by the monitoring system (e.g. gas detectors) may pass.

The allowable crack size is to be considered by the Society on a case-by-case basis; in any event, it is to be taken far less than the critical crack length, defined in [2.1.6].

2.1.6 Critical crack length

The critical crack length is the crack length from which a brittle fracture may initiate and it is to be considered by the Society on a case-by-case basis. In any event, it is to be evaluated for the most probable maximum stress experienced by the structural element during the ship life, equal to the stress in the considered detail obtained from the structural analysis to be performed in accordance with Sec 2, [16].

3 Structural details

3.1 General

3.1.1 The structural details to be checked for fatigue assessment are listed in NR467, Pt B, Ch 13, Sec 5, [2.4] depending on the type of tank.

Appendix 1 Standard for the Use of Limit State Methodologies in the Design of Fuel Containment Systems of Novel Configuration

1 General

1.1

1.1.1 *The purpose of this Annex is to provide procedures and relevant design parameters of limit state design of fuel containment systems of a novel configuration in accordance with Sec 2, [17].*

1.1.2 *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 Sec 2, [1.1.6]. A limit state can be defined as a condition beyond which the structure, or part of a structure, no longer satisfies the regulations.*

1.1.3 *The limit states are divided into the three following categories:*

- *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*
- *Fatigue Limit States (FLS), which correspond to degradation due to the effect of cyclic loading, and*
- *Accident Limit States (ALS), which concern the ability of the structure to resist accident situations.*

1.1.4 *Sec 2, [1] to Sec 2, [15] shall be complied with as applicable depending on the fuel containment system concept.*

2 Design format

2.1

2.1.1 *The design format in this Appendix 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 Ld do not exceed design resistances Rd for any of the considered failure modes in any scenario:*

$L_d \geq R_d$

A design load Fdk is obtained by multiplying the characteristic load by a load factor relevant for the given load category:

$F_{dk} = g_f \times F_k$

where:

γ_F : *Load factor*

F_k : *Characteristic load as specified in Sec 2, [10] to Sec 2, [13].*

A design load effect L_d (e.g. stresses, strains, displacements and vibrations) is the most unfavourable combined load effect derived from the design loads, and may be expressed by:

$L_d = q\ (F_{d1}, F_{d2}, \ldots, F_{dN})$

where q denotes the functional relationship between load and load effect determined by structural analyses.

The design resistance Rd is determined as follows:

$$R_d = \frac{R_k}{\gamma_R \cdot \gamma_C}$$

where:

R_k : *Characteristic resistance. In case of materials covered by Chapter 4, 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 : *Resistance factor, defined as:*

$\gamma_R = \gamma_m \cdot \gamma_s$

γ_m : *Partial resistance factor to take account of the probabilistic distribution of the material properties (material factor)*

γ_s : *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*

γ_C : *Consequence class factor, which accounts for the potential results of failure with regard to release of fuel and possible human injury.*

2.1.2 *Fuel containment design shall take into account potential failure consequences. Consequence classes are defined in Tab 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 : Consequence classes

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

3 Required analyses

3.1

3.1.1 *Three dimensional finite element analyses shall 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 shall be identified to avoid unexpected failures. Hydrodynamic analyses shall 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.*

3.1.2 *Buckling strength analyses of fuel tanks subject to external pressure and other loads causing compressive stresses shall be carried out in accordance with recognized standards. The method shall 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.*

3.1.3 *Fatigue and crack propagation analysis shall be carried out in accordance with [5.1.1].*

4 Ultimate Limit States

4.1

4.1.1 *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 shall 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).*

4.1.2 *Appropriate combinations of permanent loads, functional loads and environmental loads including sloshing loads shall be considered in the analysis. At least two load combinations with partial load factors as given in Tab 2 shall be used for the assessment of the ultimate limit states.*

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.

Table 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

4.1.3 *For sloshing loads, depending on the reliability of the estimation method, a larger load factor may be required by the Society.*

4.1.4 *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 shall 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 shall take account of factors including, but not limited to, provision of full 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 shall in any case not be less than 1,0.*

4.1.5 *The load factors and the resistance factors used shall be such that the level of safety is equivalent to that of the fuel containment systems as described in Sec 2, [2.1.1] to Sec 2, [2.1.5]. This may be carried out by calibrating the factors against known successful designs.*

4.1.6 *The material factor γ_m shall 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 Chapter 6, the material factor may be taken as:*

- γ_m *= 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*
- γ_m *= 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.*

4.1.7 *The partial resistance factors γ_{si} shall 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.*

For design against excessive plastic deformation using the limit state criteria given in [4.1.8], the partial resistance factors γ_{si} shall be taken as follows:

$$\gamma_{s1} = 0,76\frac{B}{\kappa_1}$$

$$\gamma_{s2} = 0,76\frac{D}{\kappa_2}$$

with:

$$\kappa_1 = \text{Min}\left(\frac{R_m}{R_e} \cdot \frac{B}{A};1,0\right)$$

$$\kappa_2 = \text{Min}\left(\frac{R_m}{R_e} \cdot \frac{D}{C};1,0\right)$$

A, B, C, D: Factors as defined in Sec 2, [16.2.3]

R_m, R_e : *As defined in Sec 2, [13.2.4].*

The partial resistance factors given above are the results of calibration to conventional type B independent tanks.

4.1.8 Design against excessive plastic deformation

a) *Stress acceptance criteria given below refer to elastic stress analyses.*

b) *Parts of fuel containment systems where loads are primarily carried by membrane response in the structure shall satisfy the following limit state criteria:*

$\sigma_m \leq f$

$\sigma_L \leq 1,5\ f$

$\sigma_b \leq 1,5\ F$

$\sigma_L + \sigma_b \leq 1,5\ F$

$\sigma_m + \sigma_b \leq 1,5\ F$

$\sigma_m + \sigma_b + \sigma_g \leq 3,0\ F$

$\sigma_L + \sigma_b + \sigma_g \leq 3,0\ F$

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*

$$f = \frac{R_e}{\gamma_{s1} \cdot \gamma_m \cdot \gamma_C}$$

$$F = \frac{R_e}{\gamma_{s2} \cdot \gamma_m \cdot \gamma_C}$$

Note 1: The stress summation described above shall be carried out by summing up each stress component (σ_x, σ_y, τ_{xy}), and subsequently the equivalent stress shall be calculated based on the resulting stress components as shown in the following example:

$$\sigma_L + \sigma_b = \sqrt{(\sigma_{Lx} + \sigma_{bx})^2 - (\sigma_{Lx} + \sigma_{bx})(\sigma_{Ly} + \sigma_{by}) + (\sigma_{Ly} + \sigma_{by})^2 + 3(\tau_{Lxy} + \tau_{bxy})^2}$$

c) *Parts of fuel containment systems where loads are primarily carried by bending of girders, stiffeners and plates, shall satisfy the following limit state criteria:*

$\sigma_{ms} + \sigma_{bp} \leq 1,25\ F$ *(see Note 2, Note 3)*

$\sigma_{ms} + \sigma_{bp} + \sigma_{bs} \leq 1,25\ F$ *(see Note 2)*

$\sigma_{ms} + \sigma_{bp} + \sigma_{bs} + \sigma_{bt} + \sigma_g \leq 3{,}0\ F$

Note 2: 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 3: 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.

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*

$$f = \frac{R_e}{\gamma_{s1} \cdot \gamma_m \cdot \gamma_C}$$

$$F = \frac{R_e}{\gamma_{s2} \cdot \gamma_m \cdot \gamma_C}$$

The stresses σ_{ms}, σ_{bp}, σ_{bs} and σ_{bt} are defined in item d).

Note 4: The stress summation described above shall be carried out by summing up each stress component (σ_x, σ_y, τ_{xy}), and subsequently the equivalent stress shall be calculated based on the resulting stress components.

Skin plates shall 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.

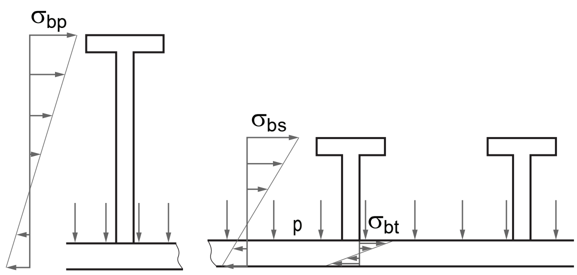
d) *Section stress category:*

Normal stress is the component of stress normal to the plane of reference.

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 item b).

Section bending stress is the component of the normal stress that is linearly distributed over a structural section exposed to bending action, as illustrated in Fig 1.

Figure 1 : Definition of the three categories of section stress (stresses σ_{bp} and σ_{bs} are normal to the cross-section shown)



4.1.9 *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.*

5 Fatigue limit states

5.1

5.1.1 *Fatigue design condition as described in Sec 2, [13.3] shall be complied with as applicable depending on the fuel containment system concept. Fatigue analysis is required for the fuel containment system designed under 6.4.16 and this Annex.*

5.1.2 *The load factors for FLS shall be taken as 1,0 for all load categories.*

5.1.3 *Consequence class factor γ_C and resistance factor γ_R shall be taken as 1,0.*

5.1.4 *Fatigue damage shall be calculated as described in Sec 2, [13.3.2] to Sec 2, [13.3.5]. The calculated cumulative fatigue damage ratio for the fuel containment systems shall be less than or equal to the values C_W given in Tab 3.*

Table 3 : Maximum allowable cumulative fatigue damage ratio

Consequence class		
Low	Medium	High **(1)**
C_W = 1,0	C_W = 0,5	C_W = 0,5
(1) Lower value shall be used in accordance with Sec 2, [13.3.7] to Sec 2, [13.3.9], depending on the detectability of defect or crack, etc.		

5.1.5 *Lower values may be fixed by the Society.*

5.1.6 *Crack propagation analyses are required in accordance with Sec 2, [13.3.6] to Sec 2, [13.3.9]. The analysis shall be carried out in accordance with methods laid down in a standard recognized by the Society.*

6 Accident limit states

6.1

6.1.1 *Accident design condition as described in Sec 2, [13.4] shall be complied with as applicable, depending on the fuel containment system concept.*

6.1.2 *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.*

6.1.3 *The load factors for ALS shall be taken as 1,0 for permanent loads, functional loads and environmental loads.*

6.1.4 *Loads mentioned in Sec 2, [10.11] and Sec 2, [10.11] need not be combined with each other or with environmental loads, as defined in 6.4.9.4.*

6.1.5 *Resistance factor* γ_R *shall in general be taken as 1,0.*

6.1.6 *Consequence class factors* γ_C *shall in general be taken as defined in [4.1.4], but may be relaxed considering the nature of the accident scenario.*

6.1.7 *The characteristic resistance* R_k *shall in general be taken as for the ultimate limit state, but may be relaxed considering the nature of the accident scenario.*

6.1.8 *Additional relevant accident scenarios shall be determined based on a risk analysis.*

7 Testing

7.1

7.1.1 *Fuel containment systems designed according to this Appendix shall be tested to the same extent as described in Ch 9, Sec 1, [2], as applicable depending on the fuel containment system concept.*

CHAPTER 4
MATERIALS

Section 1 Metallic Materials

Section 1 Metallic Materials

1 General

1.1

1.1.1 Materials for fuel containment and piping systems are to comply with the provisions of NR216.

1.1.2 *Materials for fuel containment and piping systems shall comply with the minimum regulations given in the following Tables:*

- *Tab 1: Plates, pipes (seamless and welded), sections and forgings for fuel tanks and process pressure vessels for design temperatures not lower than 0°C*
- *Tab 2: Plates, sections and forgings for fuel tanks, secondary barriers and process pressure vessels for design temperatures below 0°C and down to −55°C*
- *Tab 3: Plates, sections and forgings for fuel tanks, secondary barriers and process pressure vessels for design temperatures below −55°C and down to −165°C*
- *Tab 4: Pipes (seamless and welded), forgings and castings for fuel and process piping for design temperatures below 0°C and down to −165°C*
- *Tab 5: Plates and sections for hull structures required by Ch 3, Sec 2, [14.1.2].*

1.1.3 Refer also to IMO circular MSC.1/Circ.1599: Interim guidelines on the application of high manganese austenitic steel for cryogenic service.

The use of high manganese austenitic steel for cryogenic service may be permitted in accordance with IACS recommendation No.169.

1.1.4 *Materials having a melting point below 925°C shall not be used for piping outside the fuel tanks.*

1.1.5 *For CNG tanks, the use of materials not covered above may be specially considered by the Society.*

1.1.6 *Where required the outer pipe or duct containing high pressure gas in the inner pipe shall as a minimum fulfil the material regulations for pipe materials with design temperature down to −55°C in Tab 4.*

1.1.7 *The outer pipe or duct around liquefied gas fuel pipes shall as a minimum fulfil the material regulations for pipe materials with design temperature down to −165°C in Tab 4.*

Table 1 :

<table>
<tr><td colspan="5">PLATES, PIPES (SEAMLESS AND WELDED) (1) (2), SECTIONS AND FORGINGS FOR FUEL TANKS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES NOT LOWER THAN 0°C</td></tr>
<tr><td rowspan="5">CHEMICAL COMPOSITION AND HEAT TREATMENT</td><td colspan="4">Carbon-manganese steel</td></tr>
<tr><td colspan="4">Fully killed fine grain steel</td></tr>
<tr><td colspan="4">Small additions of alloying elements by agreement with the Society</td></tr>
<tr><td colspan="4">Composition limits to be approved by the Society</td></tr>
<tr><td colspan="4">Normalized, or quenched and tempered (4)</td></tr>
<tr><td rowspan="8">TENSILE AND TOUGHNESS (IMPACT) TEST REGULATIONS</td><td rowspan="2">Sampling frequency</td><td>Plates</td><td colspan="2">Each “piece” to be tested</td></tr>
<tr><td>Sections and forgings</td><td colspan="2">Each “batch” to be tested</td></tr>
<tr><td>Mechanical properties</td><td>Tensile properties</td><td colspan="2">Specified minimum yield stress not to exceed 410 N/mm² (5)</td></tr>
<tr><td rowspan="5">Toughness
(Charpy V-notch test)</td><td>Plates</td><td colspan="2">Transverse test pieces
Minimum average energy value (KV) 27 J</td></tr>
<tr><td>Sections and forgings</td><td colspan="2">Longitudinal test pieces
Minimum average energy value (KV) 41 J</td></tr>
<tr><td rowspan="3">Test temperature</td><td>Thickness t (mm)</td><td>Test temperature (°C)</td></tr>
<tr><td>t < 20</td><td>0</td></tr>
<tr><td>20 < t < 40 (3)</td><td>–20</td></tr>
</table>

(1) For seamless pipes and fittings normal practice applies. The use of longitudinally and spirally welded pipes shall be specially approved by the *Society*.
(2) Charpy V-notch impact tests are not required for pipes.
(3) This Table is generally applicable for material thicknesses up to 40 mm. Proposals for greater thicknesses shall be approved by the *Society*.
(4) A controlled rolling procedure or TMCP may be used as an alternative.
(5) Materials with specified minimum yield stress exceeding 410 N/mm² may be approved by the *Society*. For these materials, particular attention shall be given to the hardness of the welded and heat affected zones.

Table 2 :

<table>
<tr><td colspan="8">PLATES, SECTIONS AND FORGINGS (1) FOR FUEL TANKS, SECONDARY BARRIERS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES BELOW 0°C AND DOWN TO –55°C (Maximum thickness 25 mm (2))</td></tr>
<tr><td rowspan="10">CHEMICAL COMPOSITION AND HEAT TREATMENT</td><td colspan="7">Carbon-manganese steel</td></tr>
<tr><td colspan="7">Fully killed, aluminium treated fine grain steel</td></tr>
<tr><td colspan="7">Chemical composition (ladle analysis):</td></tr>
<tr><td rowspan="6"></td><td>C</td><td>Mn</td><td>Si</td><td>S</td><td>P</td><td></td></tr>
<tr><td>0,16% max (3)</td><td>0,70 - 1,60%</td><td>0,10 - 0,50%</td><td>0,025% max</td><td>0,025% max</td><td></td></tr>
<tr><td colspan="6">Optional additions: alloys and grain refining elements may be generally in accordance with the following:</td></tr>
<tr><td>Ni</td><td>Cr</td><td>Mo</td><td>Cu</td><td>Nb</td><td>V</td></tr>
<tr><td>0,80% max</td><td>0,25% max</td><td>0,08% max</td><td>0,35% max</td><td>0,05% max</td><td>0,10% max</td></tr>
<tr><td colspan="6">Al content total 0,020% min. (acid soluble 0,015% min.)</td></tr>
<tr><td colspan="7">Normalized, or quenched and tempered (4)</td></tr>
<tr><td rowspan="6">TENSILE AND TOUGHNESS (IMPACT) TEST REGULATIONS</td><td rowspan="2" colspan="2">Sampling frequency</td><td colspan="2">Plates</td><td colspan="3">Each “piece” to be tested</td></tr>
<tr><td colspan="2">Sections and forgings</td><td colspan="3">Each “batch” to be tested</td></tr>
<tr><td colspan="2">Mechanical properties</td><td colspan="2">Tensile properties</td><td colspan="3">Specified minimum yield stress not to exceed 410 N/mm² (5)</td></tr>
<tr><td rowspan="3" colspan="2">Toughness
(Charpy V-notch test)</td><td colspan="2">Plates</td><td colspan="3">Transverse test pieces
Minimum average energy value (KV) 27 J</td></tr>
<tr><td colspan="2">Sections and forgings</td><td colspan="3">Longitudinal test pieces
Minimum average energy value (KV) 41 J</td></tr>
<tr><td colspan="2">Test temperature</td><td colspan="3">5°C below the design temperature or –20°C, whichever is lower</td></tr>
</table>

(1) The Charpy V-notch and chemistry regulations for forgings may be specially considered by the *Society*.

(2) For material thickness t of more than 25 mm, Charpy V-notch tests shall be conducted as follows:
- for 25 mm < t ≤ 30 mm: Test temperature 10°C below design temperature or –20°C whichever is lower
- for 30 mm < t ≤ 35 mm: Test temperature 15°C below design temperature or –20°C whichever is lower
- for 35 mm < t ≤ 40 mm: Test temperature 20°C below design temperature
- for 40 mm < t: Temperature approved by the *Society*.

The impact energy value shall be in accordance with the Table for the applicable type of test specimen.

Materials for tanks and parts of tanks which are completely thermally stress relieved after welding may be tested at a temperature 5°C below design temperature or –20°C whichever is lower.

For thermally stress relieved reinforcements and other fittings, the test temperature shall be the same as that required for the adjacent tank-shell thickness.

(3) By special agreement with the *Society*, the carbon content may be increased to 0,18% maximum, provided the design temperature is not lower than –40°C.

(4) A controlled rolling procedure or TMCP may be used as an alternative.

(5) Materials with specified minimum yield stress exceeding 410 N/mm² may be approved by the *Society*. For these materials, particular attention shall be given to the hardness of the welded and heat affected zones.

Note 1: For materials exceeding 25 mm in thickness for which the test temperature is –60°C or lower, the application of specially treated steels or steels in accordance with Tab 3 may be necessary.

Table 3 :

<table>
<tr><td colspan="5">PLATES, SECTIONS AND FORGINGS (1) FOR FUEL TANKS, SECONDARY BARRIERS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES BELOW –55°C AND DOWN TO –165°C (2) (Maximum thickness 25 mm (3) (4))</td></tr>
<tr><td></td><td>Minimum design temp.</td><td colspan="2">Chemical composition (5) and heat treatment</td><td>Impact test temp.</td></tr>
<tr><td rowspan="9">CHEMICAL COMPOSITION AND HEAT TREATMENT</td><td>–60°C</td><td colspan="2">1,5% nickel steel. Normalized or normalized and tempered or quenched and tempered or TMCP (6)</td><td>–65°C</td></tr>
<tr><td>–65°C</td><td colspan="2">2,25% nickel steel. Normalized or normalized and tempered or quenched and tempered or TMCP (6) (7)</td><td>–70°C</td></tr>
<tr><td>–90°C</td><td colspan="2">3,5% nickel steel. Normalized or normalized and tempered or quenched and tempered or TMCP (6) (7)</td><td>–95°C</td></tr>
<tr><td>–105°C</td><td colspan="2">5,0% nickel steel. Normalized or normalized and tempered or quenched and tempered (6) (7) (8)</td><td>–110°C</td></tr>
<tr><td rowspan="5">–165°C</td><td colspan="2">9,0% nickel steel. Double normalized and tempered or quenched and tempered (6)</td><td>–196°C</td></tr>
<tr><td colspan="2">Austenitic steels, such as types 304, 304L, 316, 316L, 321 and 347. Solution treated (9)</td><td>–196°C</td></tr>
<tr><td colspan="2">High manganese austenitic steel hot rolling and controlled cooling) (10) (11)</td><td>–196°C</td></tr>
<tr><td colspan="2">Aluminium alloys; such as type 5083 annealed</td><td>not required</td></tr>
<tr><td colspan="2">Austenitic Fe-Ni alloy (36% nickel), heat treatment as agreed</td><td>not required</td></tr>
<tr><td rowspan="4">TENSILE AND TOUGHNESS (IMPACT) TEST REGULATIONS</td><td rowspan="2">Sampling frequency</td><td>Plates</td><td colspan="2">Each “piece” to be tested</td></tr>
<tr><td>Sections and forgings</td><td colspan="2">Each “batch” to be tested</td></tr>
<tr><td rowspan="2">Toughness
(Charpy V-notch test)</td><td>Plates</td><td colspan="2">Transverse test pieces
Minimum average energy value (KV) 27 J</td></tr>
<tr><td>Sections and forgings</td><td colspan="2">Longitudinal test pieces
Minimum average energy value (KV) 41 J</td></tr>
</table>

(1) The impact test required for forgings used in critical applications shall be subject to special consideration by the *Society*.
(2) The regulations for design temperatures below –165°C shall be specially agreed with the *Society*.
(3) For materials 1,5% Ni, 2,25% Ni, 3,5% Ni and 5,0% Ni, with thicknesses t greater than 25 mm, the impact tests shall be conducted as follows:
- for 25 mm < t ≤ 30 mm: Test temperature 10°C below design temperature
- for 30 mm < t ≤ 35 mm: Test temperature 15°C below design temperature
- for 35 mm < t ≤ 40 mm: Test temperature 20°C below design temperature.

The energy value shall be in accordance with the table for the applicable type of test specimen. For material thickness of more than 40 mm, the Charpy V-notch values shall be specially considered.
(4) For 9,0% Ni steels, austenitic stainless steels and aluminium alloys, thickness t greater than 25 mm may be used.
(5) The chemical composition limits shall be in accordance with recognized standards.
(6) TMCP nickel steels will be subject to acceptance by the *Society*.
(7) A lower minimum design temperature for quenched and tempered steels may be specially agreed with the *Society*.
(8) A specially heat treated 5,0% nickel steel, for example triple heat treated 5,0% nickel steel, may be used down to –165°C, provided that the impact tests are carried out at –196°C.
(9) The impact test may be omitted subject to agreement with the *Society*.
(10) The use of the material shall be subject to the required conditions specified by the Society based on the IMO Circular MSC.1/Circ.1599/Rev.3
(11) The impact test may not be omitted for high manganese austenitic steel.

Table 4 :

PIPES (SEAMLESS AND WELDED) **(1)**, FORGINGS **(2)** AND CASTINGS **(2)** FOR FUEL AND PROCESS PIPING FOR DESIGN TEMPERATURES BELOW 0°C AND DOWN TO –165°C **(3)** (Maximum thickness 25 mm)				
	Minimum design temp.	Chemical composition **(5)** and heat treatment	Impact test	
			Test temp.	Min. average energy
CHEMICAL COMPOSITION AND HEAT TREATMENT	–55°C	Carbon-manganese steel. Fully killed fine grain. Normalized or as agreed **(6)**	See **(4)**	27 KV
	–65°C	2,25% nickel steel. Normalized, normalized and tempered or quenched and tempered **(6)**	–70°C	34 KV
	–90°C	3,5% nickel steel. Normalized, normalized and tempered or quenched and tempered **(6)**	–95°C	34 KV
	–165°C	9,0% nickel steel **(7)**. Double normalized and tempered or quenched and tempered	–196°C	41 KV
		Austenitic steels, such as types 304, 304L, 316, 316L, 321 and 347. Solution treated **(8)**	–196°C	41 KV
		Aluminium alloys; such as type 5083 annealed		not required
TENSILE AND TOUGHNESS (IMPACT) TEST REGULATIONS	Sampling frequency		Each "batch" to be tested	
	Toughness (Charpy V-notch test)		Impact test: Longitudinal test pieces	

(1) The use of longitudinally or spirally welded pipes shall be specially approved by the *Society*.
(2) The regulations for forgings and castings may be subject to special consideration by the *Society*.
(3) The regulations for design temperatures below –165°C shall be specially agreed with the *Society*.
(4) The test temperature shall be 5°C below the design temperature or –20°C whichever is lower.
(5) The composition limits shall be in accordance with Recognized Standards.
(6) A lower design temperature may be specially agreed with the *Society* for quenched and tempered materials.
(7) This chemical composition is not suitable for castings.
(8) Impact tests may be omitted subject to agreement with the *Society*.

Table 5 :

PLATES AND SECTIONS FOR HULL STRUCTURES REQUIRED BY Ch 3, Sec 2, [14.1.2]								
Minimum design temperature of hull structure	Maximum thickness (mm) for steel grades							
	A	B	D	E	AH	DH	EH	FH
0°C and above	Recognized standards							
down to –5°C	15	25	30	50	25	45	50	50
down to –10°C	x	20	25	50	20	40	50	50
down to –20°C	x	x	20	50	x	30	50	50
down to –30°C	x	x	x	40	x	20	40	50
below –30°C	In accordance with Tab 2 except that the thickness limitation given in Tab 2 and in footnote **(2)** of that Table does not apply							
Note 1:'x' means steel grade not to be used.								

CHAPTER 5
MACHINERY AND PIPING

Section 1	General Pipe Design
Section 2	Fuel Supply to Consumers
Section 3	Power Generation Including Propulsion and Other Gas Consumers

Section 1 General Pipe Design

1 General

1.1 Functional requirements

1.1.1 *This section relates to functional requirements in Ch 1, Sec 3, [1.1.1], Ch 1, Sec 3, [1.1.2], Ch 1, Sec 3, [1.1.6], Ch 1, Sec 3, [1.1.8], Ch 1, Sec 3, [1.1.9] and Ch 1, Sec 3, [1.1.10]. In particular the following apply:*

- *Fuel piping shall be capable of absorbing thermal expansion or contraction caused by extreme temperatures of the fuel without developing substantial stresses.*
- *Provision shall be made to protect the piping, piping system and components and fuel tanks from excessive stresses due to thermal movement and from movements of the fuel tank and hull structure.*
- *If the fuel gas contains heavier constituents that may condense in the system, means for safely removing the liquid shall be fitted.*
- *Low temperature piping shall be thermally isolated from the adjacent hull structure, where necessary, to prevent the temperature of the hull from falling below the design temperature of the hull material.*
- Where filters are fitted, means are to be provided to indicate that they are becoming blocked and to isolate, depressurise and clean the filters safely.

1.2 Classes of LNG and gas piping systems

1.2.1 Purpose of the classes of piping systems

Piping systems are subdivided into three classes, denoted as class I, class II and class III, for the purpose of acceptance of materials, selection of joints, heat treatment, welding, pressure testing and the certification of fittings.

1.2.2 Determination of the classes of piping system

Piping classes I, II and III are to be determined in accordance with the provisions of Tab 1 for gas fuel piping system and in accordance with the provisions of Tab 2 for all vent pipes and open ended lines, including:

- discharge lines from thermal relief valves (see [2.2.5])
- discharge lines from tank pressure relief valves (see Ch 3, Sec 5, [2.1.9])
- venting lines from “bleed” valves (see Sec 2, [1.3.7])
- purging lines from engines and other gas consumers
- vent lines from tank connection spaces (see Ch 3, Sec 1, [2.1.8]).

Table 1 : Classes of liquid and gas fuel piping systems

Piping system		Design conditions		Class of the gas fuel piping		
		Design pressure	Design temperature	Single wall arrangement	Double wall arrangement	
					Inner pipe	Outer pipe **(1)**
Gaseous methane	low pressure lines	p = 10 bar **(2)**	any	Class I	Class II	Class II
	high pressure lines	p > 10 bar	any	Class I	Class I	Class II
Liquefied methane (LNG)		any	any	Class I	Class I	Class II

(1) The design pressure of the outer pipe or duct of fuel systems is to comply with Sec 2, [4.1.3]
(2) The design pressure is not to be taken less than 10 bar. See [3.2.2]

Table 2 : Classes of vent pipes and bleed lines

Design conditions		Class of the gas vent piping		
Vent pipe design pressure	Vent pipe design temperature	Single wall arrangement	Double wall arrangement	
			Inner pipe	Outer pipe **(1)**
p = 5 bar **(2)**	any	Class II	Class II	Class III
p > 5 bar **(3)**	any	Class I	Class II	Class III

(1) The design pressure of the outer pipe or duct of vent pipes or open ended lines is to comply with Sec 2, [4.1.3]
(2) The design pressure of vent pipes or open ended lines is not to be taken less than 5 bar. See [3.2.2]
(3) The design pressure of vent pipes or open ended lines is not to be less than the maximum expected pressure, which is to be justified

2 Arrangement and installation of piping systems

2.1 Location and protection of fuel piping

2.1.1 *Fuel pipes shall not be located less than 800 mm from the ship's side.*

2.1.2 [2.1.1] applies to any piping system that may contain liquid or gaseous fuel. It applies in particular to venting systems.
For double-walled pipes, the distance referred to in [2.1.1] is the distance between the inner pipe and the ship's side.

2.1.3 *Fuel piping shall not be led directly through accommodation spaces, service spaces, electrical equipment rooms or control stations as defined in the SOLAS Convention.*

2.1.4 The following additional requirements apply:

a) In accordance with Ch 6, Sec 1, [4.2] and Sec 2, [2]:
   - gas fuel piping may be led through other enclosed spaces outside machinery spaces provided it is protected by a secondary enclosure, arranged in accordance with Sec 2, [2.1.2]
   - liquefied fuel piping outside machinery spaces are to be protected by a secondary enclosure, arranged in accordance with Sec 2, [2.2.2].

   The secondary enclosure may however be omitted in the cases mentioned in Ch 6, Sec 1, Tab 1 and Sec 2, Tab 1.

b) Gas fuel piping may be routed through service spaces, electrical equipment rooms, control stations or through the area of the ship containing general accommodation spaces, provided it is arranged in accordance with one of the requirements below:
   - The piping is protected by a secondary enclosure complying with Sec 2, [2.1.2] and placed in a structural trunk or casing designed to "A-0" class standard.
   - The piping is located directly in a structural trunk or casing:
     - designed for a pressure not less than the maximum working pressure of the gas piping
     - insulated to "A-0" fire integrity standard in accordance with SOLAS II-2 reg. 9.2
     - ventilated in accordance with Note 1, and
     - provided with a gas detection arrangement in accordance with Ch 8, Sec 1, [7]

c) Liquid fuel piping may be routed through service spaces, electrical equipment rooms, control stations or through the area of the ship containing general accommodation spaces, provided the piping is protected by a secondary enclosure complying with Sec 2, [2.2] and placed in a structural trunk or casing designed to "A-0" class standard.

d) Fuel piping routing through individual accommodation spaces (such as cabins) is not permitted.

e) Gas fuel piping may be routed on open decks without protective enclosure against leakage.

f) Bunkering liquid piping located on open decks or in enclosed or semi-enclosed bunkering stations need not be fitted with a protective enclosure against leakage.

2.1.5 *Fuel pipes led through ro-ro spaces, special category spaces and on open decks shall be protected against mechanical damage.*

2.1.6 The provisions of [2.1.5] apply to gas and liquefied fuel pipes.
Gas and liquid fuel pipes may be led through ro-ro spaces and special category spaces provided they are arranged in accordance with [2.1.4], except that the fire integrity of the trunk or casing is to be according to the "A-60" standard.

2.1.7 *Gas fuel piping in ESD protected machinery spaces shall be located as far as practicable from the electrical installations and tanks containing flammable liquids.*

2.1.8 [2.1.7]applies only to the single wall gas fuel piping.

2.1.9 *Gas fuel piping in ESD protected machinery spaces shall be protected against mechanical damage.*

2.1.10 [2.1.9] applies only to the single wall gas fuel piping.

2.2 Piping systems general requirements

2.2.1 Liquid and gas fuel pressure vessels including surge tanks, heat exchangers and accumulators are to be considered as class 1 pressure vessels, in accordance with NR467, Pt C, Ch 1, Sec 3, [1.4].

2.2.2 *Fuel pipes and all the other piping needed for a safe and reliable operation and maintenance shall be colour marked in accordance with a standard at least equivalent to those acceptable to the Organization.* [13]

Note 1: *Refer to EN ISO 14726:2008 Ships and marine technology – Identification colours for the content of piping systems.*

2.2.3 *Where tanks or piping are separated from the ship's structure by thermal* insulation*, provision shall be made for electrically bonding to the ship's structure both the piping and the tanks. All gasketed pipe joints and hose connections shall be electrically bonded.*

2.2.4 Except where bonding straps are used, it is to be demonstrated that the electrical resistance of each joint or connection is less than 1MΩ.

Bonding straps are required for gas fuel tanks, fuel piping systems and equipment which are not permanently connected to the hull of the ship, for example:

- independent gas fuel tanks
- gas fuel tank piping systems which are electrically separated from the hull of the ship
- pipe connections arranged for the removal of the spool pieces.

Where bonding straps are required, they are to be:

- clearly visible so that any shortcoming can be clearly detected
- designed and sited so that they are protected against mechanical damage and are not affected by high resistivity contamination, e.g. corrosive products or paint
- easy to install and replace.

2.2.5 *All pipelines or components which may be isolated in a liquid full condition shall be provided with relief valves.*

2.2.6 These relief valves are to comply with Ch 3, Sec 5, [2.1.12].

2.2.7 *Pipework, which may contain low temperature fuel, shall be thermally insulated to an extent which will minimize condensation of moisture.*

2.2.8 *Piping other than fuel supply piping and cabling may be arranged in the double wall piping or duct provided that they do not create a source of ignition or compromise the integrity of the double pipe or duct. The double wall piping or duct shall only contain piping or cabling necessary for operational purposes.*

2.2.9 Piping may be arranged in the double wall piping or duct only when it is pressurized with inert gas in accordance with Sec 2, [3.1.1], a).

Cabling may be arranged in a ventilated double wall piping or duct arranged in accordance with Sec 2, [3.1.1], b) only if it is intended for the monitoring of the gas piping parameters or of the double wall piping or duct parameters. The electrical equipment located in the double wall piping or duct is to be of the intrinsically safe type.

2.3 Flexibility of piping

2.3.1 *The arrangement and installation of fuel piping shall provide the necessary flexibility to maintain the integrity of the piping system in the actual service situations, taking potential for fatigue into account.*

3 Wall thickness

3.1 Calculation of the wall thickness

3.1.1 *The minimum wall thickness, in mm, shall be calculated as follows:*

$$t = \frac{t_0 + b + c}{1 - \frac{|a|}{100}}$$

where:

t_0 : *Theoretical thickness, in mm:*

$$t_0 = \frac{P D}{2{,}0 K e + P}$$

with:

P : *Design pressure, in MPa, referred to in [3.2]*

D : *Outside diameter, in mm*

K : *Allowable stress, in N/mm², referred to in [3.3]*

e : *Efficiency factor equal to 1,0 for seamless pipes and for longitudinally or spirally welded pipes, delivered by approved manufacturers of welded pipes, that are considered equivalent to seamless pipes when non-destructive testing on welds is carried out in accordance with recognized standards. In other cases an efficiency factor of less than 1,0, in accordance with recognized standards, may be required depending on the manufacturing process*

b : *Allowance for bending, in mm. The value of b shall be chosen so that the calculated stress in the bend, due to internal pressure only, does not exceed the allowable stress. Where such justification is not given, b shall be:*

$$b = \frac{Dt_0}{2{,}5\ R}$$

with:

r : *Mean radius of the bend, in mm*

c : *Corrosion allowance, in mm. If corrosion or erosion is expected the wall thickness of the piping shall be increased over that required by other design regulations. This allowance shall be consistent with the expected life of the piping*

a : *Negative manufacturing tolerance for thickness (%), i.e. where a is the manufacturing tolerance of −5%, |a| is equal to 5 and shall be entered into the formula as 1− (5/100).*

3.1.2 *The absolute minimum wall thickness shall be in accordance with a standard acceptable to the Society.*

3.1.3 The minimum wall thickness of heat exchanger and vaporizer tubes containing gas fuel are to comply with the provisions of this article.

3.2 Design condition

3.2.1 *The greater of the following design conditions shall be used for piping, piping system and components as appropriate [14] [15]:*

a) *for systems or components which may be separated from their relief valves and which contain only vapour at all times, vapour pressure at 45°C assuming an initial condition of saturated vapour in the system at the system operating pressure and temperature, or*

b) *the MARVS of the fuel tanks and fuel processing systems, or*

c) *the pressure setting of the associated pump or compressor discharge relief valve, or*

d) *the maximum total discharge or loading head of the fuel piping system, or*

e) *the relief valve setting on a pipeline system.*

Note 1: Lower values of ambient temperature regarding design condition in [3.2.1], a) may be accepted by the Society for ships operating in restricted areas. Conversely, higher values of ambient temperature may be required.

Note 2: For ships on voyages of restricted duration, P_0 may be calculated based on the actual pressure rise during the voyage and account may be taken of any thermal insulation of the tank. Reference is made to the Application of amendments to gas carrier codes concerning type C tank loading limits (SIGTTO/IACS).

3.2.2 *Piping, piping systems and components shall have a minimum design pressure of 1,0 MPa except for open ended lines where it is not to be less than 0,5 MPa.*

3.2.3 The design temperature of the very high pressure gas supply piping systems and of related venting pipes is to take into account the cooling effect associated with the pressure drop in way of restrictions (Joule-Thomson cooling effect).

3.3 Allowable stress

3.3.1 *For pipes made of steel including stainless steel, the allowable stress to be considered in the formula of the strength thickness in [3.1.1] shall be the lower of the following values:*

$R_m / 2{,}7$ or $R_e / 1{,}8$

where:

R_m : *Specified minimum tensile strength at room temperature, in N/mm²*

R_e : *Specified minimum yield stress at room temperature, in N/mm². If the stress strain curve does not show a defined yield stress, the 0,2% proof stress applies.*

3.3.2 *Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipes due to superimposed loads, the wall thickness shall be increased over that required by [3] or, if this is impracticable or would cause excessive local stresses, these loads shall be reduced, protected against or eliminated by other design methods. Such superimposed loads may be due to; supports, ship deflections, liquid pressure surge during transfer operations, the weight of suspended valves, reaction to loading arm connections, or otherwise.*

3.3.3 *For pipes made of materials other than steel, the allowable stress shall be considered by the Society.*

3.3.4 *High pressure fuel piping systems shall have sufficient constructive strength. This shall be confirmed by carrying out stress analysis and taking into account:*

a) *stresses due to the weight of the piping system*

b) *acceleration loads when significant, and*

c) *internal pressure and loads induced by hog and sag of the ship.*

3.3.5 *When the design temperature is minus 110°C or colder, a complete stress analysis, taking into account all the stresses due to weight of pipes, including acceleration loads if significant, internal pressure, thermal contraction and loads induced by hog and sag of the ship shall be carried out for each branch of the piping system.*

4 Piping fabrication and joining details

4.1 General requirements

4.1.1 *Flanges, valves and other fittings shall comply with a standard acceptable to the Society, taking into account the design pressure defined in [3.2.1]. For bellows and expansion joints used in vapour service, a lower minimum design pressure than defined in [3.2.1] may be accepted.*

4.1.2 *All valves and expansion joints used in high pressure fuel piping systems shall be approved according to a standard acceptable to the Society.*

4.1.3 Each size and type of valve intended to be used at a working temperature below –55°C is to be approved through design assessment and prototype testing. See Ch 9, Sec 1, [7.1].

4.1.4 *The piping system shall be joined by welding with a minimum of flange connections. Gaskets shall be protected against blow-out.*

4.1.5 Spectacle flanges are not allowed in gas fuel piping systems.

4.1.6 *Piping fabrication and joining details shall comply with the following:*

a) *Direct connections*

   1) *Butt-welded joints with complete penetration at the root may be used in all applications. For design temperatures colder than minus 10°C, butt welds shall be either double welded or equivalent to a double welded butt joint. This may be accomplished by use of a backing ring, consumable insert or inert gas back-up on the first pass. For design pressures in excess of 1,0 MPa and design temperatures of minus 10°C or colder, backing rings shall be removed.*

   2) *Slip-on welded joints with sleeves and related welding, having dimensions in accordance with recognized standards, shall only be used for instrument lines and open-ended lines with an external diameter of 50 mm or less and design temperatures not colder than minus 55°C.*

   3) *Screwed couplings complying with recognized standards shall only be used for accessory lines and instrumentation lines with external diameters of 25 mm or less.*

b) *Flanged connections*

   1) *Flanges in flange connections shall be of the welded neck, slip-on or socket welded type, and*

   2) *For all piping except open ended, the following restrictions apply:*

      - *For design temperatures colder than –55°C, only welded neck flanges shall be used, and*
      - *For design temperatures colder than –10°C, slip-on flanges shall not be used in nominal sizes above 100 mm and socket welded flanges shall not be used in nominal sizes above 50 mm.*

c) *Expansion joints*

   Where bellows and expansion joints are provided in accordance with [4.1.1], the following applies:

   1) *if necessary, bellows shall be protected against icing*

   2) *slip joints shall not be used except within the liquefied gas fuel storage tanks, and*

   3) *bellows shall normally not be arranged in enclosed spaces.*

d) *Other connections*

   Piping connections shall be joined in accordance with the requirements of item a) to item c) but for other exceptional cases the Society may consider alternative arrangements.

Section 2 Fuel Supply to Consumers

1 General design requirements

1.1 Functional requirements

1.1.1 *This Section relates to functional requirements in Ch 1, Sec 3, [1.1.1], Ch 1, Sec 3, [1.1.6], Ch 1, Sec 3, [1.1.8], Ch 1, Sec 3, [1.1.11] and Ch 1, Sec 3, [1.1.13]] to Ch 1, Sec 3, [1.1.17]. In particular the following apply:*

a) *The fuel supply system shall be so arranged that the consequences of any release of fuel will be minimized, while providing safe access for operation and inspection.*

b) *The piping system for fuel transfer to the consumers shall be designed in a way that a failure of one barrier cannot lead to a leak from the piping system into the surrounding area causing danger to the persons on board, the environment or the ship, and*

c) To comply with the provisions of item b), [3.1.1] and Sec 1, [4.1.4], two independent safety barriers should be in place, while, as far as practicable, using a minimum of flange connections. There should be no single common flange or other component where one single failure itself may overcome both primary and secondary barriers and may result in a gas leak into the surrounding area causing danger to the persons on board, the environment or the ship.

   A single common flange (ensuring ventilation flow with two sealing systems) may be accepted at the fuel connection to the gas consumers including internal combustion engines, GCUs, boilers and components on the engine, such as gas regulating valve units provided that the technical justification is submitted to the *Society* or its recognized organization demonstrating:

   1) the impracticability of the installation of a double flange connection (two independent flanges, one on the gas pipe and one on the secondary enclosure), and

   2) compliance of single common flange with the safety criterion in item a) (i.e. no leak from the piping system into the surrounding area in case of failure of one sealing system), including at least the consideration of the rupture or loosening of bolts, depending on arrangement of components which should not result in flange failure when piping is exposed to a sudden movement (e.g. hog and sag of the ship or excessive vibration).

d) *The fuel lines outside the machinery spaces shall be installed and protected so as to minimize the risk of injury to personnel and damage to the ship in case of leakage.*

1.2 Redundancy of fuel supply

1.2.1 *For single fuel installations the fuel supply system shall be arranged with redundancy and segregation, so that a leakage in one system, or failure of one of the fuel supply essential auxiliaries, does not lead to an unacceptable loss of power.*

In the event of a leakage or failure, having regard to overall safety considerations, a partial reduction in propulsion capability from normal operation may be accepted by the Society

1.2.2 *For single fuel installations, the fuel storage shall be divided between two or more tanks. The tanks shall be located in separate compartments.*

1.2.3 *For type C tank only, one tank may be accepted if two completely separate tank connection spaces are installed for the one tank.*

1.3 Safety functions of gas supply system

1.3.1 Requirements [1.3.9] [1.3.10] [1.3.11] and [1.3.14] also apply to all gas fuel consumers

1.3.2 *Fuel storage tank inlets and outlets shall be provided with valves located as close to the tank as possible. Valves required to be operated during normal operation [16] which are not accessible shall be remotely operated. Tank valves whether accessible or not shall be automatically operated when the safety system required in Ch 8, Sec 1, [1] is activated.*

Note 1: Normal operation in this context is when gas is supplied to consumers and during bunkering operations.

1.3.3 The provisions of [1.3.2] apply to all liquid and vapour connections except for safety relief valves and liquid level gauging devices.

1.3.4 *The main gas supply line to each gas consumer or set of consumers shall be equipped with a manually operated stop valve and an automatically operated "master gas fuel valve" coupled in series or a combined manually and automatically operated valve. The valves shall be situated in the part of the piping that is outside the machinery space containing gas consumers, and placed as near as possible to the installation for heating the gas, if fitted. The master gas fuel valve shall automatically cut off the gas supply when activated by the safety system required in Ch 8, Sec 1, [1].*

1.3.5 The manually operated stop valves (or combined manually and automatically operated valves) are to be readily accessible. Such valves may be located inside TCS only for low pressure gas supply systems in the following cases:

- when the access to the TCS is through a door provided with an airlock,
- when the valves can be manually closed from outside the TCS

The master gas fuel valve is to be located downstream of the installation for heating the gas.

1.3.6 *The automatic master gas fuel valve shall be operable from safe locations on escape routes inside a machinery space containing a gas consumer, the engine control room, if applicable; outside the machinery space, and from the navigation bridge.*

1.3.7 *Each gas consumer shall be provided with "double block and bleed" valves arrangement. These valves shall be arranged as outlined in a) or b) so that when the safety system required in Ch 8, Sec 1, [1] is activated this will cause the shut off valves that are in series to close automatically and the bleed valve to open automatically and:*

a) *the two shut-off valves shall be in series in the gas fuel pipe to the gas consuming equipment. The bleed valve shall be in a pipe that vents to a safe location in the open air that portion of the gas fuel piping that is between the two valves in series, or*

b) *the function of one of the shut off valves in series and the bleed valve can be incorporated into one valve body, so arranged that the flow to the* gas consumers *will be blocked and the ventilation opened.*

1.3.8 *The two valves shall be of the fail-to-close type, while the ventilation valve shall be fail-to-open.*

1.3.9 *The double block and bleed valves shall also be used for normal stop of the engine.*

1.3.10 *In cases where the master gas fuel valve is automatically shut down when the safety system as required in Ch 8, Sec 1, [1.1.1], item b) is activated, the complete gas supply pipe between this master gas fuel valve and the double block and bleed valves and between the double block and bleed valves and the consumer shall be automatically vented.*

1.3.11 *There shall be one manually operated shutdown valve in the gas supply line to each gas consumer upstream of the double block and bleed valves to assure safe isolation during maintenance on the gas consumer.*

1.3.12

- The manually operated shutdown valve is to be readily accessible.
- Where located inside the TCS or GVU enclosure arranged with bolted access hatch, the valve is to be arranged for manual closing from outside the TCS or GVU enclosure.
- Where located inside the TCS, the manual valve required by [1.3.11] may be arranged for local operation only, provided the access to the TCS is through a door provided with an airlock.
- Requirement [1.3.11] applies to engines and to other gas consumers.

1.3.13 *For single-engine installations and multi-engine installations, where a separate master valve is provided for each engine, the master gas fuel valve and the double block and bleed valve functions can be combined.*

1.3.14 *For each main gas supply line entering an ESD protected machinery space, and each gas supply line to high pressure installations means shall be provided for rapid detection of a rupture in the gas line in the engine-room. When rupture is detected a valve shall be automatically shut off.* [17] *This valve shall be located in the gas supply line before it enters the engine-room or as close as possible to the point of entry inside the engine-room. It can be a separate valve or combined with other functions, e.g. the master valve.*

Note 1: The shutdown should be time delayed to prevent shutdown due to transient load variations.

1.4 Additional requirements

1.4.1 The following requirements a) to c) apply in addition to [2] and [3]:

a) All gas and liquid fuel pipes are to be arranged with a secondary enclosure, except where permitted by Tab 1.

b) The outlets of the relief valve discharge lines and vent lines are to be arranged in accordance with the provisions of [6.1].

c) Liquid fuel piping systems are to be provided with a thermal insulation system as required to minimize heat leak during transfer operations and to protect personnel from direct contact with cold surfaces.

Note 1: The thermal insulation may be omitted in the following cases:

- surfaces of fuel piping systems which are protected by physical screening measures to prevent direct contact with personnel;
- surfaces of manual valves, having extended spindles that protect the operator from the fuel temperature;
- surfaces of fuel piping systems whose design temperature (to be determined from inner fluid temperature) is above minus 10°C.

Table 1 : Summary table for the secondary enclosure of gas and liquid fuel piping

Nature of the piping		Locations where single wall arrangement is permitted	Observations
Vent pipes and discharge lines from safety valves and pressure relief valves		• in mechanically ventilated spaces (see [2.1.3]) including gas-safe machinery spaces • in ESD-protected machinery spaces • on open decks • in other locations where single wall arrangement is accepted for low pressure gas fuel pipes	Pipes are to be fully welded
Gas fuel pipes	Low pressure	• in gas fuel piping systems with negative pressure (supply of pre-mixed engines) • in GVU spaces / enclosures • in tank connection spaces • in fuel preparation rooms • on open decks	Pipes are to be fully welded (full penetration butt-welded joints) and welded joints are to be inspected according to the requirements of Ch 9, Sec 1, [6.3]
	High pressure	• in GVU spaces / enclosures • in fuel preparation rooms • on open decks **(1)**	
Liquid fuel pipes		• in tank connection space downstream of the first valve (see Ch 3, Sec 1, [2.1.13]) and upstream of the first valve for connections to type C tanks located above the highest liquid level • in other spaces designed in accordance with Ch 2, Sec 5 to safely contain liquid fuel leakages (such as fuel preparation room)	Pipes are to be fully welded (full penetration butt-welded joints) and welded joints are to be inspected according to the requirements of Ch 9, Sec 1, [6.3]
(1) Subject to risk assessment			

2 Fuel distribution outside of machinery space

2.1 Gaseous fuel pipes

2.1.1 *Where gaseous fuel pipes pass through enclosed spaces in the ship, they shall be protected by a secondary enclosure. This enclosure can be a ventilated duct or a double wall piping system. The duct or double wall piping system shall be mechanically under pressure ventilated with 30 air changes per hour, and gas detection as required in Ch 8, Sec 1, [7] shall be provided. Other solutions providing an equivalent safety level may also be accepted by the Society.*

2.1.2 The secondary enclosure can also be a pipe or duct pressurised with inert gas in accordance with [3.1.1], a).

2.1.3 *The requirement in [2.1.1] need not be applied for fully welded fuel gas vent pipes led through mechanically ventilated spaces.*

2.2 Liquefied fuel pipes

2.2.1 *Liquefied fuel pipes shall be protected by a secondary enclosure able to contain leakages. If the piping system is in a fuel preparation room or a tank connection space, the Society may waive this requirement. Where gas detection as required in Ch 8, Sec 1, [7.1.1], b) is not fit for purpose, the secondary enclosures around liquefied fuel pipes shall be provided with leakage detection by means of pressure or temperature monitoring systems, or any combination thereof. The secondary enclosure shall be able to withstand the maximum pressure that may build up in the enclosure in case of leakage from the fuel piping. For this purpose, the secondary enclosure may need to be arranged with a pressure relief system that prevents the enclosure from being subjected to pressures above their design pressures.*

2.2.2

a) The secondary enclosure may consist of a pipe or duct:

- pressurised with inert gas in accordance with [3.1.1], a), or
- ventilated in accordance with [3.1.1] , b) with dried air, or
- kept under vacuum and provided with means to detect a loss of vacuum.

b) The pressure relief system is to comply with Ch 3, Sec 5, [2.1.12]

c) The enclosure is to be made of a material complying with Ch 4, Sec 1, [1.1.7].

3 Fuel supply to consumers

3.1 In gas-safe machinery spaces

3.1.1 *Gas fuel piping in gas-safe machinery spaces shall be completely enclosed by a double pipe or duct fulfilling one of the following conditions:*

a) *The gas fuel piping shall be a double wall piping system with the gas fuel contained in the inner pipe. The space between the concentric pipes shall be pressurized with inert gas at a pressure greater than the gas fuel pressure. Suitable alarms shall be provided to indicate a loss of inert gas pressure between the pipes, or*

b) *The gas fuel piping shall be installed within a ventilated pipe or duct. The air space between the gas fuel piping and the wall of the outer pipe or duct shall be equipped with mechanical under pressure ventilation having a capacity of at least 30 air changes per hour. This ventilation capacity may be reduced to 10 air changes per hour provided automatic filling of the duct with nitrogen upon detection of gas is arranged for. The fan motors shall comply with the required explosion protection in the installation area. The ventilation outlet shall be covered by a protection screen and placed in a position where no flammable gas-air mixture may be ignited, or*

Note 1: The ventilation outlet from the duct is to be located on the open deck. The inlet to the duct is to comply with the provisions of Ch 7, Sec 3, [7.1.5].

c) *Other solutions providing an equivalent safety level may also be accepted by the Society.*

3.1.2 *The connecting of gas piping and ducting to the gas injection valves shall be completely covered by the ducting. The arrangement shall facilitate replacement and/or overhaul of injection valves and cylinder covers. The double ducting is also required for all gas pipes on the engine itself, until gas is injected into the chamber.* [18]

Note 1: If gas is supplied into the air inlet directly on each individual cylinder during air intake to the cylinder on a low pressure engine, such that a single failure will not lead to release of fuel gas into the machinery space, double ducting may be omitted on the air inlet pipe.

3.2 In ESD-protected machinery spaces

3.2.1 *The pressure in the gas fuel supply system shall not exceed 1,0 MPa.*

3.2.2 *The gas fuel supply lines shall have a design pressure not less than 1,0 MPa.*

4 Regulations for the design of ventilated duct and outer pipe against inner pipe gas leakage

4.1 General requirements

4.1.1 The provisions of [4] apply only to gas fuel piping. For liquid fuel piping, refer to [2.2.1] and [2.2.2].

4.1.2 The design temperature of the outer pipe or duct of very high pressure gas fuel systems is to take into account the low gas temperatures associated with the cooling effect that may occur in case of rupture of the inner pipe (Joule-Thomson cooling effect).

4.1.3 *The design pressure of the outer pipe or duct of fuel systems shall not be less than the maximum working pressure of the inner pipe. Alternatively, the design pressure of the outer pipe or duct may be calculated in accordance with [4.1.4].*

4.1.4 *Alternatively to [4.1.3], the design pressure of the outer pipe or duct shall be taken as the higher of the following:*

a) *the maximum built-up pressure: static pressure in way of the rupture resulting from the gas flowing in the annular space*

b) *local instantaneous peak pressure in way of the rupture: this pressure shall be taken as the critical pressure given by the following expression:*

$$p = p_0\left(\frac{2}{k+1}\right)^{\frac{k}{k-1}}$$

where:

p_0 : *Maximum working pressure of the inner pipe*

$k = C_p / C_v$ *constant pressure specific heat divided by the constant volume specific heat*

$k = 1,31$ *for* CH_4.

The tangential membrane stress of a straight pipe shall not exceed the tensile strength divided by 1,5 (R_m / 1,5) when subjected to the above pressures. The pressure ratings of all other piping components shall reflect the same level of strength as straight pipes.

As an alternative to using the peak pressure from the above formula, the peak pressure found from representative tests can be used. Test reports shall then be submitted.

4.1.5 *Verification of the strength shall be based on calculations demonstrating the duct or pipe integrity. As an alternative to calculations, the strength can be verified by representative tests.*

4.1.6 *The duct shall be pressure tested to show that it can withstand the expected maximum pressure at fuel pipe rupture.*

4.1.7 In case of gas fuel piping arranged in accordance with [3.1.1], b), the testing pressure of the outer pipe or duct is not to be less than its design pressure. This also applies to GVU enclosures.

5 Compressors, pumps and pressure built-up heat exchangers

5.1 Compressors and pumps

5.1.1 *If compressors or pumps are driven by shafting passing through a bulkhead or deck, the bulkhead penetration shall be of gastight type.*

5.1.2 *Compressors and pumps shall be suitable for their intended purpose. All equipment and machinery shall be such as to be adequately tested to ensure suitability for use within a marine environment. Such items to be considered would include, but not be limited to:*

- *environmental*
- *shipboard vibrations and accelerations*
- *effects of pitch, heave and roll motions, etc., and*
- *gas composition.*

5.1.3

a) The Shipbuilder is to identify and document the ship accelerations and motions periods to which the compressors and pumps might be subjected to. The expected accelerations and ship motions periods are to be within the equipment manufacturer's requirements. The estimations are to consider vessel type, equipment location and expected service conditions.

b) The compressors and pumps manufacturers are to submit evidence to the Society that such equipment can operate under:
   - the required static and dynamic inclinations as stated in NR467, Pt C, Ch 1, Sec 1, [2.4.1] and
   - at least at the levels of shipboard accelerations and motion periods as stated in item a) above.

5.1.4 *Arrangements shall be made to ensure that under no circumstances liquefied gas can be introduced in the gas control section or gas-fuelled machinery, unless the machinery is designed to operate with gas in liquid state.*

5.1.5 *Compressors and pumps shall be fitted with accessories and instrumentation necessary for efficient and reliable function.*

5.1.6 Gas control section means the part of the gas supply system located downstream of the liquefied gas vaporizing equipment.

5.2 Pressure built-up heat exchangers

5.2.1 Where type C tanks are pressurized by means of pressure built-up heat exchangers, the following requirements apply.

Single tanks provided in accordance with [1.2.3] are to be fitted with at least two independent heat exchangers. Other tanks may be fitted with only one heat exchanger.

The aggregate capacity of the heat exchangers is to be sufficient to maintain a sufficient pressure in the tank to supply all the consumers at their nominal power for all operating coheat exchangers nditions, in particular in transient conditions (e.g. during engine load increase following bunkering operations). Relevant justifications are to be submitted.

For single fuel (gas only) ships, the procedure for bringing the machinery into operation from the dead ship condition is to be submitted. See SOLAS Convention, Regulations II-1 / 3.8 and 26.4.

The aggregate capacity of the heat exchangers is to be sufficient to maintain a sufficient pressure in the tank to supply all the consumers at their nominal power for all operating coheat exchangers nditions, in particular in transient conditions (e.g. during engine load increase following bunkering operations). Relevant justifications are to be submitted.

6 Arrangement of relief valve discharge and vent outlets

6.1 General design requirements

6.1.1 The outlets of the relief valve discharge lines and vent lines are to be arranged in accordance with the provisions of Tab 2.

All outlets from:

- pressure relief valves from CNG tanks,
- pressure relief valves from the fuel preparation equipment,
- thermal relief valves.

are to comply with requirements Ch 3, Sec 5, [2.1.9] and Ch 3, Sec 5, [2.1.11].

All vents and bleed lines that may contain or be contaminated by gas fuel are to be routed to a safe location external to the machinery space and be fitted with a flame screen.

6.1.2 Pressure relief discharge lines and vent lines are not to be connected to a common venting system unless arrangements are made to prevent unintended backflow.

6.1.3 Discharge lines from pressure relief valves are to be so arranged as to avoid excessive loads on the valve body.

Table 2 : Arrangement of relief valve discharge line outlets and vent line outlets

Description of the vent line or discharge line		Location permitted for the outlet
Discharge line from LNG tank relief valves		Vent mast **(1) (2)**
Discharge line from LNG type C tank vacuum space		• Vent mast **(1)** • Direct release into the atmosphere **(3) (5)**
Discharge from CNG tank relief valves		Vent mast **(4)**
Discharge from pressure relief systems fitted to fuel storage hold spaces and tank cofferdams		Safe location in the open air **(5)**
Discharge from pressure relief systems fitted to interbarrier spaces		Vent mast **(1)**
Discharge from pressure relief systems fitted to tank connection spaces **(6)**		Safe location in the open air **(5)**
Discharge line from relief valves from the fuel piping and equipment	Low pressure and high pressure gas fuel	• Discharge back within the fuel gas handling system where possible • Vent mast **(1)**
	Very high pressure gas fuel **(11)**	• Discharge back within the fuel gas handling system where possible • Very high pressure vent mast **(13)** • To a buffer tank, from which it will be supplied to gas consumers
	Low pressure and high pressure liquid fuel	• Tank • Vent mast
	Very high pressure liquid fuel	• Discharge back within the fuel gas handling system where possible • Tank **(12)** • Very high pressure vent mast **(13)**
Venting lines from "bleed" valves in low pressure systems **(7)**		Safe location in the open air **(5)**
Venting lines from "bleed" valves in very high pressure systems **(11)**		• Very high pressure vent mast **(13)** • To a buffer tank, from which it will be supplied to gas consumers
Venting lines from gas fuel pipe enclosure (double walled pipe or duct) **(10)**		Safe location in the open air **(5)**
Venting lines from liquid fuel pipe enclosure (double walled pipe or duct)		Vent mast

(1) See Ch 3, Sec 5, [2.1.9] and Ch 3, Sec 5, [2.1.11]. The discharge line outlet is to be fitted with a protection screen complying with Ch 3, Sec 5, [2.1.15]
(2) Also applies to portable tanks. See Ch 3, Sec 3, [1.1.9].
(3) only for tanks on open with a size < 40 m^3. See Ch 3, Sec 5, [2.1.2]
(4) see Ch 3, Sec 4, [1.1.2], Ch 3, Sec 5, [2.1.9] and Ch 3, Sec 5, [2.1.11]
(5) where no flammable gas-air mixture may be ignited. See **5.2.1.2.**
(6) see Ch 3, Sec 1, [2.1.9]
(7) see [1.3.7]
(8) see Ch 6, Sec 1, [2.1.5]
(9) the discharge line outlet is to be fitted with a protection screen complying with Ch 3, Sec 5, [2.1.15]
(10) See [3.1.1], b)
(11) In case of very high pressure gas supply, means are to be taken to manage the large gas influx without release to atmosphere.
(12) Risk of pressurisation of the tank is to be considered.
(13) See Ch 3, Sec 5, [2.1.9]

Section 3 Power Generation Including Propulsion and Other Gas Consumers

1 Functional requirements

1.1 General

1.1.1 *This section is related to functional requirements in Ch 1, Sec 3, [1.1.1], Ch 1, Sec 3, [1.1.11], Ch 1, Sec 3, [1.1.13], Ch 1, Sec 3, [1.1.16] and Ch 1, Sec 3, [1.1.17]. In particular the following apply:*

a) *the exhaust systems shall be configured to prevent any accumulation of unburnt gaseous fuel*
b) *unless designed with the strength to withstand the worst case over pressure due to ignited gas leaks, engine components or systems containing or likely to contain an ignitable gas and air mixture shall be fitted with suitable pressure relief systems. Dependent on the particular engine design this may include the air inlet manifolds and scavenge spaces*
c) *the explosion venting shall be led away from where personnel may normally be present, and*
d) *all gas consumers shall have a separate exhaust system.*

2 Regulations for internal combustion engines of piston type

2.1 General

2.1.1 *The exhaust system shall be equipped with explosion relief systems unless designed to accommodate the worst case overpressure due to ignited gas leaks or justified by the safety concept of the engine. A detailed evaluation of the potential for unburnt gas in the exhaust system is to be undertaken covering the complete system from the cylinders up to the open end. This detailed evaluation shall be reflected in the safety concept of the engine.*

2.1.2 *The air inlet system is to be equipped with explosion relief devices unless designed to accommodate the worst-case overpressure due to ignited gas leaks or justified by the safety concept of the engine.*

2.1.3 *Explosion relief devices for air inlet and exhaust systems are to comply with the requirements mentioned in NR467, Pt C, Ch 1, Sec 2, NR467, Pt C, Ch 1, App 2 and NR467, Pt C, Ch 1, App 8.*

2.1.4 *For engines where the space below the piston is in direct communication with the crankcase a detailed evaluation regarding the hazard potential of fuel gas accumulation in the crankcase shall be carried out and reflected in the safety concept of the engine.*

2.1.5 *Each engine other than two-stroke crosshead diesel engines shall be fitted with vent systems independent of other engines for crankcases and sumps.*

2.1.6 Vent pipes from engine crankcases and sumps are to be led to a safe location on the open deck.

2.1.7 *Where gas can leak directly into the auxiliary system medium (lubricating oil, cooling water), an appropriate means shall be fitted after the engine outlet to extract gas in order to prevent gas dispersion. The gas extracted from auxiliary systems media shall be vented to a safe location in the atmosphere.*

2.1.8 *For engines fitted with ignition systems, prior to admission of gas fuel, correct operation of the ignition system on each unit shall be verified.*

2.1.9 *A means shall be provided to monitor and detect poor combustion or misfiring. In the event that it is detected, gas operation may be allowed provided that the gas supply to the concerned cylinder is shut-off and provided that the operation of the engine with one cylinder cut-off is acceptable with respects to torsional vibrations.*

2.1.10 *For engines starting on fuels covered by this Rule Note, if combustion has not been detected by the engine monitoring system within an engine specific time after the opening of the fuel supply valve, the fuel supply valve shall be automatically shut off. Means to ensure that any unburnt fuel mixture is purged away from the exhaust system shall be provided.*

2.1.11 Gas engine and dual fuel engines are to comply with the provisions of NR467, Pt C, Ch 1, App 2.

2.2 Regulations for dual fuel engines

2.2.1 *In case of shut-off of the gas fuel supply, the engines shall be capable of continuous operation by oil fuel only without interruption.*

2.2.2 *An automatic system shall be fitted to change over from gas fuel operation to oil fuel operation and vice versa with minimum fluctuation of the engine power. Acceptable reliability shall be demonstrated through testing. In the case of unstable operation on engines when gas firing, the engine shall automatically change to oil fuel mode. Manual activation of gas system shutdown shall always be possible.*

2.2.3 *In case of a normal stop or an emergency shutdown, the gas fuel supply shall be shut off not later than the ignition source. It shall not be possible to shut off the ignition source without first or simultaneously closing the gas supply to each cylinder or to the complete engine.*

2.3 Regulations for gas-only engines

2.3.1 *In case of a normal stop or an emergency shutdown, the gas fuel supply shall be shut off not later than the ignition source. It shall not be possible to shut off the ignition source without first or simultaneously closing the gas supply to each cylinder or to the complete engine.*

2.4 Regulations for multi-fuel engines

2.4.1 *In case of shut-off of one fuel supply, the engines shall be capable of continuous operation by an alternative fuel with minimum fluctuation of the engine power.*

2.4.2 *An automatic system shall be fitted to change over from one fuel operation to an alternative fuel operation with minimum fluctuation of the engine power. Acceptable reliability shall be demonstrated through testing. In the case of unstable operation on an engine when using a particular fuel, the engine shall automatically change to an alternative fuel mode. Manual activation shall always be possible.*

3 Regulations for main and auxiliary boilers

3.1 General

3.1.1 *Each boiler shall have a dedicated forced draught system. A crossover between boiler force draught systems may be fitted for emergency use providing that any relevant safety functions are maintained.*

3.1.2 *Combustion chambers and uptakes of boilers shall be designed to prevent any accumulation of gaseous fuel.*

3.1.3 *Burners shall be designed to maintain stable combustion under all firing conditions.*

3.1.4 *On main/propulsion boilers an automatic system shall be provided to change from gas fuel operation to oil fuel operation without interruption of boiler firing.*

3.1.5 *Gas nozzles and the burner control system shall be configured such that gas fuel can only be ignited by an established oil fuel flame, unless the boiler and combustion equipment is designed and approved by the Society to light on gas fuel.*

3.1.6 *There shall be arrangements to ensure that gas fuel flow to the burner is automatically cut off unless satisfactory ignition has been established and maintained.*

3.1.7 *On the fuel pipe of each gas burner a manually operated shut-off valve shall be fitted.*

3.1.8 *Provisions shall be made for automatically purging the gas supply piping to the burners, by means of an inert gas, after the extinguishing of these burners.*

3.1.9 *The automatic fuel changeover system required by [3.1.4] shall be monitored with alarms to ensure continuous availability.*

3.1.10 *Arrangements shall be made that, in case of flame failure of all operating burners, the combustion chambers of the boilers are automatically purged before relighting.*

3.1.11 *Arrangements shall be made to enable the boilers purging sequence to be manually activated.*

4 Regulations for gas turbines

4.1 General

4.1.1 *Unless designed with the strength to withstand the worst case over pressure due to ignited gas leaks, pressure relief systems shall be suitably designed and fitted to the exhaust system, taking into consideration of explosions due to gas leaks. Pressure relief systems within the exhaust uptakes shall be led to a safe location, away from personnel.*

4.1.2 *The gas turbine may be fitted in a gas-tight enclosure arranged in accordance with the ESD principle outlined in Ch 2, Sec 4 and Sec 2, [5], however a pressure above 1,0 MPa in the gas supply piping may be accepted within this enclosure.*

4.1.3 *Gas detection systems and shut down functions shall be as outlined for ESD protected machinery spaces.*

4.1.4 *Ventilation for the enclosure shall be as outlined in Ch 7, Sec 3 for ESD protected machinery spaces, but shall in addition be arranged with full redundancy (2x100% capacity fans from different electrical circuits).*

4.1.5 *For other than single fuel gas turbines, an automatic system shall be fitted to change over easily and quickly from fuel gas operation to fuel oil operation and vice-versa with minimum fluctuation of the engine power.*

4.1.6 *Means shall be provided to monitor and detect poor combustion that may lead to unburnt fuel gas in the exhaust system during operation. In the event that it is detected, the fuel gas supply shall be shut down.*

4.1.7 *Each turbine shall be fitted with an automatic shutdown device for high exhaust temperatures.*

5 Regulations for fuel cells

5.1 General

5.1.1 Fuel cell systems using natural gas are to comply with the relevant requirements given in NR547.

CHAPTER 6
BUNKERING

Section 1 General

Section 1 General

1 Functional requirements

1.1 General

1.1.1 *This chapter relates to functional requirements in Ch 1, Sec 3, [1.1.1] to Ch 1, Sec 3, [1.1.11] and Ch 1, Sec 3, [1.1.13] to Ch 1, Sec 3, [1.1.17].*

In particular, the piping system for transfer of fuel to the storage tank shall be designed such that any leakage from the piping system cannot cause danger to personnel, the environment or the ship.

2 Bunkering station

2.1 General

2.1.1 *The bunkering station shall be located on open deck so that sufficient natural ventilation is provided. Closed or semi-enclosed bunkering stations shall be subject to special consideration within the risk assessment.*

2.1.2 The special consideration should as a minimum include but not be restricted to the following design features:

- segregation towards other areas on the ship
- hazardous area plans for the ship
- requirements for forced ventilation
- requirements for leakage detection (e.g. gas detection and low temperature detection)
- safety actions related to leakage detection (e.g. gas detection and low temperature detection)
- access to bunkering station from non-hazardous areas through air locks; and
- monitoring of bunkering station by direct line of sight or by CCTV.

2.1.3 *Connections and piping shall be so positioned and arranged that any damage to the fuel piping does not cause damage to the ship's fuel containment system resulting in an uncontrolled gas discharge.*

2.1.4 *Arrangements shall be made for safe management of any spilled fuel.*

2.1.5 *Suitable means shall be provided to relieve the pressure and remove liquid contents from pump suctions and bunker lines. Liquid is to be discharged to the liquefied gas fuel tanks or other suitable location.*

2.1.6 *The surrounding hull or deck structures shall not be exposed to unacceptable cooling, in case of leakage of fuel.*

2.1.7 A drip tray complying with the provisions of Ch 2, Sec 6, [2] is to be fitted in way of the bunkering manifold. The drip tray is to be fitted with a temperature sensor located in a small well to detect a possible leakage and activate the safety system.

Permanent or temporary arrangements for draining liquid fuel from the drip tray in case of leakage during the bunkering operations are permitted provided that the draining pipe is led over the ship's side at the sea level and subject to the risk assessment.

2.1.8 *For CNG bunkering stations, low temperature steel shielding shall be considered to determine if the escape of cold jets impinging on surrounding hull structure is possible.*

2.1.9 A water distribution system is to be fitted in way of the hull under the bunkering area to provide a low-pressure water curtain for additional protection of the hull steel and the ship's side structure. Removable equipment connected to suitable fresh or sea water piping system by means of a flexible hose is acceptable. This system is to be operated during bunkering operations.

2.2 Ship’s fuel hoses

2.2.1 *Liquid and vapour hoses used for fuel transfer shall be compatible with the fuel and suitable for the fuel temperature.*

2.2.2 *Hoses subject to tank pressure, or the discharge pressure of pumps or vapour compressors, shall be designed for a bursting pressure not less than five times the maximum pressure the hose can be subjected to during bunkering.*

3 Regulations for manifold

3.1

3.1.1 *The bunkering manifold shall be designed to withstand the external loads during bunkering. The connections at the bunkering station shall be arranged in order to achieve a dry-disconnect operation in one of the followings ways:*

a) a dry-disconnect / connect coupling in accordance with a standard at least equivalent to those acceptable to the Society, or

b) a manual connect coupler or hydraulic connect coupler, used to connect the bunker system to the receiving vessel bunkering manifold presentation flange, or

c) a bolted flange to flange assembly.

3.1.2 *When intended to use either of the connections specified in [3.1.1], item b) and c), these shall be combined with operating procedures that ensure a dry-disconnect is achieved. The arrangement shall be subject to special consideration informed by a bunkering arrangement risk assessment conducted at the design stage and considering dynamic loads at the bunkering manifold connection to a recognized standard acceptable to the Society, the safe operation of the ship and other hazards that may be relevant to the ship during bunkering operation. The fuel handling manual required by IGF Code Part C-1, 18.2.3 shall include documentation that the bunkering arrangement risk assessment was conducted, and that special consideration was granted under this requirement.*

3.1.3 *An emergency release coupler (ERC) / Emergency Release System (ERS) or equivalent means shall be provided, unless installed on the bunkering supply side of the bunkering line, and the said means shall be in accordance with a standard equivalent to those acceptable to the Society; it shall enable a quick physical disconnection "dry break-away" of the bunker system in an emergency event.*

3.1.4 Dry disconnect method by procedural practice in accordance with ISO standard 20519:2017 may be accepted subject to approval by the Administration of the State whose flag the ship is entitled to fly.

3.1.5 Any reducer, spoolpiece or other removable device intended to be fitted to the bunkering flange for bunkering purposes is to be considered as part of the bunkering piping system of the gas-fuelled ship and accordingly certified by the Society.

3.1.6 Additional requirements for manifolds

The dry break-away coupling / self-sealing quick release may be permanently attached to the bunkering manifold of the ship or part of the fuel transfer system supplied by the bunkering facility.

Where the dry break-away coupling/self-sealing quick release coupling is not fitted directly to the bunkering connection, the pressure relief device required in [2.1.5] is to be so designed that, in the event of break-away of the coupling, the pressure built-up in the part of the fuel transfer system located between the bunkering connection and the coupling does not exceed its design pressure. Relevant justifications are to be provided.

4 Bunkering system

4.1

4.1.1 *An arrangement for purging fuel bunkering lines with inert gas shall be provided.*

4.1.2 Fuel purged from bunkering lines is to discharge to the fuel storage tank, to the bunkering facility or to other suitable location (GCU).

4.1.3 *The bunkering system shall be so arranged that no gas is discharged to the atmosphere during filling of storage tanks.*

4.1.4 *A manually operated stop valve and a remote operated shutdown valve in series, or a combined manually operated and remote valve shall be fitted in every bunkering line close to the connecting point. It shall be possible to operate the remote valve in the control location for bunkering operations and/or from another safe location.*

4.1.5 *Means shall be provided for draining any fuel from the bunkering pipes upon completion of operation.*

4.1.6 Fuel drained from bunkering lines is to discharge to the fuel storage tank or to the bunkering facility.

4.1.7 *Bunkering lines shall be arranged for inerting and gas freeing. When not engaged in bunkering, the bunkering pipes shall be free of gas, unless the consequences of not gas freeing are evaluated and approved.*

4.1.8 The provisions of [4.1.7] apply to the part of the bunkering lines used only for bunkering.

When connected to a portable tank, the inerting or gas-freeing is to be ensured up to the first valve that can be actuated for isolation purpose on each side of the connection.

4.1.9 *In case bunkering lines are arranged with a cross-over it shall be ensured by suitable isolation arrangements that no fuel is transferred inadvertently to the ship side not in use for bunkering.*

4.1.10 *A ship-shore link (SSL) or an equivalent means for automatic and manual ESD communication to the bunkering source shall be fitted.*

4.1.11 *If not demonstrated to be required at a higher value due to pressure surge considerations a default time as calculated in accordance with Ch 9, Sec 1, [7.3.9] from the trigger of the alarm to full closure of the remote operated valve required by [4.1.4] shall be adjusted.*

4.2 Protection of bunkering lines

4.2.1

a) Bunkering lines are to be protected by a secondary enclosure complying with Ch 5, Sec 2, [2.1.2] for gaseous fuel pipes or Ch 5, Sec 2, [2.2.2] for liquid fuel pipes, except where single wall arrangement is permitted by Tab 1.

b) Liquid bunkering lines are to be provided with a thermal insulation system as required to minimize heat leak during bunkering operations and to protect personnel from direct contact with cold surfaces.

Note 1: The thermal insulation may be omitted in the following cases:

- surfaces of fuel piping systems which are protected by physical screening measures to prevent direct contact with personnel;
- surfaces of manual valves, having extended spindles that protect the operator from the fuel temperature.

c) The outlets of the relief valve discharge lines from bunkering lines are to be arranged in accordance with the provisions of Ch 5, Sec 2, Tab 2 and are to comply with the general principles given in Ch 5, Sec 2, [6.1]. The outlets of the relief pressure means from LNG bunker lines are to comply with requirements of Ch 3, Sec 5, [2.1.9] and Ch 3, Sec 5, [2.1.11].

Table 1 : Summary table for the secondary enclosure of bunkering lines

Nature of the piping	Locations where single wall arrangement is permitted	Observations
Vent pipes and discharge lines from safety valves and pressure relief valves	• on open decks • in other locations where single wall arrangement is accepted for low pressure gas fuel pipes	Pipes are to be fully welded
Bunkering lines (liquid or gas)	• on open decks **(1)** • enclosed or semi-enclosed bunkering stations • In tank connection spaces • In fuel preparation rooms	Pipes are to be fully welded (full penetration butt-welded joints) and welded joints are to be inspected according to the requirements of Ch 9, Sec 1, [6.3.1]
(1) Subject to risk assessment		

CHAPTER 7
FIRE SAFETY AND ELECTRICITY

Section 1	Fire Safety
Section 2	Explosion Prevention
Section 3	Ventilation
Section 4	Electrical Installation

Section 1 Fire Safety

1 Functional requirements

1.1 General

1.1.1 *This Section relates to functional requirements in Ch 1, Sec 3, [1.1.2], Ch 1, Sec 3, [1.1.4], Ch 1, Sec 3, [1.1.5], Ch 1, Sec 3, [1.1.7], Ch 1, Sec 3, [1.1.12], Ch 1, Sec 3, [1.1.14], Ch 1, Sec 3, [1.1.15] and Ch 1, Sec 3, [1.1.17].*

2 Structural fire protection

2.1 General

2.1.1 *Fuel preparation rooms shall, for the purpose of the application of SOLAS regulation II-2/9, be regarded as a machinery space of category A.*

2.1.2 Notwithstanding [2.1.1], any enclosed spaces containing equipment for fuel preparation such as pumps or compressors or other potential ignition sources are to comply with [7].

2.1.3 *Any boundary of accommodation spaces, service spaces, control stations, escape routes and machinery spaces, facing fuel tanks on open deck, shall be shielded by A-60 class divisions. The A-60 class divisions shall extend up to the underside of the deck of the navigation bridge. In addition, fuel tanks shall be segregated from cargo in accordance with the requirements of the International Maritime Dangerous Goods (IMDG) Code where the fuel tanks are regarded as bulk packaging. For the purposes of the stowage and segregation requirements of the IMDG Code, a fuel tank on the open deck shall be considered a class 2.1 package.*

2.1.4 When the fuel containment system is located on open deck directly above a space with high fire risk, the separation is to be done by a cofferdam of at least 900 mm with insulation of A-60 class. For type C tanks, the cofferdam may be omitted, subject to special consideration by the Society.

2.1.5 *The space containing the fuel containment system shall be separated from the machinery spaces of category A or other rooms with high fire risks. The separation shall be done by a cofferdam of at least 900 mm with insulation of A-60 class. When determining the insulation of the space containing the fuel containment system from other spaces with lower fire risks, the fuel containment system shall be considered as a machinery space of category A, in accordance with SOLAS regulation II-2/9. For type C tanks, the fuel storage hold space may be considered as a cofferdam.*

Note 1: Rooms with high fire risk are defined in Ch 1, Sec 1, [5.1.45].

2.1.6 *Notwithstanding the last sentence in [2.1.5], the fuel storage hold space may be considered as a cofferdam provided that:*

- *the type C tank is not located directly above machinery spaces of category A or other rooms with high fire risk; and*
- *the minimum distance to the A-60 boundary from the outer shell of the type C tank or the boundary of the tank connection space, if any, is not less than 900 mm.*

2.1.7 Fuel preparation rooms located above or adjacent to a machinery space of category A or other rooms with high fire risk are to be separated from these spaces by A-60 class divisions.

2.1.8 *The fuel storage hold space shall not be used for machinery or equipment that may have a fire risk.*

2.1.9 *The fire protection of fuel pipes led through ro-ro spaces shall be subject to special consideration by the Society depending on the use and expected pressure in the pipes*

2.1.10 *The bunkering station shall be separated by A-60 class divisions towards machinery spaces of category A, accommodation, control stations and high fire risk spaces, except for spaces such as tanks, voids, auxiliary machinery spaces of little or no fire risk, sanitary and similar spaces where the insulation standard may be reduced to class A-0.*

2.1.11 *If an ESD protected machinery space is separated by a single boundary, the boundary shall be of A-60 class division.*

2.1.12 The provisions of [2.1.11] apply to the separation between ESD protected machinery spaces and other ESD protected machinery spaces, machinery spaces of category A, accommodation spaces, control stations and high fire risk spaces, except for spaces such as tanks, voids, auxiliary machinery spaces of little or no fire risk, sanitary and similar spaces where the insulation standard may be reduced to class A-0.

3 Water supply systems

3.1 Fire main and hydrants

3.1.1 *The water spray system required below may be part of the fire main system provided that the required fire pump capacity and working pressure are sufficient for the operation of both the required numbers of hydrants and hoses and the water spray system simultaneously.*

3.1.2 *When the fuel storage tank(s) is located on the open deck, isolating valves shall be fitted in the fire main in order to isolate damaged sections of the fire main. Isolation of a section of fire main shall not deprive the fire line ahead of the isolated section from the supply of water.*

4 Fixed fire-extinguishing systems

4.1 Fixed pressure water spraying fire-extinguishing system

4.1.1 *A water spray system shall be installed for cooling and fire prevention to cover exposed parts of fuel storage tank(s) located on open deck.*

4.1.2 For tankers, special attention is to be paid to the interaction between fixed foam fire extinguishing system and water spray system.

4.1.3 *The water spray system shall also provide coverage for boundaries of the superstructures, compressor rooms, pump-rooms, cargo control rooms, bunkering control stations, bunkering stations and any other normally occupied deck houses that face the storage tank on open decks unless the tank is located 10 metres or more from the boundaries.*

Water spray systems are to cover also bunkering connections and fuel preparation equipment located on open deck unless the tank on open deck is located 10 meters or more from them.

Note 1: Normally occupied deckhouse means deckhouse containing essential equipment or normally manned or accessible to passengers.

4.1.4 *The system shall be designed to cover all areas as specified above with an application rate of 10 l/min/m² for the largest horizontal projected surfaces and 4 l/min/m² for vertical surfaces.*

4.1.5 *Stop valves shall be fitted in the water spray application main supply line(s), at intervals not exceeding 40 metres, for the purpose of isolating damaged sections. Alternatively, the system may be divided into two or more sections that may be operated independently, provided the necessary controls are located together in a readily accessible position not likely to be inaccessible in case of fire in the areas protected.*

4.1.6 *The capacity of the water spray pump shall be sufficient to deliver the required amount of water to the hydraulically most demanding area as specified above in the areas protected.*

4.1.7 *If the water spray system is not part of the fire main system, a connection to the ship's fire main through a stop valve shall be provided.*

4.1.8 *Remote start of pumps supplying the water spray system and remote operation of any normally closed valves to the system shall be located in a readily accessible position which is not likely to be inaccessible in case of fire in the areas protected.*

4.1.9 *The nozzles shall be of an approved full bore type and they shall be arranged to ensure an effective distribution of water throughout the space being protected.*

5 Dry chemical powder fire-extinguishing system

5.1 General

5.1.1 *A permanently installed dry chemical powder fire-extinguishing system shall be installed in the bunkering station area to cover all possible leak points. The capacity shall be at least 3,5 kg/s for a minimum of 45 s. The system shall be arranged for easy manual release from a safe location outside the protected area.*

5.1.2 For tankers, special attention is to be paid to the possible interaction between fixed foam and powder fire extinguishing systems.

5.1.3 Fixed powder fire extinguishing systems including powder are to be type-approved based on IMO Circular MSC.1/ Circ.1315.

Dry chemical powder is to be based on potassium bicarbonate.

5.1.4 *In addition to any other portable fire extinguishers that may be required elsewhere in IMO instruments, one portable dry powder extinguisher of at least 5 kg capacity shall be located near the bunkering station and in the fuel preparation room.*

6 Fire detection and alarm system

6.1 General

6.1.1 *A fixed fire detection and fire alarm system complying with the Fire Safety Systems Code shall be provided for the fuel storage hold spaces and the ventilation trunk to the tank connection space and in the tank connection space, and for all other rooms of the fuel gas system where fire cannot be excluded.*

6.1.2 Fire detection is required in:

- fuel preparation rooms
- enclosed and semi enclosed bunkering stations

A section of fire detectors which covers a control station a service space or an accommodation space is not to include a space related to fuel storage or fuel preparation.

6.1.3 *Smoke detectors alone shall not be considered sufficient for rapid detection of a fire.*

6.1.4 Fusible plugs, in addition to smoke detectors, are considered as acceptable means for rapid detection of a fire.

7 Fuel preparation room fire-extinguishing systems

7.1 General

7.1.1 *Fuel preparation rooms containing pumps, compressors or other potential ignition sources shall be provided with a fixed fire-extinguishing system complying with the provisions of SOLAS regulation II-2/10.4.1.1 and taking into account the necessary concentrations/application rate required for extinguishing gas fires.*

Section 2 Explosion Prevention

1 Functional Requirements

1.1 General

1.1.1 *This Section relates to functional requirements in Ch 1, Sec 3, [1.1.2] to Ch 1, Sec 3, [1.1.5], Ch 1, Sec 3, [1.1.7], Ch 1, Sec 3, [1.1.8], Ch 1, Sec 3, [1.1.12] to Ch 1, Sec 3, [1.1.14] and Ch 1, Sec 3, [1.1.17].*

In particular, the probability of explosions shall be reduced to a minimum by:

a) *reducing number of sources of ignition, and*

b) *reducing the probability of formation of ignitable mixtures.*

2 Location

2.1 General

2.1.1 *Hazardous areas on open deck and other spaces not addressed in this Section shall be decided based on a recognized standard. The electrical equipment fitted within hazardous areas shall be according to the same standard.*

Note 1: Refer to IEC standard 60092-502, part 4.4: Tankers carrying flammable liquefied gases as applicable.

2.1.2 *Electrical equipment and wiring shall in general not be installed in hazardous areas unless essential for operational purposes based on a recognized standard.*

Note 1: Refer to IEC standard 60092-502: IEC 60092-502:1999 Electrical Installations in Ships – Tankers – Special Features and IEC 60079-10-1:2008 Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres, according to the area classification.

2.1.3 *Electrical equipment fitted in an ESD-protected machinery space shall fulfil the following:*

- *In addition to fire and gas hydrocarbon detectors and fire and gas alarms, lighting and ventilation fans shall be certified safe for hazardous area zone 1, and*
- *All electrical equipment in a machinery space containing gas-fuelled engines, and not certified for zone 1 shall be automatically disconnected, if gas concentration above 40% LEL is detected by two detectors in the space containing gas-fuelled consumers.*

2.1.4 Arrangements are to be made for automatic shutdown of the engines in case of gas detection.

3 Hazardous area classification

3.1 General

3.1.1 The provisions of the present Rule Note prevail over those of IEC 60092-502:1999.

3.1.2 The following functional requirements are to be applied to gas admission valves at dual fuel engines and gas engines:

- The risk assessment, in accordance with the relevant standards on area classification as set out in [3], is to be understood as a procedure equivalently applicable to the examples for hazardous area zones as laid out in [4] for the categorization of gas admission valves at dual fuel engines and gas engines.
- The provisions of [3] are to be interpreted as the guiding methodology for the categorization of gas admission valves at dual fuel engines and gas engines. If no additional safety measures and no corresponding risk assessment in accordance with [3] are available, the examples in [4] are to apply.

3.1.3 *Area classification is a method of analysing and classifying the areas where explosive gas atmospheres may occur. The object of the classification is to allow the selection of electrical apparatus able to be operated safely in these areas.*

3.1.4 *In order to facilitate the selection of appropriate electrical apparatus and the design of suitable electrical installations, hazardous areas are divided into zones 0, 1 and 2. See also [4].*

Note 1: Refer to standards IEC 60079-10-1:2008 Explosive atmospheres part 10-1: Classification of areas – Explosive gas atmospheres and guidance and informative examples given in IEC 60092-502:1999, Electrical Installations in Ships – Tankers – Special Features for tankers.

3.1.5 *Ventilation ducts shall have the same area classification as the ventilated space.*

4 Hazardous area zones

4.1 Hazardous area zone 0

4.1.1 *This zone includes, but is not limited to the interiors of fuel tanks, any pipework for pressure-relief or other venting systems for fuel tanks, pipes and equipment containing fuel and interbarrier spaces as defined by the second bullet point of Ch 1, Sec 1, [5.1.17].*

4.2 Hazardous area zone 1

4.2.1 *This zone includes, but is not limited to:*

a) *tank connection spaces and fuel storage hold spaces*

   For the purposes of hazardous area classification, fuel storage hold spaces containing portable type C tanks are to be considered as follows:

   1) 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, are to be considered non-hazardous

   2) Where the fuel storage hold spaces include potential leakage sources, e.g. tank connections, they are to be considered hazardous area zone 1.

   3) Where the fuel storage hold spaces include bolted access to the tank connection space, they are to be considered hazardous area zone 2.

Note 1: Fuel storage hold spaces for type C tanks are normally not considered as zone 1.

b) *fuel preparation room arranged with ventilation according to Sec 3, [5]*

c) *areas on open deck, or semi-enclosed spaces on deck, within 3 m of any fuel tank outlet, gas or vapour outlet, bunker manifold valve, other fuel valve, fuel pipe flange, fuel preparation room ventilation outlets and fuel tank openings for pressure release provided to permit the flow of small volumes of gas or vapour mixtures caused by thermal variation*

Note 2: Such areas are, 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.

d) *areas on open deck or semi-enclosed spaces on deck, within 1,5 m of fuel preparation room entrances, fuel preparation room ventilation inlets and other openings into zone 1 spaces*

e) *areas on the open deck within spillage coamings surrounding gas bunker manifold valves and 3 m beyond these, up to a height of 2,4 m above the deck*

f) *enclosed or semi-enclosed spaces in which pipes containing fuel are located, e.g. ducts around fuel pipes, semi-enclosed bunkering stations*

g) Ducts around pipes are to be considered as hazardous areas zone 1, whatever their arrangement (ventilated duct, duct pressurized with inert gas, vacuum-insulated pipes)

h) GVU spaces and GVU enclosures are to be considered as hazardous areas zone 1.

i) *the ESD-protected machinery space is considered a non-hazardous area during normal operation, but will require equipment required to operate following detection of gas leakage to be certified as suitable for zone 1*

j) *a space protected by an airlock is considered as non-hazardous area during normal operation, but will require equipment required to operate following loss of differential pressure between the protected space and the hazardous area to be certified as suitable for zone 1*

Note 3: An enclosed space with access to any zone 1 location may be considered non-hazardous if:

- The access is fitted with two doors forming an air-lock, both self-closing and without holding back arrangements, capable of maintaining the over-pressure in each of the spaces, and
- the space and the airlock are ventilated by over-pressure in accordance with IEC 60092-502, paragraph 8.4 and Table 5.

k) *except for type C tanks, an area within 2,4 m of the outer surface of a fuel containment system where such surface is exposed to the weather.*

l) *Instrumentation and electrical apparatus installed within these areas should be of a type suitable for zone 1.*

4.3 Hazardous area zone 2

4.3.1 *This zone includes, but is not limited to areas within 1,5 m surrounding open or semi-enclosed spaces of zone 1*

4.3.2 *Space containing bolted hatch to tank connection space.*

4.3.3 *Instrumentation and electrical apparatus installed within these areas should be of a type suitable for zone 2*

Section 3 Ventilation

1 Functional requirements

1.1 General

1.1.1 *This Section relates to functional requirements in Ch 1, Sec 3, [1.1.2], Ch 1, Sec 3, [1.1.5], Ch 1, Sec 3, [1.1.8], Ch 1, Sec 3, [1.1.10] Ch 1, Sec 3, [1.1.12] to Ch 1, Sec 3, [1.1.14] and Ch 1, Sec 3, [1.1.17].*

2 General

2.1 Hazardous spaces

2.1.1 *Any ducting used for the ventilation of hazardous spaces shall be separate from that used for the ventilation of non-hazardous spaces. The ventilation shall function at all temperatures and environmental conditions the ship will be operating in.*

2.1.2 *Electric motors for ventilation fans shall not be located in ventilation ducts for hazardous spaces unless the motor is certified for the same hazard zone as the space served.*

2.1.3 *Design of ventilation fans serving spaces containing gas sources shall fulfil the following:*

- *Ventilation fans shall not produce a source of vapour ignition in either the ventilated space or the ventilation system associated with the space. Ventilation fans and fan ducts, in way of fans only, shall be of non-sparking construction defined as:*
  - *impellers or housings of non-metallic material, due regard being paid to the elimination of static electricity*
  - *impellers and housings of non-ferrous metals*
  - *impellers and housing of austenitic stainless steel*
  - *impellers of aluminium alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous materials is fitted in way of the impeller, due regard being paid to static electricity and corrosion between ring and housing, or*
  - *any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm tip design clearance.*
- *In no case shall the radial air gap between the impeller and the casing be less than 0,1 of the diameter of the impeller shaft in way of the bearing but not less than 2 mm. The gap need not be more than 13 mm.*
- *Any combination of an aluminium or magnesium alloy fixed or rotating component and a ferrous fixed or rotating component, regardless of tip clearance, is considered a sparking hazard and shall not be used in these places.*

2.1.4 Complete fans are to be of a type approved by the Society and follow national or international standards accepted by the Society.

2.1.5 *Ventilation systems required to avoid any gas accumulation shall consist of independent fans, each of sufficient capacity, unless otherwise specified in this Rule Note.*

2.1.6 *Air inlets for hazardous enclosed spaces shall be taken from areas that, in the absence of the considered inlet, would be non-hazardous. Air inlets for non-hazardous enclosed spaces shall be taken from non-hazardous areas at least 1,5 m away from the boundaries of any hazardous area. Where the inlet duct passes through a more hazardous space, the duct shall be gas-tight and have over-pressure relative to this space.*

2.1.7 *Air outlets from non-hazardous spaces shall be located outside hazardous areas.*

2.1.8 *Air outlets from hazardous enclosed spaces shall be located in an open area that, in the absence of the considered outlet, would be of the same or lesser hazard than the ventilated space.*

2.1.9 *The required capacity of the ventilation plant is normally based on the total volume of the room. An increase in required ventilation capacity may be necessary for rooms having a complicated form.*

2.1.10 *Non-hazardous spaces with entry openings to a hazardous area shall be arranged with an air-lock and be maintained at overpressure relative to the external hazardous area. The overpressure ventilation shall be arranged according to the following:*

- *During initial start-up or after loss of overpressure ventilation, before energizing any electrical installations not certified safe for the space in the absence of pressurization, it shall be required to:*
  - *proceed with purging (at least 5 air changes) or confirm by measurements that the space is non-hazardous, and*
  - *pressurize the space.*

- *Operation of the overpressure ventilation shall be monitored and in the event of failure of the overpressure ventilation:*
  - *an audible and visual alarm shall be given at a manned location, and*
  - *if overpressure cannot be immediately restored, automatic or programmed, disconnection of electrical installations according to a recognized standard shall be required.*

Note 1: Refer to IEC 60092-502:1999 Electrical Installations in Ships – Tankers – Special Features, table 5.

2.1.11 *Non-hazardous spaces with entry openings to a hazardous enclosed space shall be arranged with an airlock and the hazardous space shall be maintained at under pressure relative to the non-hazardous space. Operation of the extraction ventilation in the hazardous space shall be monitored and in the event of failure of the extraction ventilation:*

- *an audible and visual alarm shall be given at a manned location, and*
- *if under pressure cannot be immediately restored, automatic or programmed, disconnection of electrical installations according to a recognized standard in the non-hazardous space shall be required.*

  Immediate restoration of the under pressure is deemed satisfied if the extraction ventilation is served by redundant fans arranged with automatic change-over to the standby fan in case of loss of under pressure.

  Alternative solutions where an acceptable relative pressure between the concerned spaces can be maintained may be considered on a case-by-case basis.

3 Ventilation of tank connection space

3.1 General

3.1.1 *The tank connection space shall be provided with an effective mechanical forced ventilation system of extraction type. A ventilation capacity of at least 30 air changes per hour shall be provided. The rate of air changes may be reduced if other adequate means of explosion protection are installed. The equivalence of alternative installations shall be demonstrated by a risk assessment.*

3.1.2 A ventilation capacity less than 30 air changes per hour may be accepted if the gas concentration calculated in Ch 3, Sec 1, [2.1.4] does not exceed 40% LEL.

3.1.3 The number and power of the ventilation fans are be such that the full required ventilation capacity remains available after failure of a fan with a separate circuit from the main switchboard or emergency switchboard or of a group of fans with common circuit from the main switchboard or emergency switchboard.

3.1.4 *Approved automatic fail-safe fire dampers shall be fitted in the ventilation trunk for tank connection space.*

4 Ventilation of machinery spaces

4.1 General

4.1.1 The ventilation systems serving ESD-protected spaces are to be designed and arranged such as to avoid dangerous gas concentration in the vicinity of potential ignition sources. Suitable analyses (e.g. CFD calculations) or tests are to be performed, assuming a rupture of a gas fuel pipe and taking into account:

- the engine power
- the ventilation fan capacity
- the position of the ventilation inlets and outlets
- the distribution of the ventilation flows.

4.1.2 *The ventilation system for machinery spaces containing gas-fuelled consumers shall be independent of all other ventilation systems.*

4.1.3 Spaces enclosed in the boundaries of machinery spaces (such as purifier's room, engine room workshops and stores) are considered integral part of machinery spaces containing gas-fuelled consumers and therefore their ventilation system does not need to be independent of the one of machinery spaces.

4.1.4 *ESD protected machinery spaces shall have ventilation with a capacity of at least 30 air changes per hour. The ventilation system shall ensure a good air circulation in all spaces, and in particular ensure that any formation of gas pockets in the room are detected. As an alternative, arrangements whereby under normal operation the machinery spaces are ventilated with at least 15 air changes an hour is acceptable provided that, if gas is detected in the machinery space, the number of air changes will automatically be increased to 30 an hour.*

4.1.5 *For ESD protected machinery spaces the ventilation arrangements shall provide sufficient redundancy to ensure a high level of ventilation availability as defined in a standard acceptable to the Organization.*

Note 1: Refer to IEC 60079-10-1.

4.1.6 *The number and power of the ventilation fans for ESD protected engine-rooms and for double pipe ventilation systems for gas safe engine-rooms shall be such that the capacity is not reduced by more than 50% of the total ventilation capacity if a fan* *with a separate circuit from the main switchboard or emergency switchboard or a group of fans with common circuit from the main switchboard or emergency switchboard, is inoperable.*

5 Ventilation of fuel preparation room

5.1 General

5.1.1 *Fuel preparation rooms, shall be fitted with effective mechanical ventilation system of the under pressure type, providing a ventilation capacity of at least 30 air changes per hour.*

5.1.2 *The number and power of the ventilation fans shall be such that the capacity is not reduced by more than 50%, if a fan with a separate circuit from the main switchboard or emergency switchboard or a group of fans with common circuit from the main switchboard or emergency switchboard, is inoperable.*

5.1.3 *Ventilation systems for fuel preparation rooms, shall be in operation when pumps or compressors are working.*

5.1.4 The ventilation systems are to remain in operation as long as parts of the fuel piping and equipment are under pressure.

6 Ventilation of bunkering station

6.1 General

6.1.1 *Bunkering stations that are not located on open deck shall be suitably ventilated to ensure that any vapour being released during bunkering operations will be removed outside. If the natural ventilation is not sufficient, mechanical ventilation shall be provided in accordance with the risk assessment required by Ch 6, Sec 1, [2.1.1].*

6.1.2 Enclosed and semi-enclosed bunkering stations are to be fitted with effective mechanical ventilation system of the under pressure type, providing a ventilation capacity of at least 30 air changes per hour.

Ventilation systems for bunkering stations are to be in operation during bunkering operations.

In case of loss of the ventilation, the bunkering operation is to be automatically stopped

7 Regulations for ducts and double pipes

7.1

7.1.1 *Ducts and double pipes containing fuel piping shall be fitted with effective mechanical ventilation system of the extraction type, providing a ventilation capacity of at least 30 air changes per hour. This is not applicable to double pipes in the engine-room if fulfilling Ch 5, Sec 2, [3.1.1].*

This requirement applies to ducts and double pipes containing liquid fuel piping in accordance with Ch 5, Sec 2, [2.2.2].

7.1.2 *The ventilation system for double piping and for gas valve unit spaces in gas safe engine-rooms shall be independent of all other ventilation systems.*

7.1.3 Double piping and gas valve unit spaces in gas safe engine-room are considered integral part of the fuel supply systems and therefore their ventilation system does not need to be independent of other fuel supply ventilation systems provided such fuel supply systems contain only gaseous fuel.

The ventilation system (including air inlet and outlet) for double wall gas fuel piping and for gas valve unit spaces may be common.

The ventilation systems for liquid fuel piping systems and those for gas fuel piping systems are to be independent.

The ventilation systems for high pressure piping systems and those for low pressure systems are to be independent, except if it is demonstrated that there is no risk of over-pressurizing the low pressure fuel piping enclosure in case of failure of the high pressure fuel piping.

7.1.4 *The ventilation inlet for the double wall piping or duct shall always be located in a non-hazardous area away from ignition sources. The inlet opening shall be fitted with a suitable wire mesh guard and protected from ingress of water.*

7.1.5 The ventilation inlet for the double wall piping or duct is always to be located in a non-hazardous area in open air away from ignition sources.

7.1.6 *The capacity of the ventilation for a pipe duct or double wall piping may be below 30 air changes per hour if a flow velocity of minimum 3 m/s is ensured. The flow velocity shall be calculated for the duct with fuel pipes and other components installed.*

Section 4 Electrical Installation

1 Functional requirements

1.1 General

1.1.1 *This Section relates to functional requirements in Ch 1, Sec 3, [1.1.1], Ch 1, Sec 3, [1.1.2], Ch 1, Sec 3, [1.1.4], Ch 1, Sec 3, [1.1.7], Ch 1, Sec 3, [1.1.8], Ch 1, Sec 3, [1.1.11], Ch 1, Sec 3, [1.1.13] and Ch 1, Sec 3, [1.1.16] to Ch 1, Sec 3, [1.1.18].*

In particular, electrical generation and distribution systems, and associated control systems, shall be designed such that a single fault will not result in the loss of ability to maintain fuel tank pressures and hull structure temperature within normal operating limits.

2 General

2.1 System Design

2.1.1 *Electrical installation shall be in compliance with a standard at least equivalent to those acceptable to the Organization.*

Note 1: Refer to IEC 60092 series standards, as applicable.

2.1.2 *Electrical equipment or wiring shall not be installed in hazardous areas unless essential for operational purposes or safety enhancement.*

2.1.3 *Where electrical equipment is installed in hazardous areas as provided in [2.1.2], it shall be selected, installed and maintained in accordance with standards at least equivalent to those acceptable to the Organization.*

Equipment for hazardous areas shall be evaluated and certified or listed by an accredited testing authority or notified body recognized by the Society.

Note 1: Refer to the recommendation published by the International Electrotechnical Commission, in particular to publication IEC 60092-502:1999.

2.1.4 *Failure modes and effects of single failure for electrical generation and distribution systems in [1.1] shall be analysed and documented to be at least equivalent to those acceptable to the Organization.*

Note 1: Refer to IEC 60812.

2.1.5 *The lighting system in hazardous areas shall be divided between at least two branch circuits. All switches and protective devices shall interrupt all poles or phases and shall be located in a non-hazardous area.*

2.1.6 *The installation on board of the electrical equipment units shall be such as to ensure the safe bonding to the hull of the units themselves.*

2.1.7 *Arrangements shall be made to alarm in low liquid level and automatically shut down the motors in the event of low-low liquid level. The automatic shutdown may be accomplished by sensing low pump discharge pressure, low motor current, or low-low liquid level. This shutdown shall give an audible and visual alarm on the navigation bridge, continuously manned central control station or onboard safety centre.*

See also Ch 8, Sec 1, [3.3.8].

2.1.8 *Submerged fuel pump motors and their supply cables may be fitted in liquefied gas fuel containment systems. Fuel pump motors shall be capable of being isolated from their electrical supply during gas-freeing operations.*

2.1.9 *For non-hazardous spaces with access from hazardous open deck where the access is protected by an airlock, electrical equipment which is not of the certified safe type shall be de-energized upon loss of overpressure in the space.*

2.1.10 *Electrical equipment for propulsion, power generation, manoeuvring, anchoring and mooring, as well as emergency fire pumps, that are located in spaces protected by airlocks, shall be of a certified safe type.*

2.1.11 Electrical equipment necessary for maintaining propulsion and other essential services are not to be located in a gas safe space protected by an airlock.

CHAPTER 8
CONTROL, MONITORING AND SAFETY SYSTEM

Section 1 General

Section 1 General

1 Functional requirements

1.1 General

1.1.1 *This Section relates to functional requirements in Ch 1, Sec 3, [1.1.1], Ch 1, Sec 3, [1.1.2], Ch 1, Sec 3, [1.1.11], Ch 1, Sec 3, [1.1.13] to Ch 1, Sec 3, [1.1.15], Ch 1, Sec 3, [1.1.17] and Ch 1, Sec 3, [1.1.18].*

a) *The control, monitoring and safety systems of the gas-fuelled installation shall be so arranged that the remaining power for propulsion and power generation is in accordance with Ch 5, Sec 2, [1.3] in the event of single failure.*

b) *A gas safety system shall be arranged to close down the gas supply system automatically, upon failure in systems as described in Table 1 and upon other fault conditions which may develop too fast for manual intervention.*

c) *For ESD protected machinery configurations the safety system shall shut down gas supply upon gas leakage and in addition disconnect all non-certified safe type electrical equipment in the machinery space.*

d) *The safety functions shall be arranged in a dedicated gas safety system that is independent of the gas control system in order to avoid possible common cause failures. This includes power supplies and input and output signal.*

e) *The safety systems including the field instrumentation shall be arranged to avoid spurious shutdown, e.g. as a result of a faulty gas detector or a wire break in a sensor loop.*

f) *Where two or more gas supply systems are required to meet the regulations, each system shall be fitted with its own set of independent gas control and gas safety systems.*

2 Location

2.1 General

2.1.1 *Suitable instrumentation devices shall be fitted to allow a local and a remote reading of essential parameters to ensure a safe management of the whole fuel-gas equipment including bunkering.*

2.1.2 *A bilge well in each tank connection space of an independent liquefied gas storage tank shall be provided with both a level indicator and a temperature sensor. Alarm shall be given at high level in the bilge well. Low temperature indication shall activate the safety system.*

2.1.3 The level indicator required by [2.1.2] is required for the purposes of indicating an alarm status only; a level switch (float switch) is an instrument example considered to meet this requirement.

2.1.4 *For tanks not permanently installed in the vessel a monitoring system shall be provided as for permanently installed tanks.*

2.1.5 Monitoring and alarm sensors intended for fuel bunkering, storage, preparation and supply systems are to be of a type approved by the Society.

3 Liquefied gas fuel storage monitoring

3.1 Level indicators for liquefied gas fuel tanks

3.1.1 *Each liquefied gas fuel tank shall be fitted with liquid level gauging device(s), arranged to ensure a level reading is always obtainable whenever the liquefied gas fuel tank is operational. The device(s) shall be designed to operate throughout the design pressure range of the liquefied gas fuel tank and at temperatures within the fuel operating temperature range.*

3.1.2 *Where only one liquid level gauge is fitted it shall be arranged so that it can be maintained in an operational condition without the need to empty or gas-free the tank.*

3.1.3 *Liquefied gas fuel tank liquid level gauges may be of the following types:*

a) *indirect devices, which determine the amount of fuel by means such as weighing or in-line flow metering, or*

b) *closed devices, which do not penetrate the liquefied gas fuel tank, such as devices using radio-isotopes or ultrasonic devices, or*

c) *closed devices which penetrate the liquefied gas fuel tank but which form part of a closed system and keep the gas fuel from being released. Such devices shall be considered as tank connections. If the closed gauging device is not mounted directly onto the tank, it shall be provided with a shutoff valve located as close as possible to the tank.*

Liquefied gas fuel tank liquid level gauges may also be closed devices which penetrate the liquefied gas fuel tank, but which form part of a closed system and keep the gas fuel from being released. Such devices are to be considered as tank connections.

If the closed gauging device is not mounted directly onto the tank, it is to be provided with a shutoff valve located as close as possible to the tank.

3.2 Overflow control

3.2.1 *Each liquefied gas fuel tank shall be fitted with a high liquid level alarm operating independently of other liquid level indicators and giving an audible and visual warning when activated.*

3.2.2 *An additional sensor operating independently of the high liquid level alarm shall automatically actuate a shutoff valve in a manner that will both avoid excessive liquid pressure in the bunkering line and prevent the liquefied gas fuel tank from becoming liquid full.*

3.2.3 *The position of the sensors in the liquefied gas fuel tank shall be capable of being verified before commissioning. At the first occasion of full loading after delivery and after each dry-docking, testing of high level alarms shall be conducted by raising the fuel liquid level in the liquefied gas fuel tank to the alarm point.*

Note 1: The expression “each dry-docking” refers to:

- for cargo ships, 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; and
- for passenger ships, the survey of the outside of the ship's bottom to be carried out according to paragraphs Ch 2, Sec 6, [2.1.1] and Ch 2, Sec 6, [2.1.3] of the Survey Guidelines under the Harmonized System of Survey and Certification, (HSSC), 2017 (resolution A.1121(30), as may be amended).

3.2.4 *All elements of the level alarms, including the electrical circuit and the sensor(s), of the high, and overfill alarms, shall be capable of being functionally tested. Systems shall be tested prior to fuel operation.*

3.2.5 *Where arrangements are provided for overriding the overflow control system, they shall be such that inadvertent operation is prevented. When this override is operated continuous visual indication is to be provided at the navigation bridge, continuously manned central control station or onboard safety centre.*

3.3 Miscellaneous

3.3.1 *The vapour space of each liquefied gas fuel tank shall be provided with a direct reading gauge. Additionally, an indirect indication is to be provided on the navigation bridge, continuously manned central control station or onboard safety centre.*

3.3.2 *The pressure indicators shall be clearly marked with the highest and lowest pressure permitted in the liquefied gas fuel tank.*

3.3.3 *A high-pressure alarm and, if vacuum protection is required, a low-pressure alarm shall be provided on the navigation bridge and at continuously manned central control station or onboard safety centre. Alarms shall be activated before the set pressures of the safety valves are reached.*

3.3.4 *Each fuel pump discharge line and each liquid and vapour fuel manifold shall be provided with at least one local pressure indicator.*

3.3.5 *Local-reading manifold pressure indicator shall be provided to indicate the pressure between ship's manifold valves and hose connections to the shore.*

3.3.6 *Fuel storage hold spaces and interbarrier spaces without open connection to the atmosphere shall be provided with pressure indicator.*

3.3.7 *At least one of the pressure indicators provided shall be capable of indicating throughout the operating pressure range.*

3.3.8 *For submerged fuel-pump motors and their supply cables, arrangements shall be made to alarm in low liquid level and automatically shut down the motors in the event of low-low liquid level. The automatic shutdown may be accomplished by sensing low pump discharge pressure, low motor current, or low-low liquid level. This shutdown shall give an audible and visual alarm on the navigation bridge, continuously manned central control station or onboard safety centre.*

See also Ch 7, Sec 4, [2.1.7].

3.3.9 *Except for independent tanks of type C supplied with vacuum insulation system and pressure build-up fuel discharge unit, each fuel tank shall be provided with devices to measure and indicate the temperature of the fuel in at least three locations; at the bottom and middle of the tank as well as the top of the tank below the highest allowable liquid level.*

3.4 Summary of requirements for control, monitoring and safety systems

3.4.1 The requirements for monitoring, alarms and safety systems of LNG fuel storage systems are summarized in Tab 1.

4 Bunkering control

4.1 General

4.1.1 *Control of the bunkering shall be possible from a safe location remote from the bunkering station. At this location the tank pressure, tank temperature if required by [3.3.9], and tank level shall be monitored. Remotely controlled valves required by Ch 6, Sec 1, [4.1.4] and Ch 7, Sec 1, [4.1.8] shall be capable of being operated from this location. Overfill alarm and automatic shutdown shall also be indicated at this location.*

4.1.2 Manual Emergency shutdown of the bunkering is to be possible from the bunkering control location and from the wheelhouse.

4.1.3 *If the ventilation in the ducting enclosing the bunkering lines stops, an audible and visual alarm shall be provided at the bunkering control location, see also [7].*

4.1.4 An automatic shutdown is also to be activated upon stop of the ventilation defined in [4.1.3].

4.1.5 *If gas is detected in the ducting around the bunkering lines an audible and visual alarm and emergency shutdown shall be provided at the bunkering control location.*

Note 1: Clarifications:

- "Emergency shutdown" in [4.1.5] is understood to mean "automatic shutdown".
- The ducting is to be fitted for the bunkering lines only when required by Ch 6, Sec 1, Tab 1.

4.1.6 If the ventilation serving enclosed and semi-enclosed bunkering stations stops, an audible and visual alarm is to be provided at the bunkering control station.

4.1.7 The requirements for monitoring, alarms and safety systems of LNG fuel bunkering systems are summarized in Tab 1.

Table 1 : Monitoring, alarms and safeties for LNG bunkering and storage systems

Parameter		Monitoring		Shutdown				
		Alarm	Indication	Tank inlet valve, see Ch 5, Sec 2, [1.3.2]	Remote operated bunkering valves, see Ch 6, Sec 1, [4.1.4]		LNG Fuel pump	LNG Bunkering facility **(1)**
					LNG	Vapour		
LNG bunkering system	Pressure at the LNG manifold **(2)**		Local + Remote					
	Activation of emergency shutdown **(3)**	X			X	X		X

Note 1: Alarms and remote indications are to be provided at the bunkering control station, and at the navigation bridge.
(1) A signal is to be delivered to the bunkering facility to activate its shutdown
(2) See [3.3.4] and [3.3.5]
(3) See [4]
(4) See [4.1.2]
(5) See [4.1.5]
(6) For enclosed and semi-enclosed bunkering stations. See Ch 7, Sec 3, [6.1]
(7) See Ch 2, Sec 6, [2.2.7]
(8) For enclosed and semi-enclosed bunkering stations. See [7.1.1], Note 1
(9) See [3.1.1]. At least two indicators except if permitted by [3.2.2]
(10) See [3.2.1]
(11) Overfill alarm, see [3.2.2]
(12) See Ch 7, Sec 4, [2.1.7] and [3.3.8]
(13) The automatic shutdown of the pump may also be accomplished by low pump discharge pressure or low motor current. See Ch 7, Sec 4, [2.1.7]
(14) See [3.3.1]
(15) See [3.3.3]
(16) During bunkering operations
(17) in the following cases:
- If vacuum protection is required. See [3.3.3]
- For type C tanks fitted with pressure build-up units

(18) Measurements in at least 3 locations except for type C, vacuum-insulated tanks fitted with pressure build-up unit. See [3.3.9]

Parameter		Monitoring		Shutdown				
		Alarm	Indication	Tank inlet valve, see Ch 5, Sec 2, [1.3.2]	Remote operated bunkering valves, see Ch 6, Sec 1, [4.1.4]		LNG Fuel pump	LNG Bunkering facility **(1)**
					LNG	Vapour		
LNG bunkering line	Loss of ducting ventilation **(4)**	X			X	X		X
	Gas detection in the ducting **(5)**	X			X	X		X
LNG bunkering station	Loss of ventilation **(6)**	X			X	X		X
	Leakage detection in the drip-tray **(7)**	X			X	X		X
	Gas detection **(8)**	X			X	X		X
LNG fuel tank	Level		Remote **(9)**					
		H **(10)**						
		HH **(11)**		X				
		L **(12)**						
		LL **(12)**					X **(13)**	
	Pressure		Local + Remote **(14)**					
		H **(15)**		X **(16)**			X **(16)**	
		L **(17)**						
	Temperature **(18)**		Remote					

Note 1: Alarms and remote indications are to be provided at the bunkering control station, and at the navigation bridge.

(1) A signal is to be delivered to the bunkering facility to activate its shutdown
(2) See [3.3.4] and [3.3.5]
(3) See [4]
(4) See [4.1.2]
(5) See [4.1.5]
(6) For enclosed and semi-enclosed bunkering stations. See Ch 7, Sec 3, [6.1]
(7) See Ch 2, Sec 6, [2.2.7]
(8) For enclosed and semi-enclosed bunkering stations. See [7.1.1], Note 1
(9) See [3.1.1]. At least two indicators except if permitted by [3.2.2]
(10) See [3.2.1]
(11) Overfill alarm, see [3.2.2]
(12) See Ch 7, Sec 4, [2.1.7] and [3.3.8]
(13) The automatic shutdown of the pump may also be accomplished by low pump discharge pressure or low motor current. See Ch 7, Sec 4, [2.1.7]
(14) See [3.3.1]
(15) See [3.3.3]
(16) During bunkering operations
(17) in the following cases:
- If vacuum protection is required. See [3.3.3]
- For type C tanks fitted with pressure build-up units

(18) Measurements in at least 3 locations except for type C, vacuum-insulated tanks fitted with pressure build-up unit. See [3.3.9]

5 Gas compressor monitoring

5.1 General

5.1.1 *Gas compressors shall be fitted with audible and visual alarms both on the navigation bridge and in the engine control room. As a minimum the alarms shall include low gas input pressure, low gas output pressure, high gas output pressure and compressor operation.*

5.1.2 *Temperature monitoring for the bulkhead shaft glands and bearings shall be provided, which automatically give a continuous audible and visual alarm on the navigation bridge or in a continuously manned central control station.*

6 Gas engine monitoring

6.1 General

6.1.1 *In addition to the instrumentation provided in accordance with part C of SOLAS chapter II-1, indicators shall be fitted on the navigation bridge, the engine control room and the manoeuvring platform for:*

a) operation of the engine in case of gas-only engines, or

b) operation and mode of operation of the engine in the case of dual fuel engines.

7 Gas detection

7.1 General

7.1.1 *Permanently installed gas detectors shall be fitted in:*

a) the tank connection spaces

b) all ducts around fuel pipes

c) machinery spaces containing gas piping, gas equipment or gas consumers

Note 1: This requirement applies to both gas-safe and ESD-protected machinery spaces. However, gas detection is not required in a gas safe machinery space containing only fully welded double-wall piping without valves or flanges and no gas consumer nor gas equipment.

d) compressor rooms and fuel preparation rooms

e) other enclosed spaces containing fuel piping or other fuel equipment without ducting

f) other enclosed or semi-enclosed spaces where fuel vapours may accumulate including interbarrier spaces and fuel storage hold spaces of independent tanks other than type C

g) airlocks

h) gas heating circuit expansion tanks

i) motor rooms associated with the fuel systems, and

j) at ventilation inlets to accommodation and machinery spaces if required based on the risk assessment required in Ch 1, Sec 2, [1].

7.1.2 In addition to [7.1.1], permanently installed gas detectors are to be fitted:

- in GVU spaces and enclosures
- at ventilation inlets to ro-ro spaces and special category spaces
- in space containing bolted hatch to tank connection space
- in enclosed and semi-enclosed bunkering stations
- for membrane containment systems, in the primary and secondary insulation spaces.

7.1.3 *In each ESD-protected machinery space, redundant gas detection systems shall be provided.*

7.1.4 *The number of detectors in each space shall be considered taking into account the size, layout and ventilation of the space.*

7.1.5 *The detection equipment shall be located where gas may accumulate and in the ventilation outlets. Gas dispersal analysis or a physical smoke test shall be used to find the best arrangement.*

7.1.6 Gas dispersal analysis or smoke tests are required for the following spaces:

- ESD-protected machinery spaces
- Fuel preparation rooms
- Tank connection spaces
- Enclosed and semi-enclosed bunkering stations.

7.1.7 *Gas detection equipment shall be designed, installed and tested in accordance with a recognized standard.*

Note 1: Refer to IEC 60079-29-1 – Explosive atmospheres – Gas detectors – Performance requirements of detectors for flammable detectors.

7.1.8 The gas detection equipment is to be type-approved and suitable for all expected ambient conditions including air flow velocities.

7.1.9 *An audible and visible alarm shall be activated at a gas vapour concentration of 20% of the lower explosion limit (LEL). The safety system shall be activated at 40% of LEL at two detectors (see footnote (1) in Tab 2.*

7.1.10 *For ventilated ducts around gas pipes in the machinery spaces containing gas-fuelled engines, the alarm limit can be set to 30% LEL. The safety system shall be activated at 60% of LEL at two detectors (see footnote (1) in Tab 2).*

7.1.11 *Audible and visible alarms from the gas detection equipment shall be located on the navigation bridge or in the continuously manned central control station.*

7.1.12 *Gas detection required by Article [7] shall be continuous without delay.*

8 Fire detection

8.1 General

8.1.1 *Required safety actions at fire detection in the machinery space containing gas-fuelled engines and rooms containing independent tanks for fuel storage hold spaces are given in Tab 2.*

Table 2 : Monitoring of gas supply system to engines

Parameter	Alarm	Automatic shutdown of tank valve **(6)**	Automatic shutdown of gas supply to machinery space containing gas-fuelled engines	Comments
Gas detection in tank connection space at 20% LEL	X			
Gas detection on two detectors **(1)** in tank connection space at 40% LEL	X	X		
Fire detection in fuel storage hold space	X			
Fire detection in ventilation trunk to the tank connection space and in the tank connection space	X			
Bilge well high level tank connection space	X			
Bilge well low temperature in tank connection space	X	X		
Gas detection in duct between tank and machinery space containing gas-fuelled engines at 20% LEL	X			
Gas detection on two detectors **(1)** in duct between tank and machinery space containing gas-fuelled engines at 40% LEL	X	X **(2)**		
Gas detection in fuel preparation room at 20% LEL	X			
Gas detection on two detectors **(1)** in fuel preparation room at 40% LEL	X	X **(2)**		
Gas detection in duct inside machinery space containing gas-fuelled engines at 30% LEL	X			If double pipe fitted in machinery space containing gas-fuelled engines
Gas detection on two detectors **(1)** in duct inside machinery space containing gas-fuelled engines at 60% LEL	X		X **(3)**	If double pipe fitted in machinery space containing gas-fuelled engines
Gas detection in ESD protected machinery space containing gas-fuelled engines at 20% LEL	X			
Gas detection on two detectors **(1)** in ESD protected machinery space containing gas-fuelled engines at 40% LEL	X		X	It shall also disconnect non certified safe electrical equipment in machinery space containing gas-fuelled engines It is also to activate the automatic shutdown of the engines and other gas consumers.
Loss of ventilation in duct between tank and machinery space containing gas-fuelled engines	X		X **(2)**	
Loss of ventilation in duct inside machinery space containing gas-fuelled engines **(5)**	X		X **(3)**	If double pipe fitted in machinery space containing gas-fuelled engines
Loss of ventilation in ESD protected machinery space containing gas-fuelled engines	X		X	

Parameter	Alarm	Automatic shutdown of tank valve **(6)**	Automatic shutdown of gas supply to machinery space containing gas-fuelled engines	Comments
Fire detection in machinery space containing gas-fuelled engines	X			
Abnormal gas pressure in gas supply pipe	X			
Failure of valve control actuating medium	X		X **(4)**	Time delayed as found necessary
Automatic shutdown of engine (engine failure)	X		X **(4)**	
Manually activated emergency shutdown of engine	X		X	
Loss of ventilation in TCS	X	X		
Abnormal gas temperature in gas supply pipe	X			

(1) Two independent gas detectors located close to each other are required for redundancy reasons. If the gas detector is of self-monitoring type the installation of a single gas detector can be permitted.
(2) If the tank is supplying gas to more than one engine and the different supply pipes are completely separated and fitted in separate ducts and with the master valves fitted outside of the duct, only the master valve on the supply pipe leading into the duct where gas or loss of ventilation is detected shall close.
(3) If the gas is supplied to more than one engine and the different supply pipes are completely separated and fitted in separate ducts and with the master valves fitted outside of the duct and outside of the machinery space containing gas-fuelled engines, only the master valve on the supply pipe leading into the duct where gas or loss of ventilation is detected shall close.
(4) Only double block and bleed valves to close.
(5) If the duct is protected by inert gas (see Ch 5, Sec 2, [3.1.1], a) then loss of inert gas overpressure shall lead to the same actions as given in this Table.
(6) Valves referred to in Ch 5, Sec 2, [1.3.2]

9 Ventilation monitoring

9.1 General

9.1.1 *Any loss of the required ventilating capacity shall give an audible and visual alarm on the navigation bridge or in a continuously manned central control station or safety centre.*

9.1.2 The following solutions are acceptable means to confirm that the ventilation system has the required ventilating capacity in operation:

- monitoring of the ventilation electric motor or fan operation combined with under pressure indication; or
- monitoring of the ventilation electric motor or fan operation combined with ventilation flow indication; or
- monitoring of ventilation flow rate to indicate that the required air flow rate is established.

Alternative solutions may however be considered on a case-by-case basis.

9.1.3 *For ESD protected machinery spaces the safety system shall be activated upon loss of ventilation in engine-room.*

10 Safety functions of fuel supply systems

10.1 General

10.1.1 *If the fuel supply is shut off due to activation of an automatic valve, the fuel supply shall not be opened until the reason for the disconnection is ascertained and the necessary precautions taken. A readily visible notice giving instruction to this effect shall be placed at the operating station for the shut-off valves in the fuel supply lines.*

10.1.2 *If a fuel leak leading to a fuel supply shutdown occurs, the fuel supply shall not be operated until the leak has been found and dealt with. Instructions to this effect shall be placed in a prominent position in the machinery space.*

10.1.3 *A caution placard or signboard shall be permanently fitted in the machinery space containing gas-fuelled engines stating that heavy lifting, implying danger of damage to the fuel pipes, shall not be done when the engine(s) is running on gas.*

10.1.4 *Compressors, pumps and fuel supply shall be arranged for manual remote emergency stop from the following locations as applicable:*

a) *navigation bridge*
b) *cargo control room*
c) *on-board safety centre*
d) *engine control room*
e) *fire control station, and*
f) *adjacent to the exit of fuel preparation rooms.*

The gas compressor shall also be arranged for manual local emergency stop.

CHAPTER 9
MANUFACTURE, WORKMANSHIP AND TESTING

Section 1 General

Section 2 Certification of Equipment

Section 1 General

1 Definitions

1.1 General

1.1.1 "Fuel" in this section means Natural gas, either in its liquefied or gaseous form.

1.1.2 *The manufacture, testing, inspection and documentation shall be in accordance with recognized standards and the regulations given in this Rule Note.*

1.1.3 Materials and welding of fuel piping systems are to comply with the provisions of NR216.

Inspection and testing of fuel piping systems are to comply with NR467, Pt C, Ch 1, Sec 10, Tab 39.

1.1.4 *Where post-weld heat treatment is specified or required, the properties of the base material shall be determined in the heat treated condition, in accordance with the applicable tables of Chapter 5, and the weld properties shall be determined in the heat treated condition in accordance with [3]. In cases where a post-weld heat treatment is applied, the test regulations may be modified at the discretion of the Society.*

2 General test regulations and specifications

2.1 Tensile test

2.1.1 *Tensile testing shall be carried out in accordance with recognized standards*

2.1.2 *Tensile strength, yield stress and elongation shall be to the satisfaction of the Society. For carbon-manganese steel and other materials with definitive yield points, consideration shall be given to the limitation of the yield to tensile ratio.*

2.2 Toughness test

2.2.1 *Acceptance tests for metallic materials shall include Charpy V-notch toughness tests unless otherwise specified by the Society. The specified Charpy V-notch regulations are minimum average energy values for three full size (10 mm × 10 mm) specimens and minimum single energy values for individual specimens. Dimensions and tolerances of Charpy V-notch specimens shall be in accordance with recognized standards. The testing and regulations for specimens smaller than 5,0 mm in size shall be in accordance with recognized standards. Minimum average values for sub-sized specimens shall be as per Tab 1.*

Only one individual value may be below the specified average value, provided it is not less than 70% of that value.

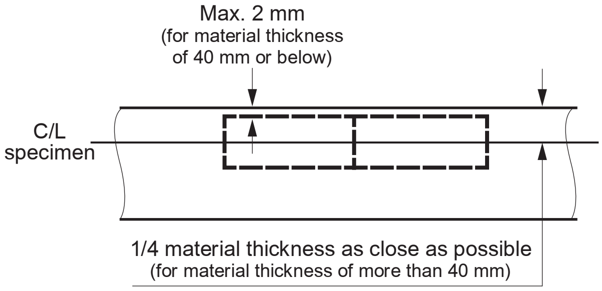
Table 1 :

Charpy V-notch specimen size (mm)	Minimum average energy of three specimens
10 x 10	KV
10 x 7,5	5/6 KV
10 x 5,0	2/3 KV
KV : Energy values, in J, specified in Ch 4, Sec 1, Tab 1 to Ch 4, Sec 1, Tab 4.	

2.2.2 *For base metal, the largest size Charpy V-notch specimens possible for the material thickness shall be machined with the specimens located as near as practicable to a point midway between the surface and the centre of the thickness and the length of the notch perpendicular to the surface as shown in Fig 1.*

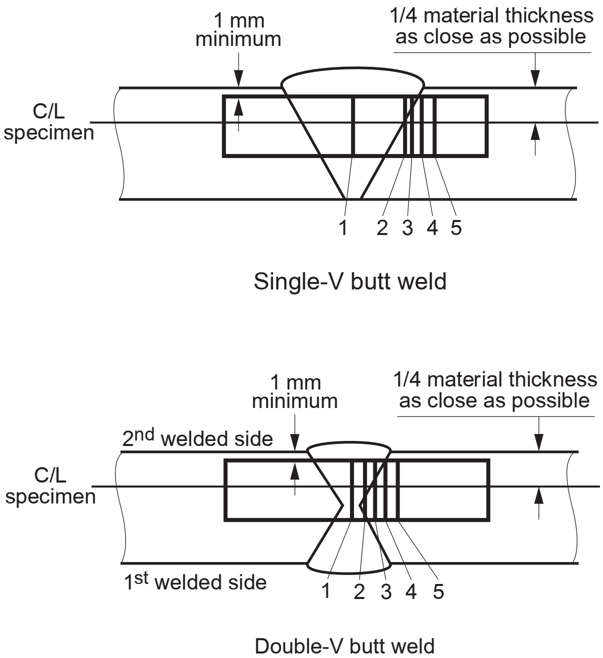
2.2.3 In the case where the material thickness is 40 mm or below, the Charpy V-notch impact test specimens are to be cut with their edge within 2 mm from the "as rolled" surface with their longitudinal axes either parallel or transverse to the final direction of rolling of the material.

Figure 1 : Orientation of base metal test specimen



2.2.4 *For a weld test specimen, the largest size Charpy V-notch specimens possible for the material thickness shall be machined, with the specimens located as near as practicable to a point midway between the surface and the centre of the thickness. In all cases the distance from the surface of the material to the edge of the specimen shall be approximately 1 mm or greater. In addition, for double-V butt welds, specimens shall be machined closer to the surface of the second welded section. The specimens shall be taken generally at each of the following locations, as shown in Fig 2, on the centreline of the welds, the fusion line and 1 mm, 3 mm and 5 mm from the fusion line.*

Figure 2 : Orientation of weld test specimen



Notch locations are defined in [3.3.4] item d)

2.2.5 *If the average value of the three initial Charpy V-notch specimens fails to meet the stated regulations, or the value for more than one specimen is below the required average value, or when the value for one specimen is below the minimum value permitted for a single specimen, three additional specimens from the same material may be tested and the results combined with those previously obtained to form a new average. If this new average complies with the regulations and if no more than two individual results are lower, than the required average and no more than one result is lower than the required value for a single specimen, the piece or batch may be accepted.*

2.3 Bend test

2.3.1 *The bend test may be omitted as a material acceptance test, but is required for weld tests. Where a bend test is performed, this shall be done in accordance with recognized standards.*

2.3.2 *The bend tests shall be transverse bend tests, which may be face, root or side bends at the discretion of the Society. However, longitudinal bend tests may be required in lieu of transverse bend tests in cases where the base material and weld metal have different strength levels.*

2.4 Section observation and other testing

2.4.1 *Macrosection, microsection observations and hardness tests may also be required by the Society, and they shall be carried out in accordance with recognized standards, where required.*

3 Welding of metallic materials and non-destructive testing for the fuel containment system

3.1 General

3.1.1 *This Section shall apply to primary and secondary barriers only, including the inner hull where this forms the secondary barrier. Acceptance testing is specified for carbon, carbon-manganese, nickel alloy and stainless steels, but these tests may be adapted for other materials. At the discretion of the Society, impact testing of stainless steel and aluminium alloy weldments may be omitted and other tests may be specially required for any material.*

3.1.2 The provisions of [3.1.1] are also applicable for austenitic steels and aluminium alloy.

3.2 Welding consumables

3.2.1 *Consumables intended for welding of fuel tanks shall be in accordance with recognized standards. Deposited weld metal tests and butt weld tests shall be required for all consumables. The results obtained from tensile and Charpy V-notch impact tests shall be in accordance with recognized standards. The chemical composition of the deposited weld metal shall be recorded for information.*

3.3 Welding procedure tests for fuel tanks and process pressure vessels

3.3.1 *Welding procedure tests for fuel tanks and process pressure vessels are required for all butt welds.*

3.3.2 The test assemblies shall be representative of:

a) each base material

b) each type of consumable and welding process, and

c) each welding position.

3.3.3 For butt welds in plates, the test assemblies are to be so prepared that the rolling direction is parallel to the direction of welding. The range of thickness qualified by each welding procedure test shall be in accordance with recognized standards. Radiographic or ultrasonic testing may be performed at the option of the fabricator.

3.3.4 *The following welding procedure tests for fuel tanks and process pressure vessels shall be done in accordance with [2] with specimens made from each test assembly:*

a) cross-weld tensile tests

b) longitudinal all-weld testing where required by the recognized standards

c) transverse bend tests, which may be face, root or side bends. However, longitudinal bend tests may be required in lieu of transverse bend tests in cases where the base material and weld metal have different strength levels

d) one set of three Charpy V-notch impacts, generally at each of the following locations, as shown in Fig 2:

  1) centreline of the welds

  2) fusion line

  3) 1 mm from the fusion line

  4) 3 mm from the fusion line, and

  5) 5 mm from the fusion line

e) macrosection, microsection and hardness survey may also be required.

3.3.5 *Each test shall satisfy the following:*

a) Tensile tests: cross-weld tensile strength is not to be less than the specified minimum tensile strength for the appropriate parent materials. For materials such as aluminium alloys, reference shall be made to Ch 3, Sec 2, [13.2.1], c) with regard to the regulations for weld metal strength of under-matched welds (where the weld metal has a lower tensile strength than the parent metal). In every case, the position of fracture shall be recorded for information

b) Bend tests: no fracture is acceptable after a 180° bend over a former of a diameter four times the thickness of the test pieces, and

c) Charpy V-notch impact tests: Charpy V-notch tests shall be conducted at the temperature prescribed for the base material being joined. The results of weld metal impact tests, minimum average energy KV, shall be no less than 27 J. The weld metal regulations for sub-size specimens and single energy values shall be in accordance with [2.2.1]. The results of fusion line and heat affected zone impact tests shall show a minimum average energy KV in accordance with the transverse or longitudinal regulations of the base material, whichever is applicable, and for sub-size specimens, the minimum average energy KV shall be in accordance with [2.2.1]. If the material thickness does not permit machining either full-size or standard sub-size specimens, the testing procedure and acceptance standards shall be in accordance with recognized standards.

3.3.6 *Procedure tests for fillet welding shall be in accordance with recognized standards. In such cases, consumables shall be so selected that exhibit satisfactory impact properties.*

3.4 Welding procedure tests for piping

3.4.1 *Welding procedure tests for piping shall be carried out and shall be similar to those detailed for fuel tanks in Article [6].*

3.5 Production weld tests

3.5.1 *For all fuel tanks and process pressure vessels except membrane tanks, production weld tests shall generally be performed for approximately each 50 m of butt-weld joints and shall be representative of each welding position. For secondary barriers, the same type production tests as required for primary barriers shall be performed, except that the number of tests may be reduced subject to agreement with the Society. Tests, other than those specified in [3.5.2] to [3.5.5] may be required for fuel tanks or secondary barriers.*

3.5.2 The production tests for types A and B independent tanks are to include bend tests and, where required for procedure tests, one set of three Charpy V-notch tests. The tests are to be made for each 50 m of weld. The Charpy V-notch tests are to be made with specimens having the notch alternately located in the centre of the weld and in the heat affected zone (most critical location based on procedure qualification results). For austenitic stainless steel, all notches are to be in the centre of the weld.

3.5.3 For type C independent tanks and process pressure vessels, transverse weld tensile tests are required in addition to the tests listed in [3.5.2]. Tensile tests shall meet [3.5.5].

3.5.4 The quality assurance/quality control (QA/QC) program is to ensure the continued conformity of the production welds as defined in the material manufacturers quality manual (QM).

3.5.5 The test regulations for membrane tanks are the same as the applicable test regulations listed in [3.3].

3.6 Non-destructive testing

3.6.1 *All test procedures and acceptance standards shall be in accordance with recognized standards, unless the designer specifies a higher standard in order to meet design assumptions. Radiographic testing shall be used in principle to detect internal defects. However, an approved ultrasonic test procedure in lieu of radiographic testing may be conducted, but in addition supplementary radiographic testing at selected locations shall be carried out to verify the results. Radiographic and ultrasonic testing records shall be retained.*

3.6.2 For the fabrication of independent fuel tanks, the requirements for the entity carrying out NDT are as follows:

a) In case of non-destructive testing carried out by an independent company from the manufacturer or shipyard, such company has to comply with the requirements for the independent NDT service supplier as set out in NR669 Requirements for Non-Destructive Testing suppliers.
b) In case of non-destructive testing carried out directly by the shipyard or manufacturer, the requirements for the internal NDT department as set out in NR669 Requirements for Non-Destructive Testing suppliers are to be complied with.

3.6.3 *For type A independent tanks where the design temperature is below −20°C, and for type B independent tanks, regardless of temperature, all full penetration butt welds of the shell plating of fuel tanks shall be subjected to non-destructive testing suitable to detect internal defects over their full length. Ultrasonic testing in lieu of radiographic testing may be carried out under the same conditions as described in [3.6.1].*

3.6.4 *In each case the remaining tank structure, including the welding of stiffeners and other fittings and attachments, shall be examined by magnetic particle or dye penetrant methods as considered necessary.*

3.6.5 *For type C independent tanks, the extent of non-destructive testing shall be total or partial according to recognized standards, but the controls to be carried out shall not be less than the following:*

a) Total non-destructive testing referred to in Ch 3, Sec 2, [16.3.2], c).
   1) Radiographic testing:
      - *all butt welds over their full length*
   2) Non-destructive testing for surface crack detection:
      - *all welds over 10% of their length*
      - *reinforcement rings around holes, nozzles, etc. over their full length.*
   3) As an alternative, ultrasonic testing, as described in 16.3.6.1, may be accepted as a partial substitute for the radiographic testing. In addition, the Society may require total ultrasonic testing on welding of reinforcement rings around holes, nozzles, etc.

b) Partial non-destructive testing referred to in Ch 3, Sec 2, [16.3.2], c)
   1) Radiographic testing:
   all butt welded crossing joints and at least 10% of the full length of butt welds at selected positions uniformly distributed
   2) Non-destructive testing for surface crack detection:
   reinforcement rings around holes, nozzles, etc. over their full length

3) Ultrasonic testing:
as may be required by the Society in each instance.

3.6.6 *The quality assurance/quality control (QA/QC) program shall ensure the continued conformity of the non-destructive testing of welds, as defined in the material manufacturer's quality manual (QM).*

3.6.7 *Inspection of piping shall be carried out in accordance with the regulations of Chapter 5.*

3.6.8 *The secondary barrier shall be non-destructive tested for internal defects as considered necessary. Where the outer shell of the hull is part of the secondary barrier, all sheer strake butts and the intersections of all butts and seams in the side shell shall be tested by radiographic testing.*

4 Construction in metallic materials

4.1 General

4.1.1 *Inspection and non-destructive testing of welds shall be in accordance with regulations in [3.5] and [3.6]. Where higher standards or tolerances are assumed in the design, they shall also be satisfied.*

4.2 Independent tank

4.2.1 *For type C tanks and type B tanks primarily constructed of bodies of revolution the tolerances relating to manufacture, such as out-of-roundness, local deviations from the true form, welded joints alignment and tapering of plates having different thicknesses, shall comply with recognized standards. The tolerances shall also be related to the buckling analysis referred to in Ch 3, Sec 2, [16.2.3], a) and Ch 3, Sec 2, [15.2.1], b).*

4.3 Secondary barriers

4.3.1 *During construction the regulations for testing and inspection of secondary barriers shall be approved or accepted by the Society (see also Ch 3, Sec 2, [4.1.1], e) and f)).*

4.4 Membrane tanks

4.4.1 *The quality assurance/quality control (QA/QC) program shall ensure the continued conformity of the weld procedure qualification, design details, materials, construction, inspection and production testing of components. These standards and procedures shall be developed during the prototype testing programme.*

5 Testing

5.1 Testing and inspections during construction

5.1.1 *All liquefied gas fuel tanks and process pressure vessels shall be subjected to hydrostatic or hydro-pneumatic pressure testing in accordance with [5.2] to Article [5], as applicable for the tank type.*

5.1.2 *All tanks shall be subject to a tightness test which may be performed in combination with the pressure test referred to in [5.1.1].*

5.1.3 *The gas tightness of the fuel containment system with reference to Ch 3, Sec 1, [2.1.3] shall be tested.*

5.1.4 *Regulations with respect to inspection of secondary barriers shall be decided by the Society in each case, taking into account the accessibility of the barrier (see also Ch 3, Sec 2, [4.1.1]).*

5.1.5 *The Society may require that for ships fitted with novel type B independent tanks, or tanks designed according to Ch 3, Sec 1, [2.1.6] at least one prototype tank and its support shall be instrumented with strain gauges or other suitable equipment to confirm stress levels during the testing required in [5.1.1]. Similar instrumentation may be required for type C independent tanks, depending on their configuration and on the arrangement of their supports and attachments.*

5.1.6 *The overall performance of the fuel containment system shall be verified for compliance with the design parameters during the first LNG bunkering, when steady thermal conditions of the liquefied gas fuel are reached, in accordance with the requirements of the Society. Records of the performance of the components and equipment, essential to verify the design parameters, shall be maintained on board and be available to the Society.*

5.1.7 *The fuel containment system shall be inspected for cold spots during or immediately following the first LNG bunkering, when steady thermal conditions are reached. Inspection of the integrity of thermal insulation surfaces that cannot be visually checked shall be carried out in accordance with the requirements of the Society.*

5.1.8 *Heating arrangements, if fitted in accordance with Ch 3, Sec 2, [14.1.3] and Ch 3, Sec 2, [14.1.4], shall be tested for required heat output and heat distribution.*

5.2 Type A independent tanks

5.2.1 *All type A independent tanks shall be subjected to a hydrostatic or hydro-pneumatic pressure testing. This test shall be performed such that the stresses approximate, as far as practicable, the design stresses, and that the pressure at the top of the tank corresponds at least to the MARVS. When a hydropneumatic test is performed, the conditions shall simulate, as far as practicable, the design loading of the tank and of its support structure including dynamic components, while avoiding stress levels that could cause permanent deformation.*

5.2.2 Additional requirement for type A independent tanks

The conditions in which testing is performed are to simulate as far as possible the actual loading on the tank and its supports.

When testing takes place after installation of the gas fuel tank, provision is to be made prior to the launching of the ship in order to avoid excessive stresses in the ship structures.

5.3 Type B independent tanks

5.3.1 *Type B independent tanks shall be subjected to a hydrostatic or hydro-pneumatic pressure testing as follows:*

a) *The test shall be performed as required in [5.2.1] for type A independent tanks.*

b) *In addition, the maximum primary membrane stress or maximum bending stress in primary members under test conditions shall not exceed 90% of the yield strength of the material (as fabricated) at the test temperature. To ensure that this condition is satisfied, when calculations indicate that this stress exceeds 75% of the yield strength the test of the first of a series of identical tanks shall be monitored by the use of strain gauges or other suitable equipment.*

5.3.2 Additional requirement for type B independent tanks

The conditions in which testing is performed are to simulate as far as possible the actual loading on the tank and its supports.

When testing takes place after installation of the gas fuel tank, provision is to be made prior to the launching of the ship in order to avoid excessive stresses in the ship structures.

5.4 Type C independent tanks and other pressure vessels

5.4.1 *Each pressure vessel shall be subjected to a hydrostatic test at a pressure measured at the top of the tanks, of not less than 1,5 P_0. In no case during the pressure test shall the calculated primary membrane stress at any point exceed 90% of the yield strength of the material at the test temperature. To ensure that this condition is satisfied where calculations indicate that this stress will exceed 0,75 times the yield strength, the test of the first of a series of identical tanks shall be monitored by the use of strain gauges or other suitable equipment in pressure vessels other than simple cylindrical and spherical pressure vessels.*

5.4.2 *The temperature of the water used for the test shall be at least 30°C above the nil-ductility transition temperature of the material, as fabricated.*

5.4.3 *The pressure shall be held for 2 hours per 25 mm of thickness, but in no case less than 2 hours.*

5.4.4 *Where necessary for liquefied gas fuel pressure vessels, a hydro-pneumatic test may be carried out under the conditions prescribed in [5.4.1] to [5.4.3].*

5.4.5 *Special consideration may be given to the testing of tanks in which higher allowable stresses are used, depending on service temperature. However, regulation in [5.4.1] shall be fully complied with.*

5.4.6 *After completion and assembly, each pressure vessel and its related fittings shall be subjected to an adequate tightness test, which may be performed in combination with the pressure testing referred to in [5.4.1] or [5.4.3] as applicable.*

5.4.7 *Pneumatic testing of pressure vessels other than liquefied gas fuel tanks shall be considered on an individual case basis. Such testing shall only be permitted for those vessels designed or supported such that they cannot be safely filled with water, or for those vessels that cannot be dried and are to be used in a service where traces of the testing medium cannot be tolerated.*

5.4.8 Additional requirement for type C independent tanks and other pressure vessels

The conditions in which testing is performed are to simulate as far as possible the actual loading on the tank and its supports.

When testing takes place after installation of the gas fuel tank, provision is to be made prior to the launching of the ship in order to avoid excessive stresses in the ship structures.

5.5 Membrane tanks

5.5.1 Design development testing

The design development testing required in Ch 3, Sec 2, [16.4.1], b) shall include a series of analytical and physical models of both the primary and secondary barriers, including corners and joints, tested to verify that they will withstand the expected combined strains due to static, dynamic and thermal loads at all filling levels. This will culminate in the construction of a prototype scaled model of the complete liquefied gas fuel containment system. Testing conditions considered in the analytical and physical model shall represent the most extreme service conditions the liquefied gas fuel containment system will be likely to encounter over its life. Proposed acceptance criteria for periodic testing of secondary barriers required in 6.4.4 may be based on the results of testing carried out on the prototype scaled model.

5.5.2 *The fatigue performance of the membrane materials and representative welded or bonded joints in the membranes shall be determined by tests. The ultimate strength and fatigue performance of arrangements for securing the thermal insulation system to the hull structure shall be determined by analyses or tests.*

5.5.3 Testing

a) *In ships fitted with membrane liquefied gas fuel containment systems, all tanks and other spaces that may normally contain liquid and are adjacent to the hull structure supporting the membrane, shall be hydrostatically tested.*

b) *All hold structures supporting the membrane shall be tested for tightness before installation of the liquefied gas fuel containment system.*

c) *Pipe tunnels and other compartments that do not normally contain liquid need not be hydrostatically tested.*

5.5.4 Additional requirement for membrane tanks

The testing of membrane and semi-membrane tanks is to comply with the requirements in NR467, Pt B, Ch 13, Sec 6 and NR467, Pt D, Ch 9, Sec 4, [11.10].

5.5.5 Testing, first LNG bunkering operation and first loaded voyage

a) Tests are to be performed at the minimum service temperature or at a temperature very close to it.

b) Inert gas production systems, if any, and the installation, if any, for use of gas as fuel for boilers and internal combustion engines are also to be tested to the satisfaction of the Surveyor.

c) LNG transfer system trials in working condition

   LNG transfer system, is to be examined by Surveyor during the first LNG bunkering operation.

   The following examinations are to be conducted during the first LNG transfer:

   1) a) Examination of transfer piping systems including supporting arrangements.

   2) b) Witness satisfactory operation of the following:
      - Control and monitoring systems
      - Connections systems (QCDC).

d) First loaded voyage of ships

   All operating data and temperature readings during the first loaded voyage of the ship are to be submitted to the Society:

   - Review gas fuel logs and alarm reports.
   - Witness satisfactory operation of the following:
     - gas detection system
     - gas fuel control and monitoring systems such as level gauging equipment, temperature sensors, pressure gauges, gas fuel pumps and compressors, proper control of gas fuel heat exchangers, if operating, etc.
     - nitrogen generating plant or inert gas generator, if operating
     - nitrogen pressure control system for insulation, interbarrier, and annular spaces, as applicable
     - cofferdam heating system, if in operation
     - reliquefaction plant, if fitted
   - Examination of gas fuel piping systems including expansion and supporting arrangements.
   - Witness topping off process for gas fuel tanks including high level alarms activated during normal loading.
   - Obtain written statement from the Master that the cold spot examination was carried out during the first loaded voyage and found satisfactory. Where possible, the Surveyor should examine selected spaces.

e) All data and temperatures read during subsequent voyages are to be kept at the disposal of the Society for a suitable period of time.

6 Welding, post-weld heat treatment and non-destructive testing

6.1 General

6.1.1 *Welding shall be carried out in accordance with [3].*

6.2 Post-weld heat treatment

6.2.1 *Post-weld heat treatment shall be required for all butt welds of pipes made with carbon, carbon- manganese and low alloy steels. The Society may waive the regulations for thermal stress relieving of pipes with wall thickness less than 10 mm in relation to the design temperature and pressure of the piping system concerned.*

6.3 Non-destructive testing

6.3.1 *In addition to normal controls before and during the welding, and to the visual inspection of the finished welds, as necessary for proving that the welding has been carried out correctly and according to the regulations in this paragraph, the following tests shall be required:*

a) *100% radiographic or ultrasonic inspection of butt-welded joints for piping systems with:*
   1) *design temperatures colder than −10°C, or*
   2) *design pressure greater than 1,0 MPa, or*
   3) *gas supply pipes in ESD protected machinery spaces, or*
   4) *inside diameters of more than 75 mm, or*
   5) *wall thicknesses greater than 10 mm.*

b) *When such butt welded joints of piping sections are made by automatic welding procedures approved by the Society, then a progressive reduction in the extent of radiographic or ultrasonic inspection can be agreed, but in no case to less than 10% of each joint. If defects are revealed the extent of examination shall be increased to 100% and shall include inspection of previously accepted welds. This approval can only be granted if well-documented quality assurance procedures and records are available to assess the ability of the manufacturer to produce satisfactory welds consistently.*

c) *The radiographic or ultrasonic inspection regulation may be reduced to 10% for butt-welded joints in the outer pipe of double-walled fuel piping.*

d) *For other butt-welded joints of pipes not covered by [6.3.1], a) and c), spot radiographic or ultrasonic inspection or other non-destructive tests shall be carried out depending upon service, position and materials. In general, at least 10% of butt-welded joints of pipes shall be subjected to radiographic or ultrasonic inspection.*

7 Testing

7.1 Type testing of piping components

7.1.1 *Valves*

Each type of piping component intended to be used at a working temperature below −55°C shall be subject to the following type tests:

a) *Each size and type of valve shall be subjected to seat tightness testing over the full range of operating pressures and temperatures, at intervals, up to the rated design pressure of the valve. Allowable leakage rates shall be to the requirements of the Society. During the testing satisfactory operation of the valve shall be verified.*

b) *The flow or capacity shall be certified to a recognized standard for each size and type of valve.*

c) *Pressurized components shall be pressure tested to at least 1,5 times the design pressure.*

d) *For emergency shutdown valves, with materials having melting temperatures lower than 925°C, the type testing shall include a fire test to a standard acceptable to the Society.*

Note 1: Refer to the recommendations by the International Organization for Standardization, in particular publications:

ISO 19921:2005, Ships and marine technology - Fire resistance of metallic pipe components with resilient and elastomeric seals - Test methods

ISO 19922:2005, Ships and marine technology - Fire resistance of metallic pipe components with resilient and elastomeric seals - Requirements imposed on the test bench

7.1.2 In addition to requirements stated in [7.1.1]:

- Prototype testing for all valves to the minimum design temperature or lower and to a pressure not lower than the maximum design pressure foreseen for the valves is to be witnessed by a Surveyor.
- [7.1.1], a), theseat and stem leakage test is to be carried out at a pressure equal to 1,1 times the design pressure.
- Cryogenic testing consisting of valve operation or safety valve set pressure and leakage verification is to be carried out.

- Each type and size of pressure relief valve fitted to fuel storage tanks is to be subject to the following type tests:
  - verification of relieving capacity
  - cryogenic testing when operating at design temperatures colder than −55°C
  - seat tightness testing, and
  - pressure testing of the pressure containing parts to at least 1,5 times the design pressure.

  The tests are to be carried out in accordance with the standards ISO 21013-1:2008 - Cryogenic vessels - Pressure-relief accessories for cryogenic service - part 1: Reclosable pressure- relief valves and ISO 4126-1; 2004 Safety devices for protection against excessive pressure - part 1 and part 4: Safety valves.
- For valves intended to be used at a working temperature above −55°C, prototype testing is not required.

7.2 Expansion bellows

7.2.1 *The following type tests shall be performed on each type of expansion bellows intended for use on fuel piping outside the fuel tank as found acceptable in Ch 5, Sec 1, [4.1.6], item c) 1) and item c) 3), and where required by the Society, on those installed within the fuel tanks:*

a) *Elements of the bellows, not pre-compressed, but axially restrained shall be pressure tested at not less than five times the design pressure without bursting. The duration of the test shall not be less than five minutes.*

b) *A pressure test shall be performed on a type expansion joint, complete with all the accessories such as flanges, stays and articulations, at the minimum design temperature and twice the design pressure at the extreme displacement conditions recommended by the manufacturer without permanent deformation.*

c) *A cyclic test (thermal movements) shall be performed on a complete expansion joint, which shall withstand at least as many cycles under the conditions of pressure, temperature, axial movement, rotational movement and transverse movement as it will encounter in actual service. Testing at ambient temperature is permitted when this testing is at least as severe as testing at the service temperature.*

d) *A cyclic fatigue test (ship deformation, ship accelerations and pipe vibrations) shall be performed on a complete expansion joint, without internal pressure, by simulating the bellows movement corresponding to a compensated pipe length, for at least 2000000 cycles at a frequency not higher than 5 Hz. This test is only required when, due to the piping arrangement, ship deformation loads are actually experienced.*

7.3 System testing

7.3.1 *Requirements of the present article apply to fuel piping inside and outside the fuel tanks. However, relaxation from these regulations for piping inside fuel tanks and open ended piping may be accepted by the Society.*

7.3.2 *After assembly, all fuel piping shall be subjected to a strength test with a suitable fluid. The test pressure shall be at least 1,5 times the design pressure for liquid lines and 1,5 times the maximum system working pressure for vapour lines. When piping systems or parts of systems are completely manufactured and equipped with all fittings, the test may be conducted prior to installation on board the ship. Joints welded on board shall be tested to at least 1,5 times the design pressure.*

7.3.3 Where the test fluid is compressible, the test pressure may be limited to 1,25 times the design pressure for liquid lines and 1,25 times the maximum system working pressure for vapour lines.

7.3.4 *After assembly on board, the fuel piping system shall be subjected to a leak test using air, or other suitable medium to a pressure depending on the leak detection method applied.*

7.3.5 *In double wall fuel piping systems the outer pipe or duct shall also be pressure tested to show that it can withstand the expected maximum pressure at pipe rupture.*

7.3.6 In addition, requirements in Ch 5, Sec 2, [4.1.6] are to be complied with.

7.3.7 *All piping systems, including valves, fittings and associated equipment for handling fuel or vapours, shall be tested under normal operating conditions not later than at the first bunkering operation, in accordance with the requirements of the Society.*

7.3.8 Emergency shutdown valves in liquefied gas piping systems are to close fully and smoothly within 30 s of actuation. Information about the closure time of the valves and their operating characteristics is to be available on board, and the closing time is to be verifiable and repeatable.

7.3.9 *The closing time of the valve referred to in Ch 6, Sec 1, [4.1.11] and Ch 8, Sec 1, [3.2], b) (i.e. time from shutdown signal initiation to complete valve closure), in second, shall not be greater than:*

$$\frac{3600U}{BR}$$

where:

U : Ullage volume at operating signal level, in m^3

BR : Maximum bunkering rate agreed between ship and shore facility, in m^3/h),

or 5 seconds, whichever is the least.

The bunkering rate shall be adjusted to limit surge pressure on valve closure to an acceptable level, taking into account the bunkering hose or arm, the ship and the shore piping systems, where relevant.

7.3.10 Testing and inspections of equipment during manufacturing

a) Valves

All valves are to be tested at the plant of manufacturer in the presence of the Surveyor. Testing is to include hydrostatic test of the valve body at a pressure equal to 1,5 times the design pressure for all valves, seat and stem leakage test at a pressure equal to 1,1 times the design pressure for valves other than safety valves. In addition, cryogenic testing consisting of valve operation and leakage verification for a minimum of 10% of each type and size of valve for valves other than safety valves intended to be used at a working temperature below -55°C. The set pressure of safety valves is to be tested at ambient temperature.

For valves used for isolation of instrumentation in piping not greater than 25mm, unit production testing need not be witnessed by the Surveyor. Records of testing are to be available for review.

As an alternative to the above, if so requested by the relevant Manufacturer, the certification of a valve may be issued, subject to an alternative survey scheme as per Rule Note NR320 as amended, and the following:

- The valve has been approved as required by [7.1] for valves intended to be used at a working temperature below -55°C, and
- The manufacturer has a recognized quality system that has been assessed and certified by the Society subject to periodic audits, and
- The quality control plan contains a provision to subject each valve to a hydrostatic test of the valve body at a pressure equal to 1,5 times the design pressure for all valves and seat and stem leakage test at a pressure equal to 1,1 times the design pressure for valves other than safety valves. The set pressure of safety valves is to be tested at ambient temperature. The manufacturer is to maintain records of such tests, and
- Cryogenic testing consisting of valve operation and leakage verification for a minimum of 10% of each type and size of valve for valves other than safety valves intended to be used at a working temperature below –55°C in the presence of the Surveyor.

b) Expansion bellows

All bellows are to be tested at the plant of manufacturer in the presence of the Surveyor. Testing is to include hydrostatic test of the bellow at a pressure equal to 1,5 times the design pressure. An alternative survey scheme, BV Mode I as per NR320, may be agreed with the Society.

c) Pressure relief valves

Each PRV is to be tested at the plant of manufacturer in the presence of the Surveyor to ensure that:

- it opens at the prescribed pressure setting, with an allowance not exceeding ±10% for 0 to 0,15 MPa, ±6% for 0,15 to 0,3 MPa, ± 3% for 0,3 MPa and above;
- seat tightness is acceptable; and
- pressure containing parts will withstand at least 1,5 times the design pressure.

Section 2 Certification of Equipment

1 Certification of LNG fuel handling and containment systems of gas fuelled ships

1.1 General

1.1.1 Equipment is to be certified as listed in Tab 1.

Symbols used in the table have the following meaning:

TA : Indicates that Type Approval is required

TA(HBV): indicates that Type Approval is required with work's recognition (HBV scheme as per NR320)

DA : indicates that Design assessment / Appraisal of the product is required; this one may be carried out as applicable either for a specific unit or using the Type Approval procedure.

C : indicates that a BV product certificate is required with invitation of the Surveyor to attend the tests unless otherwise agreed, in addition to the manufacturer's document stating the results of the tests performed and/or compliance with the approved type as applicable.

W : indicates that a manufacturer's document is required, stating the results of the tests performed and/or stating compliance with the approved type (as applicable).

X : indicates that examinations and tests are required.

Where fitted, each additional index (h, ndt) indicates a specific type of test:

h : Hydraulic pressure test (or equivalent)

ndt : Non-destructive tests as per Rules.

Table 1 : Certification requirements for LNG fuel handling and containment systems of gas-fuelled ships

No.	Item	Product certification				Remarks
		Design assessment / approval	Raw material certificate	Examination and testing	Product certificate	
1	Steel plates and profiles for independent liquefied gas fuel tanks (1)	(2)	C (2)	X	C	(1) Alternative metallic materials are subject to specific approval programme (2) As per provisions of Sec 1 and Chapter 4
2	Aluminium alloy plates and profiles for independent liquefied gas fuel tanks	(1)	C (1)	X	C	(1) As per provisions of Sec 1 and Chapter 4
3	Stainless or high alloy steel for membrane fuel containment system (1)	TA (2)	C (2)	X	C	(1) Alternative metallic materials are subject to specific approval programme (2) As per provisions of Sec 1, Chapter 4, NR216 et NR480
4	Insulation materials (1)	(2)				(1) Refer to Ch 3, Sec 2, [14.3] (2) In case of combination of items, the highest design assessment scheme TA>DA applies (3) Test to be witnessed by attending surveyors unless otherwise agreed (4) DA for glue not used in secondary barrier (SB) or insulation panels (IP) bonding (5) Tensile tests for TA (6) C for polyurethane foam, W for polystyrene (7) Review of bonders operators qualifications. Review of bonding and other fabrication or testing qualifications including Flat, Corner and Tri-way panels (8) In the case of shipbuilder's own manufacturing, no certificate would be issued after inspection unless explicitly required
	1 - Paint for inner hull protection	TA			W	
	2 - Studs, nuts, washers, coupler sockets, staples and screws		W		W	
	3 - Load bearing mastic	TA (3)		X	W	
	4 - Adhesives and glue	TA (4) (5)			W	
	5 - Foam panel	TA			C / W (6)	
	6 - Plywood	TA			W	
	7 - Stainless steel sheet	TA		X	C	
	8 - Stainless steel sheet studs, nuts and washers	DA			C	
	9 - Glass wool and glass cloth	TA			W	
	10 - Thermal protection				W	
	11 - Aluminium for reinforced elements	TA		X	C	
	12 - Aluminium wedges	TA	C		W	
	13 - Secondary barrier (composite material)	TA		X	C	
	14 - Insulating panels	TA	C	X (7)	C	
	15 - Expansion rivets (15 mm)	TA	W		W	
>>	16 - Stainless steel corners and anchor strips	TA	C	X	C	

No.	Item	Product certification				Remarks
		Design assessment / approval	Raw material certificate	Examination and testing	Product certificate	
4 (continued)	17 - Primary barrier component	DA	C	X	C	
	18 - Single legs	DA	W	X	C	
	19 - Primary block assembly	DA	W		C	
	20 - Perlite	TA			W	
	21 - Insulating material flexible / rigid	TA			W	
	22 - Fe-Ni alloy (36% Nickel) strips	TA		X	C	
	23 - Anti-sticking film				W	
	24 - Insulating boxes	DA	W		W	
	25 - Fe-Ni (36% Nickel) welding filler metal	TA		X	C	
	26 - Densified wood laminated for pipe guide tower	DA	C		C (8)	
5	Gas fuel compressors and their prime movers					(1) As per provisions of Ch 5, Sec 2 (2) Cryogenic compressors - Product certificate (C) required for materials in contact with the gas fuel, both the pressure containing parts, and non-pressure containing components (shaft and impellers). (3) According to an agreed program. (4) For electrical motors, refer to NR467, Part C, Chapter 2
	• Gas fuel compressors	TA or DA (1)	C (1) (2)	X h (3)	C	
	• Prime movers (4)	(4)		X (4)	C	
6	Gas fuel pumps and their prime movers					(1) As per provisions of Ch 5, Sec 2 (2) Cryogenic pumps - Product certificate (C) required for materials in contact with the gas fuel, both the pressure containing parts, and non-pressure containing components (shaft and impellers). (3) According to an agreed program. (4) For electrical motors, refer to NR467, Part C, Chapter 2
	• Gas fuel pumps	TA or DA (1)	C (1) (2)	X h (3)	C	
	• Prime movers (4)	(4)	(4)	(4)	C	
7	Bulkhead seal and gastight shaft bulkhead penetration devices	DA or TA (1)		X h	C (2)	(1) As per Ch 5, Sec 2, [1.4]. (2) As per conditions set in the TA.
8	Fans for hazardous enclosed spaces, and their prime movers					(1) Concerns the anti-sparking fans (2) As per conditions set in the TA (3) For electrical motors, refer to NR467, Part C, Chapter 2
	• Fans	TA (1)		X	C / W (2)	
	• Prime movers (3)	(3)		X (3)	C	

No.	Item	Product certification				Remarks
		Design assessment / approval	Raw material certificate	Examination and testing	Product certificate	
9	Condensers, gasifiers or vaporizers, separators, heat exchangers, receivers, process pressure vessels, or other similar apparatus of gas fuel supply system	DA (1)	C (1)	X h ndt	C	(1) As per provisions of Chapter 4, process pressure vessels handling cargo are to be considered as Class I pressure vessels, in accordance with NR467, Pt C, Ch 1, Sec 3, [1.4.1]. Note: Running tests - during gas trials of the ship
10	Fuel pipes for liquefied gas fuel					(1) As per provisions of Sec 1, Chapter 5 and NR467, Pt C, Ch 1, Sec 10 (2) Non-destructive testing: in addition to normal controls before and during the welding, and to the visual inspection of the finished welds, as necessary for proving that the welding has been carried out correctly and according to the regulations in this paragraph, radiographic or ultrasonic inspection or other non-destructive tests shall be carried out as required by Sec 1, [6.3] (3) W for Seamless steel or stainless steel, C for longitudinally welded stainless steel pipes
	• nominal diameter ND ≥ 50mm		W	X h ndt (1) (2)	C	
	• nominal diameter ND < 50mm		W	X h ndt (1) (2)	C / W (3)	
11	Fuel pipes for gaseous gas fuel with design pressure equal or lower than 10 bar (Class I or Class II)					(1) As per provisions of Sec 1, Chapter 5 and NR467, Pt C, Ch 1, Sec 10 (2) Non-destructive testing: in addition to normal controls before and during the welding, and to the visual inspection of the finished welds, as necessary for proving that the welding has been carried out correctly and according to the regulations in this paragraph, radiographic or ultrasonic inspection or other non-destructive tests shall be carried out as required by Sec 1, [6.3] (3) W for Seamless steel or stainless steel, C for longitudinally welded stainless steel pipes.
	• **Class I**: pipes in single wall configuration, and nominal diameter ND ≥ 50mm • **Class II**: pipes in double wall configuration, and nominal diameter ND ≥ 100mm		W	X h ndt (1) (2)	C	
	• **Class I**: pipes in single wall configuration, and nominal diameter ND < 50mm • **Class II**: pipes in double wall configuration, and nominal diameter ND < 100mm		W	X h ndt (1) (2)	C / W (3)	
12	Fuel pipes for gaseous gas fuel with design pressure higher than 10 bar (Class I) (1)					(1) For both single and double wall configuration (2) As per provisions of Sec 1 and NR467, Pt C, Ch 1, Sec 10 (3) Non-destructive testing: in addition to normal controls before and during the welding, and to the visual inspection of the finished welds, as necessary for proving that the welding has been carried out correctly and according to the regulations in this paragraph, radiographic or ultrasonic inspection or other non-destructive tests shall be carried out as required by Sec 1, [6.3] (4) W for Seamless steel or stainless steel, C for longitudinally welded stainless steel pipes
	• nominal diameter ND ≥ 50mm		W	X h ndt (2) (3)	C	
	• nominal diameter ND < 50mm		W	X h ndt (2) (3)	C / W (4)	
13	Outer pipe of double wall fuel pipes (Class II) (1) (2)					(1) As per provisions of Ch 5, Sec 1and NR467, Pt C, Ch 1, Sec 10 (2) Includes the gas valve enclosure (3) Pressure test is at the maximum working pressure of the inner pipe (4) W for Seamless steel or stainless steel, C for longitudinally welded stainless steel pipes
	• nominal diameter ND ≥ 100mm		W	X h ndt (3)	C	
	• nominal diameter ND < 100mm		W	X h ndt (3)	C / W (4)	

No.	Item	Product certification				Remarks
		Design assessment / approval	Raw material certificate	Examination and testing	Product certificate	
14	Gas fuel pipe fittings (1)	DA (2)	W	X h ndt (3)	C	(1) Such as elbows, reducers, flanges: same remarks as for items 10, 11, 12 or 13, as appropriate. (2) If not already addressed within the scope of the system approval (3) When the fittings are of welded type, the welding procedures are to be examined
15	Expansion joints (1)	TA	W	X h ndt	C	(1) Specific requirements as per Sec 1, [7.2]
16	Expansion bellows (1)	TA (2)	W	X h ndt	C	(1) Specific requirements as per Sec 1, [7.2] (2) Prototype tests to be performed on each type of expansion bellows intended for use on gas fuel piping, primarily on those used outside the gas fuel tank.
17	Liquefied gas bunkering hoses (1)	TA	C	X h ndt	C	(1) Specific requirements as per Chapter 6.
18	Gas fuel valves (1)					(1) Class of piping as per provisions of Chapter 4 (2) TA for service temperature < −55°C. DA for service temperature ≥ −55°C. (3) Prototype testing as per Sec 1, [7.1.2]. (4) As per NR216, Ch 5, Sec 7, [1.8]. Non-destructive examination by both MPI and UT methods are to be carried out on all Class I drum-forgings having thickness > 10 mm, intended for Class I piping systems, typically: all valves of large size (having nominal diameter ≥ 24") (5) In case of welded construction. When the valves have welded elements, the welding procedures are to be examined (6) Unit production testing: all valves are to be tested as per Sec 1
	• nominal diameter ND ≥ 50mm	TA or DA (2) (3)	C (4)	X h ndt (5) (6)	C	
	• nominal diameter ND < 50mm	TA or DA (2) (3)	W (4)	X h ndt (5) (6)	C	
19	Safety relief valves for gas fuel piping system	TA or DA (1)	C	X h ndt (2) (3)	C	(1) TA, or case-by-case DA (2) Checking of the setting (3) When the valves have welded elements, the welding procedures are to be examined
20	Safety relief valves for gas fuel tanks	TA (1)	C	X h ndt (2) (3)	C	(1) The approval includes capacity testing (2) Checking of the setting including tightness test (3) When the valves have welded elements, the welding procedures are to be examined
21	Gas fuel process and containment sensors, transmitters, flow meters, PT100 and PLC, Circuit breakers, Electric cables	TA (1)		X	C / W (2)	(1) For some equipment, DA is applicable on a case-by-case basis; see NR467, Pt C, Ch 2 and relevant provisions of NR467, Pt F, Ch 3 (2) As per conditions set in the TA
22	Vent lines on gas fuel tanks and low pressure gas fuel system (1)	DA	W	X h ndt (2)	C	(1) Open-ended lines (the design pressure should be not less than 5 bar gauge) (2) In case of welded construction. When the vent lines have welded elements, the welding procedures are to be examined
23	Vent lines on high pressure gas fuel system (1)	DA	W	X h ndt (2)	C	(1) The design pressure of the vent pipe is not to be less than the maximum expected pressure, which is to be justified (2) In case of welded construction. When the vent lines have welded elements, the welding procedures are to be examined

No.	Item	Product certification				Remarks
		Design assessment / approval	Raw material certificate	Examination and testing	Product certificate	
24	Inert gas generation systems (1)					(1) See requirements of Ch 3, Sec 12
25	Fire prevention materials and arrangements (1)					(1) See NR467, Part C, Chapter 4 and relevant provisions of Chapter 7
26	Fire fighting systems (1)					(1) See NR467, Part C, Chapter 4 and relevant provisions of Chapter 7
27	Gas detection system	TA (1)		X	C	(1) Automation systems: see relevant provisions of NR467, Pt F, Ch 3.
28	Integrated gas fuel supply system (1)	DA		X (2)	C	(1) Complete system including fuel containment, tank connection space and gas preparation system. (2) As per agreed program, based on the requirements of this Rule Note, IMO IGF Code and/or standards recognized by the Society.
29	Boil-Off Gas (BOG) handling system, as part of refrigeration / reliquefaction systems (1)	TA or DA		X (2)	C	(1) See relevant provisions of Ch 3, Sec 7. (2) As per agreed program, based on the requirements of this Rule Note, IMO IGF Code and/or standards recognized by the Society.
30	Gas valve unit (1)	TA or DA		X (2)	C	(1) See relevant provisions of NR529. (2) As per agreed program, based on the requirements of this Rule Note, IMO IGF Code and/or standards recognized by the Society.
31	Gas combustion unit (1)	TA or DA		X (2)	C	(1) See relevant provisions of NR529 (2) As per agreed program, based on the requirements of NR467, Part C, Chapter 1, this Rule Note, IMO IGF Code and/or standards recognized by the Society
32	Independent fuel tank supporting materials	TA (1)	C (1)	X	C	(1) Provisions of Ch 3, Sec 13 are to be applied and relevant provisions of NR216 and NR480
33	Pump tower (fuel piping and supporting structure)	DA	W/C (1)	X h (2) ndt (3)	C (2)	(1) C for fuel piping, W for supporting structure (2) For fuel piping, see items 10 to 14 (3) Review of welders, and NDT operators qualifications. Review of welding, NDT and other fabrication or testing qualifications. Survey of the fabrication and witnessing of NDT at random
34	Pump tower base support	DA	C	X ndt (1)	C	(1) Review of welders, and NDT operators qualifications. Review of welding, NDT and other fabrication or testing qualifications (in particular - gas tracer/leak test). Survey of the fabrication and witnessing of NDT at random.
35	Dome cover	DA	C	X ndt (1) (2)	C (2)	(1) Review of welders, and NDT operators qualifications. Review of welding, NDT and other fabrication or testing qualifications (in particular - gas tracer/leak test). Survey of the fabrication and witnessing of NDT at random (2) For fuel piping, see items 10 to 14
36	Dome seat	DA	C	X ndt (1)	C	(1) Review of welders, and NDT operators qualifications. Review of welding, NDT and other fabrication or testing qualifications.Survey of the fabrication and witnessing of NDT at random

No.	Item	Product certification				Remarks
		Design assessment / approval	Raw material certificate	Examination and testing	Product certificate	
37	Sump well	DA	C	X ndt (1)	C	(1) Review of welders, and NDT operators qualifications.Review of welding, NDT and other fabrication or testing qualifications (in particular - gas tracer/leak test), Survey of the fabrication and witnessing of NDT at random
38	Independent cargo tank systems	DA (1)	C / W (1)	X ndt	C	(1) As per provisions of NR467 and this Rule Note
39	Double-wall flexible hose assembly (1)	TA (2)	W	X h (3) (4)	C (5)	(1) Short length of metallic hose with end fittings ready for installation (2) Prototype testing: see NR 467, Pt C, Ch 1, Sec 10 [2.6] and NR 467, Pt C, Ch 1, Sec 10 [20.2] with a bursting test performed at 5 times the design pressure (3) Inner and outer pipes are to be tested (4) Hydraulic test for the inner pipe is to be carried out at 1,5 time the maximum service pressure without pressure in the outer pipe. Pressure test for the outer pipe as per Ch 5, Sec 2, [4] (5) As per conditions set in the TA
40	Emergency release system for bunkering ship (1)					(1) Refer to NR620 (2) Performance test / Pressure and leak test (3) Power system and PERC
	1- QCDC (Quick connect disconnect coupler) (including DDCC)	TA		X h (2)	C	
	2- ERC (Emergency release coupling)	TA		X h (2)	C	
	3- PERC (Powered emergency release coupling)	TA (3)		X h (2)	C	

CHAPTER 10
LNG FUEL PREPARED SHIPS

Section 1 Additional Class Notation LNGFUEL-PREPARED

Section 1 LNG-Fuel Prepared Ships

1 General

1.1 Application

1.1.1 The additional class notation **LNGFUEL-PREPARED** is assigned, in accordance with NR467, Pt A, Ch 1, Sec 2, [6.17], to new ships that are designed to accommodate future installation of an LNG fuel system, in accordance with the requirements of this Section.

1.1.2 The additional class notation **LNGFUEL-PREPARED** may be completed by one or by a combination of the following notations:

- **S** when specific arrangements are implemented for the ship structure
- **A** when specific arrangements for ventilation and access to gas-related spaces are already on board
- **P** when specific arrangements are implemented for piping
- **ME-DF** when the main engine(s) is (are) of the dual fuel type
- **AE** when the auxiliary engines are either of the dual fuel type, or designed for future conversion to dual fuel operation
- **B** when the oil-fired boilers are either of the dual fuel type, or designed for future conversion to dual fuel operation.

Examples of notations are given below:

LNGFUEL-PREPARED

LNGFUEL-PREPARED (P)

LNGFUEL-PREPARED (P, ME-DF)

1.1.3 When the ship is effectively converted to dual fuel operation, the additional class notation **LNGFUEL-PREPARED** will be replaced by the additional class notation **LNGFUEL dualfuel**, provided that all the applicable requirements of Chapter 1 to Chapter 9 are fulfilled.

1.2 Documents to be submitted

1.2.1 The documents to be submitted to the Society in the scope of additional class notation **LNGFUEL-PREPARED** will be stamped as “examined” unless drawings are describing items actually installed during construction or maintenance period where the notation is granted.

1.2.2 The documents listed in Tab 1 are to be submitted for ships to be assigned the additional class notation **LNGFUEL-PREPARED**.

In addition, the documents to be submitted for notations **S**, **A**, **P**, **ME-DF**, **AE** or **B** are listed in the corresponding Tab 2 to Tab 7.

Table 1 : Documents to be submitted for the additional class notation LNGFUEL-PREPARED

No.	A/I **(1)**	Documents	Particulars
1	A	General arrangement drawing of the ship	• Showing the gas-related spaces and installations, either fitted at the new building stage or planned at a subsequent stage, in particular: - the LNG bunkering station(s) - the LNG tanks - the fuel gas handling system - the GVU space(s) - the GCU (where fitted) - the vent mast(s) • The equipment and systems installed at the new building stage and those intended to be installed at a subsequent stage are to be clearly identified on the drawing.
2	I	General specification of the contemplated LNG/gas fuel installation	Including: • type and capacity of the LNG storage tanks • bunkering method (from terminal, bunker ship or barge, or truck) • boil-off management principle
(1) A: To be submitted for approval; I: To be submitted for information			

No.	A/I **(1)**	Documents	Particulars
3	A	Drawing showing the hazardous areas and their classification, assuming that all LNG/ gas installations are fitted on board	
4	A	Drawing showing the structural fire protection and cofferdams provided in connection with LNG/gas installations	
5	A	Preliminary loading manual and loading conditions assuming the LNG installation in ready-for-use condition	
6	A	Tank and Capacity Plan taking into account the LNG installation in ready-for-use condition	
7	A	Intact stability calculations taking into account the LNG installation in ready-for-use condition	
8	A	Damage Control Plan, Damage Stability Booklet and Damage Stability Calculations	• For ships having the additional class notation **SDS** • As applicable and taking into account the LNG installation in ready-for-use condition
9	A	Arrangement of accesses to the gas-related spaces	
10	A	Arrangement of the ventilation systems serving the gas related spaces	
11	I	For main engine of gas-convertible type: • details of the gas conversion • list of the components that need to be replaced (e.g. cylinder heads) • list of new components (e.g. gas supply valves, pilot injection system) • reference of approval for the engine running on natural gas	
12	I	HAZID analysis	See [2.1.4]
13	A	Electrical balance and heat balance anticipated with the use of LNG as fuel	
(1) A: To be submitted for approval; I: To be submitted for information			

Table 2 : Additional Documents to be submitted for notation S

No.	A/I **(1)**	Documents
1	A	Structure drawings for all gas-related spaces: bunkering station, LNG tank holds, gas fuel handling room, GVU room
2	A	Details of structural modifications and local reinforcements in way of machinery, piping components and supports of LNG tanks
3	A	Holes and penetration drawings
4	A	Calculation of the hull temperature in all the design tank loading conditions
5	A	Distribution of quality and steel grades in relation to the values obtained from the hull temperature calculation
(1) A: To be submitted for approval; I: To be submitted for information		

Table 3 : Additional documents to be submitted for notation A

No.	A/I **(1)**	Documents
1	A	Arrangement of accesses to gas-related spaces
2	A	Arrangement of the ventilation systems serving gas-related spaces
(1) A: To be submitted for approval; I: To be submitted for information		

Table 4 : Additional documents to be submitted for notation P

No.	A/I **(1)**	Documents
1	A	Schematic diagram and arrangement of the LNG and gas piping systems, including venting systems
2	A	Arrangement of the venting mast
(1) A: To be submitted for approval; I: To be submitted for information		

Table 5 : Additional documents to be submitted for notation ME-DF

No.	A/I **(1)**	Documents
1	I	Reference of type approval for the dual fuel main engine
(1) A: To be submitted for approval; I: To be submitted for information		

Table 6 : Additional documents to be submitted for notation AE

No.	A/I **(1)**	Documents
1	I	For auxiliary engines of gas-convertible type: • details of the gas conversion • list of the components that need to be replaced (e.g. cylinder heads) • list of new components (e.g. gas supply valves, pilot injection system) • reference of approval for the engine running on natural gas
(1) A: To be submitted for approval; I: To be submitted for information		

Table 7 : Additional documents to be submitted for notation B

No.	A/I **(1)**	Documents
21	I	For boilers of gas-convertible type: • details of the gas conversion • list of the components that need to be replaced (e.g. cylinder heads) • list of new components (e.g. gas supply valves, pilot injection system) • reference of approval for the engine running on natural gas
(1) A: To be submitted for approval; I: To be submitted for information		

2 Requirements for the additional class notation LNGFUEL-PREPARED

2.1 Design principles

2.1.1 The initial design of the ship is to take into account the specific physical and chemical characteristics of LNG.

2.1.2 The design of spaces intended to accommodate the LNG storage tanks is to take into account the required fuel capacity to cover the operating range of the ship.

2.1.3 The additional electrical and thermal power that may be necessary to supply the LNG systems is to be taken into account.

2.1.4 An HAZID analysis is to be conducted to ensure that the risks arising from the use of gas fuel are addressed. Loss of function, component or system damage, spillage of liquid or release of vapours, fire and explosion are, as a minimum, to be considered. The results of the HAZID are to be implemented in the design of the LNG systems.

2.2 General arrangement

2.2.1 The initial design of the ship is to take into account the necessary spaces or zones to accommodate the following installations:

- LNG bunkering station
- LNG storage tanks
- fuel gas handling system
- ventilation systems
- GVU
- GCU, where required by this Rule Note
- vent mast.

2.2.2 The arrangement and location of gas-related spaces are to comply with the provisions of this Rule Note.

2.2.3 The hazardous / non-hazardous area classification of the gas-related spaces is to be defined in accordance with the provisions of this Rule Note.

2.2.4 The ship ventilation is to be arranged in accordance with the provisions of this Rule Note, in particular as regards the separation between the ventilation systems serving hazardous areas and those serving the non-hazardous areas.

2.3 Hull and stability

2.3.1 The ship stability is to be assessed for preliminary loading conditions, assuming the LNG installation in ready-for-use condition, and to comply with the relevant provisions of NR467, Part B, Chapter 3. The relevant loads are to be stated.

2.3.2 The longitudinal strength of the ship is to be assessed, assuming the LNG installation in ready-for-use condition, and to comply with the relevant provisions of NR467, Part B.

2.3.3 Hull material in way of the LNG storage tanks is to be selected in relation to the values obtained from the hull temperature calculation. See Ch 3, Sec 2, [14] and Ch 4, Sec 1, Tab 5.

2.4 Machinery

2.4.1 All gas-related installations and equipment that are fitted to the ship at the initial design stage are to comply with the relevant provisions of this Rule Note.

2.4.2 Main engines are to be of dual fuel approved type or gas-convertible type.

3 Additional requirements for notations S, A, P, ME-DF, AE and B

3.1 General

3.1.1 In addition to complying with the provisions of Article [2], ships assigned one or more of the following notations defined in [1.1.2] are to comply with the corresponding requirements of:

- [3.2] for notation **S**
- [3.3] for notation **A**
- [3.4] for notation **P**
- [3.5] for notation **ME-DF**
- [3.6] for notation **AE**
- [3.7] for notation **B**

3.2 Notation S

3.2.1 The structure of the gas-related spaces is to be built in compliance with the relevant provisions of the structural rules applicable to the ship.

3.2.2 The local structural reinforcements in way of the tanks are to be justified by calculation and effectively fitted onboard the ship.

3.3 Notation A

3.3.1 Access

The access to gas-related spaces is to comply with the provisions of this Rule Note. Where required, airlocks are to be provided.

3.3.2 Ventilation

The ship ventilation is to be arranged in accordance with the provisions of Ch 7, Sec 3 in particular regarding the separation between the ventilation systems serving gas-related spaces and those serving other spaces.

Ventilation systems are to be fitted with all necessary locations sized for ventilators compatible with the requirements of Ch 7, Sec 3. Such ventilators need not be installed at new construction stage.

3.4 Notation P

3.4.1 The initial design of the ship is to take into account the spaces intended for the future installations of the LNG and gas fuel piping systems.

3.5 Notation ME-DF

3.5.1 The main engine is to be of a dual fuel approved type.

3.6 Notation AE

3.6.1 The auxiliary engines are to be of dual fuel approved type or gas-convertible type, as defined in Ch 1, Sec 1, [5.1.23].

3.7 Notation B

3.7.1 The boilers are to be of a dual fuel approved type or gas-convertible type, as defined in Ch 1, Sec 1, [5.1.23].

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